PROCEEDINGS

16[TH] IFOAM ORGANIC WORLD CONGRESS
MODENA, 16-20 JUNE 2008

CULTIVATE THE FUTURE.

ISOFAR

International Society of Organic Agriculture Research

CULTIVATING THE FUTURE BASED ON SCIENCE

Proceedings of the Second Scientific Conference of the International Society of Organic Agriculture Research (ISOFAR), held - at the 16[th] IFOAM Organic World Congress - in Cooperation with the International Federation of Organic Agriculture Movements (IFOAM) and the Consorzio ModenaBio 2008.

18-20 June 2008 in Modena, Italy.

VOLUME 1
ORGANIC CROP PRODUCTION

Edited by Daniel Neuhoff, Niels Halberg, Thomas Alföldi, William Lockeretz, Andreas Thommen, Ilse. A. Rasmussen, John Hermansen, Mette Vaarst, Lorna Lueck, Fabio Caporali, Henning Hogh Jensen, Paola Migliorini, Helga Willer.

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ISOFAR

Should the publication of corrigenda become necessary, these will be posted at the conference homepage http://www.isofar.org/Modena2008/

The 2nd Scientific Conference of the International Society of Organic Agriculture Research (ISOFAR) was held June 18-20, 2008 in Modena Italy, in the frame of the 16th Organic World Congress of the International Federation of Organic Agriculture Movements (IFOAM), organised by Consorzio ModenaBio. The 4th Congress of the European Integrated Project 'Quality Low Input Food' (QLIF) was convened as part of the 2nd ISOFAR Conference (see papers in volume 2 of these proceedings).

Daniel Neuhoff, Niels Halberg, Thomas Alföldi, William Lockeretz, Andreas Thommen, Ilse. A. Rasmussen, John Hermansen, Mette Vaarst, Lorna Lueck, Fabio Caporali, Henning Hogh Jensen, Paola Migliorini, Helga Willer (Editors) (2008):

Cultivating the Future Based on Science. Volume 1 - Organic Crop Production. Proceedings of the Second Scientific Conference of the International Society of Organic Agriculture Research (ISOFAR), held at the 16th IFOAM Organic World Congress in Cooperation with the International Federation of Organic Agriculture Movements (IFOAM) and the Consorzio ModenaBio, 18 – 20 June 2008 in Modena, Italy. International Society of Organic Agriculture Research (ISOFAR), DE-Bonn; Institute of Organic Agriculture (IOL), DE-Bonn; Research Institute of Organic Agriculture (FiBL), CH-Frick, Danish Research Centre for Organic Food and Farming (DARCOF), DK-8830 Tjele, Denmark

ISBN: 978-3-03736-023-1

Cover: Officina Comunicazione, Modena, Italy

Layout: Anja Schneider, IOL, Bonn, Germany and Helga Willer, FiBL, Frick, Switzerland

Printed by: Artestampa, Modena, Italy

Distribution: Paper copies may be ordered from FiBL (see FiBL shop at http://www.fibl.org/shop); FiBL order number 1503. A PDF version can be downloaded free of charge for ISOFAR members via the member area of www.isofar.org.

The abstracts of the papers are available at http://orgprints.org/view/projects/int-conf-owc-2008-research.html.

Table of contents

Plant nutrition 133

Potentials of beneficial micro-organisms 159

Preface

To carry home these heavy two volumes of ISOFAR's 2nd Scientific Conference Proceedings might give rise to the question whether these books represent more mass than class and if they are still topical.

After all the author must wonder whether a contribution in a peer-reviewed proceedings volume is worthwhile when there is the alternative of publishing it in a highly ranked scientific journal with the same effort. Moreover, the editors as well as the numerous referees might have felt desperate at times due to the enormous amount of time and strength they invested to compile about 400 selected papers.

I would like to thank all of you for your effort. It was worthwhile since the reader now obtains a valuable overview of the current state of knowledge and research aims of the scientifically based Organic Agriculture which might be important not only for the scientist but also for all other stakeholders interested in the further development of Organic Agriculture.

I owe gratitude to all who contributed to coping with this laborious task. You have all done a tremendous job in contributing to foreseen successful scientific modules held under ISOFAR´s and IFOAM's joined conference/congress umbrella. Our collective hope is that these proceedings will represent a significant milestone on the road towards a better understanding of the potentials and effects capabilities of a scientifically based Organic Agriculture can have.

Prof Dr Ulrich Köpke

President ISOFAR

Dear Reader,

The two volumes of the Proceedings of the Second Scientific Conference of the International Society of Organic Agriculture Research, 'Cultivating the Future Based on Science', represent a considerable part of the worldwide increase in research activities in Organic Agriculture (OA). This observation is in accordance with the overall trend, at least in much of the western world, of increased production and consumption of certified organic products.

In all, 495 four-page papers were submitted to the conference, and all went through a sophisticated review process resulting in 380 papers being selected for presentation at the ISOFAR Conference. Evaluating papers is a difficult task, requiring a sure scientific instinct. It also requires a reasonable judgement of the quality of the language of each paper; since a paper's language is part of what determines its overall quality, even though this gives an unjustified advantage to native speakers of English. Supported by a review form that checked various aspects of the paper's quality, the reviewers tried their best to ensure maximum transparency of the evaluation, which basically reflected the objective of improving the paper's quality.

The first volume deals mainly with various aspects of organic crop production, which traditionally represent the largest share of all papers submitted to conferences on OA. We hope that you will find it interesting to discover the diverse research approaches regarding the management of organic crops. While a tendency to a more problem-oriented approach realized by specialists is evident, as perhaps is to be expected, there is still a strong foundation of papers on traditional agronomy with a systemic approach, which remains a key discipline in OA research. Attentive readers will realize that the diversity of papers also reflects the global differences with respect to an understanding of what OA is.

The second volume gives insights into the increasing research activities on animal husbandry, socio-economics, interdisciplinary research projects, and QLIF workshops, all related to OA. We gratefully acknowledge in particular the increasing interest in organic animal husbandry, which in the past was a poor cousin in OA research. Some topical issues such as global warming and energy supply are discussed in the interdisciplinary sessions.

The scientific committee agreed at the start that cross-disciplinary papers should be given high priority because of the very nature of organic farming and food systems. For many years we have claimed there was a need for a holistic understanding of OA, both because of the interdependencies among sub-systems on the farm (soil-crops-livestock-people) and because of the multiple objectives behind OA (producing wholesome food, conserving soil fertility, maintaining biodiversity, supporting animal welfare, reducing pollution, etc.). However, most often researchers end up meeting and discussing these matters in largely discipline-oriented sessions, even at most organic conferences. Therefore, we wanted to encourage a more cross-disciplinary approach at this ISOFAR event, and we were happy to receive a large number of papers for the cross-disciplinary topics. We hope this tendency will be strengthened in future organic conferences.

Moreover, the great number of papers submitted for the scientific part of the OWC clearly demonstrates the interest in sharing research-based knowledge within the organic sector. To achieve this, it was important to have a section of the OWC where strict methodological approaches are required for participation.

On the other hand, it is a pleasure and an advantage for a scientific conference to be part of a global event that attracts the whole sector and thus allows the researchers to disseminate their findings widely and gain inspiration from other stakeholders in the organic movement.

First and foremost many thanks to all authors who contributed to our joint conference. We also are greatly indebted to the numerous reviewers listed on the next page, who did a first-class job in evaluating hundreds of papers. It was a great pleasure to cooperate with Paola Bonfreschi from the OWC – Organizing Committee, who is the embodiment of reliability and politeness. Last but not least, many thanks to Anja Schneider, of the ISOFAR Head Office, who was mainly in charge of overall communication with the authors and substantially supported the editing of the proceedings.

Managing the review process and editing the proceedings for an international conference is a challenging task in which language difficulties and technical problems may sometimes result in confusion. We kindly ask you to accept our apologies for any problems you may encounter.

We sincerely hope that the Proceedings of the Second Scientific Conference of ISOFAR 'Cultivating the Future Based on Science' will be an important and worthwhile source of information and inspiration for you.

On behalf of the Editors,

Daniel Neuhoff, Niels Halberg, Thomas Alföldi & William Lockeretz

Acknowledgements

Thanks to the following reviewers:

Lucimar S. de Abreu; Brazil; Uygun Aksoy, Turkey; Thomas Alföldi, Switzerland; Hugo Alroe, Denmark; Miguel Altieri, United States of America; Ton Baars; Germany; Saadi Badawy, Egypt; Katja Bahrdt, Switzerland; Beat Bapst, Switzerland; Paolo Barberi, Italy; Stephane Bellon, France; Marc Benoit, France; Marianne Bonde, Denmark; Jules Bos, The Netherlands; Viv Burnett, Australia; Virgilio Caleca, Italy; Enio Campiglia, Italy; Fabio Caporali, Italy; François Casabianca, France; Edward Cocking, United Kingdom; Tommy Dalgaard, Denmark; Christophe David, France; Ken Davies, United Kingdom; Robert Delve, United Kingdom; Henrik Egelyng, Denmark; Gharieb EL-Bana, Egypt; Thomas van Elsen; Germany; Massimo Fagnano, Italy; Maria Finck, Germany; Andreas Fliessbach, Switzerland; Bernd Freyer, Austria; Jürgen Friedel, Austria; Eric Galandt, United States of America; José Granado, Switzerland; Anna-Maria Häring, Germany; Niels Halberg, Denmark; Ulrich Hamm, Germany; Peter Hanson, United States; Yousr Hashem, Egypt; Lene Hegel, Germany; John Hermansen, Denmark; Brendan Hoare, New Zealand; Beate Huber, Germany; Henning Høgh Jensen, Denmark; Todd Kabbaluk, Canada; Manolis Kabourakis, Greece; Lukas Kilcher, Switzerland; Chris Kjeldsen, Denmark; Preben Klarskov Hansen, Denmark; Peter Klocke, Switzerland; Ulrich Köpke, Germany; James Kotcon, United States of America; Ib Sillebak Kristensen, Denmark; Troels Kristensen, Denmark; Paul Kristiansen, United States of America; Stefan Kühne, Germany; Günter Leithold, Germany; Willie Lockeretz, United States of America; Andreas Lüscher, Switzerland; Paul Mäder, Switzerland; Bud Markhart, United States of America; Andrea Martini, Italy; Veronika Maurer, Switzerland; Jochen Mayer, Switzerland; Marcelo Mele, Italy; Alberto Mengi, Italy; Charles Merfield, Republic of Ireland; Ioannis Metzidakis, Greece; Paola Migliorini, Italy; Heidrun Moschitz, Switzerland; Daniel Neuhoff, Germany; Egon Noe, Denmark; Erich C. Oerke, Germany; Frank Offermann, Germany; Jørgen E. Olesen, Denmark; Susanne Padel, United Kingdom; Hans-Marten Paulsen, Germany; Bruce Pearce, United Kingdom; David Pearson, United Kingdom; Carola Pekrun, Germany; Christopher Penhold, Australia; Christine Picard, Italy; Gabriele Pietsch, Austria; Gerold Rahmann, Germany; Jesper Rasmussen, Denmark; Joachim Raupp, Germany; Angelika Riefer, Germany; Christine Rudmann, Switzerland; Jürn Sanders, Switzerland; Ulrich Schmutz, United Kingdom; Kathrin Seidel, Switzerland; Pentti Seuri; Finland; Anet Spengler, Switzerland; Christin Stark, United Kingdom; Ulrike Steiner-Stenzel, Germany; Hanna Stolz, Switzerland; Matthias Stolze, Switzerland; Wijnand Sukkel, The Netherlands; Albert Sundrum, Germany; Bertil Sylvander, France; Lucius Tamm, Switzerland; John Teasdale, United States of America; Concetta Vazzana, Italy; Els Wynen, Australia; Qiao Yuhui, China; Raffaele Zanoli, Italy; Cesare Zanasi, Italy; Christine Zundel, Switzerland.

Soil organic matter management

The Impact of Site and Management Factors on Humus Dynamics in Long-term Field Experiments

Brock, C.[1] & Leithold, G.[2]

Key words: humus dynamics, farming systems, long-term field experiments

Abstract

The impact of management and environmental site factors on quantitative and qualitative indicators of humus dynamics was investigated in eight long-term field experiments in Germany and neighbouring countries. Humus dynamics were basically influenced by environmental site conditions, but at a given site differences between farming systems could be ascerted. Mixed farming systems with farmyard manure application as a rule had a more favourable impact on humus dynamics than stockless systems. Whether an advantageous performance of humus dynamics in organic farming as compared to conventional farming will occur or not, is dependent on the respective farm types of both systems that are related to each other.

Introduction

A favourable performance of humus dynamics is commonly attributed to organic farming systems (e.g. Piorr & Werner 1999). Yet, even organic farming is subject to specialization and intensification processes, mainly induced by economic factors. As a result, the diversity of organic farming systems is increasing. It is therefore necessary to investigate impact factors behind the complex system effects in order to enable a differentiated assessment of humus dynamics. This paper presents results on site and management impact on humus dynamics in field trials displaying various organic and conventional farming systems.

Materials and methods

The performance of indicators of humus dynamics was surveyed in eight field trials in Germany, Switzerland, and Denmark (DOK trial, Therwil/CH; Crop rot. trial Viehhausen/D; Org. arable farming trial, Villmar/D; Farming systems trial Bad Lauchstädt/D; Farming systems trial Bernburg/D; Farming systems trial Dahnsdorf/D; Org. crop. rot. trial, Güterfelde/D; Crop rot. exp., Foulum/Dk and Flakkebjerg/Dk). Farming systems displayed in the trials are *organic mixed farming* (8 trials), *conventional mixed farming* (4 trials), *organic stockless farming with* (5 trials) *and without* (4 trials) *rotational ley*, *conventional stockless farming with* (2 trials) *and without* (2 trials) *rotational ley*, and *biodynamic farming* (1 trial). In some trials, farming systems are further differentiated according to crop rotation and/or fertilization.

As quantity indicators of humus dynamics we used organic carbon content (C_{org}) as well as total soil Nitrogen content (N_t), while hot water soluble fractions of C and N (C_{hws}, N_{hws}) were selected as quality indicators. Soil samples for analyses were

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[2] As Above

collected in spring 2006 from the topsoil layer (Ap horizon) of each included plot to assess the actual state of the selected humus dynamics indicators. Crop in all cases was winter cereal, previous crop was row crop. Furthermore, humus content development dependent on management factors was assessed calculating the long-term linear trends for topsoil C_{org} and N_t content, respectively. Linear trend estimations were based on measurement time series of either indicator. The estimated *b* was used both to assess humus content dynamics in a plot and as a means of levelling out variations caused by differing humus content levels.

Results

Survey of variable factors in the trials and between the trials showed a decisive impact of environmental site factors on humus dynamics indicators (tab. 1). As for content dynamics indicators (linear trend of C_{org} and N_t), the impact was not linear and could not be correlated to neither defined site nor management factors. Due to the relevance of environmental site factors, humus content (C_{org}, N_t) and quality indicators (C_{hws}, N_{hws}) were not correlated to any management factors in the overall survey. This was true referring to fertilization as well as to crop rotation impact. As for content dynamics indicators (linear trend b_C of C_{org} (b_C) and N_t (b_N)), the impact was not linear and could not be correlated to either defined site or management factors, but showed a strong dependency on "trial" as an integrative site x management indicator.

Tab. 1: Correlations between impact factors and humus dynamics indicators in eight long-term field trials in Germany, Denmark, and Switzerland. If significant correlation to more than one impact factor of either category (site, management) could be confirmed, the strongest correlation is displayed. Number of included plot data (n) variable for indicators.

Indicator	***Relevance of impact factors***
C_{org} *n=126*	*site:* r=0,59** for Ackerzahl (german site quality index) *management*: no significant impact
N_t *n=132*	*site:* r=0,68** for Ackerzahl (german site quality index) *management*: no significant impact
C_{hws} *n=128*	*site:* r=0,59** for Ackerzahl (german site quality index) *management*: no significant impact
N_{hws} *n=128*	*site:* r=0,59** for Ackerzahl (german site quality index) *management*: no significant impact
b_C *n=91*	*site x management: significant differences between trials* In ANOVA
b_N *n=91*	*site x management: significant differences between trials* In ANOVA

Yet, a differentiation of farming system impact was possible on the trial level (without figure). Stockless farming systems as a rule produced lower values for all humus dynamics indicators than mixed farming systems with farmyard manure application, especially if a rotational ley was missing. If farming systems of either type in one trial were compared referring to the overall system (conventional vs. organic), the conventional reference variants usually displayed higher values. Still, differences between farming systems were not statistically significant for any indicator, even though the pattern OrgMF > OrgSl, ConMF > ConSl was identical in all trials on the level of descriptive statistics.

Further, a correlation between average dry matter yields and Corg as well as Nt contents could be observed that was considerably stronger for organic than for conventional management (fig. 1). In addition, a negative correlation could be observed for humus content dynamics as indicated by the linear trend of Corg and Nt and yield level for conventional farming systems (without figure). The opposite situation was true for organic farming, even if the positive correlation here was fairly weak.

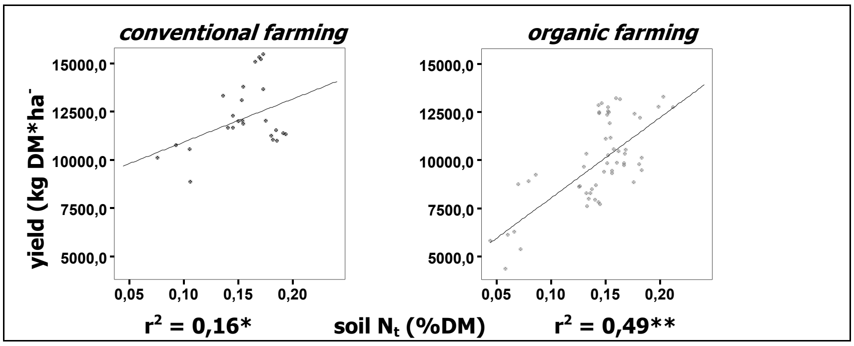

Figure 1: Correlation between Nt as humus content indicator and average dry matter yields dependent on the farming system. Number of plots included n=30 (conventional farming), n=65 (organic farming). *=significant at α=0.05, **=significant at α=0.01.

Discussion

Our results show that the specific impact of a defined farming system on humus dynamics may not be generalized. A consideration of the impact of environmental site conditions is inevitable. On the other hand, farming systems at a given site obviously have a specific impact that allow for a comparative assessment of farming systems with regard to ecological and agronomical parameters. These findings are supported by e.g. Fließbach et al. (2007) or Breland & Eltun (1999), even though differences between farming systems on a high level of spatial aggregation could not be proved by analysis of variance due to the effect of environmental site conditions as well as specific treatment of variants in a given trial. As to the apparently low impact of management/farming systems on humus dynamics indicators, the relatively young age of most trials (<10 years) has to be considered. Due to the complex interactions between mineralization and immobilization processes of soil C and N (e.g. Barrett & Burke 2000) the rather slow dynamics of the humus content level may be overlapped. It also has to be noted that conventional and organic farming systems as displayed in the trials often do not reflect the actual situation in practice. Conventional stockless cash crop farming without ley was only displayed in two out of eight trials, but is the predominant conventional farming system in arable farming practice in Germany. Results on higher humus contents and turnover intensities in organic faming systems as reported by other authors from field survey under practice conditions (e.g. Munro et al. 2002) are therefore not contradictive to our observations. On the other hand, problems regarding nutrient supply and humus reproduction in organic stockless farming without inclusion of a rotational ley or optimized compensation strategies are well known (e.g. Schmidt 2004).

The correlation between average dry matter yield level and N_t must be interpreted as interacting system. It has been assumed that high yields produce a high plant residue mass, promoting humus content (Brock et al., 2008). On the other hand, a high humus content and turnover is a prerequisite for high yields, especially if there is no mineral N fertilizer application (Stockdale et al. 2002). Our results clearly support both assumptions to be true for organic farming conditions. In conventional farming, the processes obviously are overlapped by the effect of mineral fertilization.

Conclusions

A favourable impact on humus dynamics is not an intrinsic quality of organic farming, but the result of management factors that are in principal not exclusivly linked to conventional or organic farming. Still, due to a considerably stronger interaction between soil functions and agronomic performance, a sustainable humus management is of basic interest under organic farming conditions. There is some evidence that stockless organic farming remains a challenge not only with regard to nutrient supply of crops, but also to maintenance and promotion of favourable humus dynamics. Here, further research is necessary in order to support a sustainable development of such systems.

Acknowledgments

This research was funded by the German Federal Agency for Agriculture and Food / Federal Programme of Organic Farming. The authors would further like to thank all persons contributing to this research, namely partners from the investigated field trials and laboratory staff at Giessen, Halle, and Munich universities conducting the analyses.

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Indicators for the Evaluation of Soil Organic Matter and their Application in Organic and Conventional Farming Systems

Hoyer, U.[1], Reents, H.-J. [1] & Hülsbergen, K.-J.[1]

Key words: soil organic matter, indicator, farming system, humus balancing

Abstract

In view of the problems caused by soil degradation, it becomes ever more important to estimate the influence of different management systems on soil organic matter (SOM). In the past, a number of indicators characterizing SOM have been elaborated, which, however, do not allow to draw conclusions on separate management measures or even future development tendencies. A promising approach might be humus balancing, which quantifies and evaluates the humus supply of soils on the basis of crop rotation and fertilization. Comparative studies on adjacent arable sites under both organic and conventional management in different climatic regions of Germany have revealed that the indicator soil organic carbon (SOC) depends mainly on the site conditions, whereas indicators characterizing active SOM like hot water soluble C (C_{hws}), C in microbial biomass (C_{mic}) and the enzyme activities of β-glucosidase and catalase are stronger related to management methods. It became evident that humus balancing is a good indicator of the active SOM pool and thus also a qualified tool for demonstrating management effects.

Introduction

Soil degradation caused by erosion, compaction and humus depletion is a severe problem all over the world. In order to assess the effects of agricultural landuse under different site conditions, various indicators of soil conservation have been developed. They include principally the parameters soil organic carbon (SOC), soil organic nitrogen (SON) microbial biomass and active SOM (Gregorich et al. 1994, Arshad & Martin 2002). These measurements help estimate the current quality of a soil; however, they do not allow to make statements on how a soil will respond to management influences in the future (Herrick 2000). Evaluating management effects requires to consider crop rotations, fertilizer input and tillage, in order to describe the relationships between soil properties and management. State indicators like SOC provide information on the current situation of the environment, while pressure indicators are related to the type of management and offer an indirect assessment. As methodical approach to the estimation of management effects on SOM, humus balancing was developed (Leithold et al. 2007). The necessary input data can be collected easily; humus balancing permits to assess SOM depletion and accumulation depending on the quantity and quality of C input. Adverse to C- and N-simulation models, no sophisticated processes or different pools are described, but rather the summed up net effect on SOM is calculated (Leithold et al. 2007, Körschens et al. 2005).

The following paper is to elucidate the relationships existing between different indicators for SOM and humus balancing. On the basis of comparisons between

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organically and conventionally run farms the question is pursued whether common state indicators can reflect system-related differences in management sufficiently and whether humus balancing may be a reliable indicator for the evaluation of sustainable land use.

Materials and Methods

In various agricultural regions of Germany, long-term test plots were established on adjacent arable sites, both under organic and conventional management, but with comparable soil texture. Preferably sites under humid and cool conditions in southern Germany as well as locations in eastern German dry regions were included. Soil types range from light sandy to heavy clay soils. On five plots each per site and management system, soil samples were taken from the topsoil which were then analysed for SOC, SON, C_{hws}, C_{mic}, β-glucosidase and catalase. On each plot long-term management records were kept and entered into the calculations. Humus balance sheets were computed according to the approach by Küstermann et al. (2007). The statistical analysis was executed by use of SPSS 15.0.

Results

The biological active time (BAT = f [silt + clay, air temperature, precipitation]) as site characterizing parameter (Franko & Oelschlägel 1995) was calculated as main influence factor for all investigated indicators. This has been demonstrated in Fig. 1 on the example of SOC and C_{mic}.

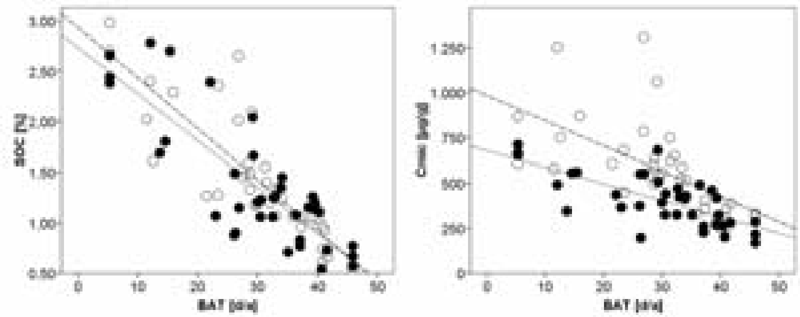

Figure 1: Relationship between biological active time (BAT) and SOC- and C_{mic}-contents; ○organic; ● conventional;
regression curves: - - - organic; ....conventional

Different management factors cause different effects even when all other site conditions coincide. Table 1 shows the results of gradual linear regression for the estimation of the parameters that influence the measurable SOM indicators. Organic farming entails slightly increased SOC contents. The measured parameters C_{mic}, C_{hws}, β-glucosidase and catalase characterizing the active SOM are related to the pH value and more or less also to the different input values. C_{hws} and catalase rise with the quantity of organic fertilizer. C_{mic} is positively influenced by the share of clover grass mixture, organic fertilization and yields. β-glucosidase is enhanced by higher yields, and a slightly negative relation was found for the rates of mineral fertilizers.

Tab. 1: Regression and correlation coefficients for the description of influences on different SOM indicators (weight of influence factors marked with a-d, a = strongest influence)

	Site			Management					R
	fU	BAT	pH	System	Yield	CG	DM_OF	N_MF	
SOC	0.06[a]	-0.02[b]	-	0.14[c]	-	-	-	-	0.91
C_{hws}	15.58[a]	-	51.41[b]	-	-	-	3.04[c]	-	0.85
C_{mic}	-	-8.71[c]	82.95[d]	-	-	4.57[a]	5.28[b]	-	0.85
Gluc	-	-	17.61[a]	-	0.6[c]	-	-	-0.21[b]	0.75
Cat	0.48[a]	-	2.98[c]	-	-	-	0.22[b]	-	0.82

fU: fine silt (%); BAT: biological active time (d a^{-1}); System: organic or conventional farming; CG: share of clover grass mixture (%); DM_OF: DM input with organic fertilizer (100 kg ha^{-1}); N_MF: mineral N input (kg ha^{-1}); Gluc: β-glucosidase; Cat: catalase

The mean value of the humus surplus quantities for all organic plots differs significantly (+246 kg C ha^{-1} a^{-1}) from the mean of the conventional plots (only -76 kg C ha^{-1} a^{-1}). The correlation between measured values and humus balance surpluses is differently pronounced (Table 2). A comparatively strong correlation was obtained for C_{mic} and the humus balance surpluses.

Tab. 2: Correlation coefficients (Pearson) between balance surpluses and measured values (organic and conventional)

	SOC	SON	C_{hws}	C_{mic}	Gluc	Cat	pH
Humus balance surplus	0.23	0.28*	0.37**	0.65**	0.29*	0.47*	0.25*

* significant for P<0.05

** significant for P<0.01

Discussion

The results obtained in regression analyses have shown that the humus level and all measured values of active SOM were mostly influenced by the site conditions. Nevertheless, these indicators can be modified to a certain extent by management methods. Organic farming entails mostly slightly increased contents of SOC, and especially C_{mic} is clearly enhanced on organically run fields. Enzyme activities and C_{hws} respond positively to yield level and organic fertilizer input. Higher yields raise the input of organic matter, mainly by root residues and rhizodeposition, which represent a preferential substrate for the cellulose-decomposing enzyme β-glucosidase and thus the nutrition of microorganisms.

Due to low portions of field forage and low spreading of stable manure, balancing of conventional farms produced lower humus surplus levels than organic systems. There are only weak correlations between measured values and balance sheet results, except for C_{mic}. C_{mic} rises markedly with an increasing share of clover grass mixture and the input of organic fertilizer. These parameters have a strong weight in humus balancing.

Conclusions

The SOC content as a state indicator can be influenced by management measures within close brackets only; the decisive effect is exerted by the site conditions. Humus balancing depends on management data; surpluses are more evidently related to the active SOM, which is likewise dependant on management. Therefore, the pressure indicator "humus balance" turned out to be a suitable indicator for describing management effects on the active SOM pool.

Acknowledgments

The authors wish to thank the Federal Agency for Agriculture and Food BLE for financial support and the Departments of Soil Physics and Site Conditions of the Bavarian State Research Center for Agriculture LfL for the execution of soil texture as well as the University in Halle for enzyme analyses.

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Organic and biodynamic cultivation - a possible way of increasing humus capital, improving soil fertility and providing a significant carbon sink in Nordic conditions

Granstedt, A. [1] & Kjellenberg, L.[2]

Key words: biodynamic farming, carbon sink, humus, organic farming, soil fertility

Abstract

In Sweden three different sets of long-term comparative trials have been carried out at the Biodynamic Research Institute since 1958. With biodynamic farming an average annual increase corresponding to 500 – 800 kg soil carbon per ha is documented.

Introduction

At the Biodynamic Research Institute three sets of long-term field trials have been conducted since 1958.

K-experiment in Järna from 1958 -1990

This first trial period ran during 32 years from 1958 to 1990. The quality of food products and interaction and influence on soil fertility of different manuring techniques were studied (Pettersson, Wistingahusen and Reents 1992; Granstedt & Kjellenberg 1999; Kjellenberg & Granstedt, 2005).

UJ (Ultuna-Järna) -experiment 1971 -1979

The results from the initial K-experiment formed the basis for a 6 and a 9-year trial, which were carried out by the Biodynamic Research Institute in collaboration with SLU (Swedish University of Agricultural Sciences) on two locations, in Ultuna near Uppsala and in Järna with four replications and all three crops in the three year crop rotation each year. In the trials Biodynamic cultivation with and without leys was compared with conventional cultivation with and without leys in three-year crop rotations (Dlouhý, 1981). The results from the two trials corresponded well with each other as well from the K experiment (Granstedt, 1995).

Skilleby long-term trial started in 1991 and still continuing

When the K-experiment ended in 1990 field studies were established within an individual farm organism making it possible to evaluate consequences of different treatments within a given farm situation with a closed recycling system and a high level of self-sufficiency in fodder and manure (Granstedt, 1998 and 2002).

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[2] As Above

Materials and methods

K-experiment

The long-term K field trial was run with one crop rotation without replications but with each crop each year from 1958 – 1990: 1) Summer wheat, 2) Ley with legumes, 3) Potatoes and 4) Beets

The 8 different treatments include: K1-Biodynamic (BD) composted manure and BD field preparation; K2-Biodynamic composted manure without the BD field preparation; K3-Raw farm yard manure; K4- Raw farm yard manure and mineral fertilizer (NPK); K5-No manure or fertilizer; K6- Low mineral fertilizer (NPK); K7-Medium mineral fertilizer (NPK); K8-High fertilizer (NPK).

Potatoes and beets were fertilized in the organic treatments and potatoes, beets and wheat were fertilized in the mineral fertilized treatments. The average annual amount of NPK per ha in the composted stable manure in K1 and K2 was averaged for the whole period to 80/38/76, in the not composted manure in K3 to 95/32/91. These amounts corresponded to the possible production of fodder-crops in the crop-rotation and with an animal density of 0,9 animal unit per ha. The average annual amount of NPK per ha in the combined organic and mineral fertilized treatment K4 was 62/24/66, in the mineral fertilized treatments K6 29/18/41, K7 58/36/81 and in K8 117/36/81. The composted manure (30 ton per ha to potatoes and 45 ton per ha to beets) applied in K1 and K2 had lost about 10 % of its biomass and 18 % of its nitrogen content during the composting process before being applied in the field compared to the raw manure applied in K 3.

UJ-experiment

The Biodynamic Institute in Järna and the Swedish University of Agricultural Sciences (SLU) Ultuna collaborated to compare biodynamic cultivation with (B2-Summer wheat, Ley with clover/grass, Potato) and without leys (B1-Summer wheat, Barley, Potato) with conventional cultivation with (A2-Summer wheat, Ley with clover/grass, Potato) and without leys (A1-Summer wheat, Barley, Potato) in three-year crop rotations.

The Biodynamic trials B1 and B2 received biodynamic composted stable manure in an amount comparable to the fodder crop's manure production (0.7 animal units per ha) while the conventional trials A1 and A2 received mineral fertilizers comparable to what was at that time the recommended standard amounts for these crops (an average of NPK 95/45/110 kg/ha). The trial B2 corresponded to standards for biodynamic cultivation with animal production and A1 the standards for conventional specialized cultivation using artificial fertilizers without animal production.

Skilleby long term trial

The effects of applications of non-composted and composted manure in the long term experiment were studied, with and without biodynamic preparation treatments, at three levels of application (12.5, 25 and 50 tons per ha 1991-1995 and 0, 25 and 50 tons per ha 1996-1997), 12 treatments with 2 – 4 replications of each crop and established on each of five fields in the five-year crop rotation: oats with under sowing, ley I, ley II, ley III and winter wheat with the application of farmyard manure. This crop rotation was designed to improve the humus content and soil fertility (Granstedt, 1992).

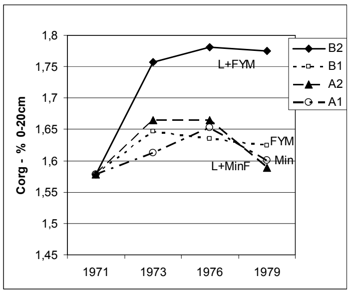
Results and discussion

In the thirty year long K-experiment after the first ten years the yields in the biodynamic (K1) and conventional (K8) fertilized system were on the same level. The treatments with organic manure (K1–K4) combined with the clover/grass ley gave a clear increase of carbon in the topsoil (K1 from 2.4 % to 2.9 % from 1958 to 1989, i.e. an increase of 20 % during 29 years). The annual support of carbon was here 1640 kg per ha and year (Reents, Pettersson & Wiestinghausen, 1992).

Samples of organic carbon were also taken at 25 – 35 cm and 50 - 60 cm depth in the soil profile both 1989 and 1985 and at 25-35 cm 1976 (not shown here). Even the organic treatment without all biodynamic preparation treatments gave a carbon accumulation but with lower values with consideration of data with humus content deeper in the soil. The mineral fertilized treatments and the unfertilized treatment gave no increase of the carbon and humus content despite the inclusion of leys in the crop rotation. The total amount of organic carbon to a depth of 60 cm, after interpolation of the humus content in the soil layers between them, can be calculated to 160 ton per ha in the biodynamic treatment (K1), 146 ton per ha in the organic raw manure treatment, and 135 ton per ha in the mineral fertilized treatment. This means that there has been an annual average increase or assimilation of organic carbon in the order of 800 kg per ha in the biodynamic treatment K1 and 300 kg per ha in the organic treatment. This amount is comparable to what is reported from the renowned Rhodale long term experiment from 1981 to 2005 in Pennsylvania in USA in a more legume based farming system with farm yard manure, Soya beans and clover/grass ley (Hepperly, Douds & Seidel, 2006). Our results also correspond with the DOK experiment in Switzerland where the effect of BD preparation and composted manure are also reported (Mäder et al, 2002).

UJ-experiment

The trial stages B2 and A2 make it possible to analyze the importance of leys in each system. The effect on the amount of humus and carbon in the soil in each system is presented below. The humus concentration in the biodynamic trial with ley increased from 2.72% to 3.06% (1.58 to 1,77 % C-org) during the 8-year trial period (slightly more than 10%) while the humus concentration remained at the same level in the trial with conventional cultivation (Figure 1).



In these trials the importance of leys and organic fertilizer for the assimilation of carbon in soil and the building up and maintenance of the humus content in the soil and with this the associated biological soil properties is apparent (Dlouhý 1981, Granstedt and Kjellenberg 1999). In this experiment the effect of specific BD was not possible to evaluate.

Figure 1: Trials comparing biodynamic and conventional cultivation in Järna 1971 – 1979.

Skilleby long term trial

During the 9 years from 1991 to 2000 the average soil organic carbon increased by 9 % from 2.18 to 2.38 %. This significant average increase in the 20 cm topsoil was calculated to 4450 kg C ha^{-1} from a level of 47850 to 52300 kg C ha^{-1}. Based on data from this study and field experiments with clover grass leys on Skilleby (Granstedt and Bäckström, 2000) it is calculated that a three-year clover grass ley with an annual nitrogen fixation between 100 – 200 kg N ha^{-1} can result in the net assimilation of 18 tons of carbon in soil biomass.

Conclusions

Humus degradation can be compensated directly through the incorporation of harvest residues from grassland into the soil and indirectly through recycling farmyard manure derived from fodder produced within the farming system. Both carbon and nitrogen management are key components in these transformations. In biodynamic farming the rebuilding of humus is further developed through composting techniques of manure combined with the use of biodynamic preparations. The importance of leys combined with the recycling of manure from the animal husbandry within the farming system is seen. Organic and biodynamic farming has the capacity to be an important carbon sink to reduce the surplus of carbon dioxide in the atmosphere.

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Are soil biological properties and microbial community structure altered by organic farm management?

Stark, C.H.[1]

Key words: DGGE; enzyme activity; farming techniques; soil biota; soil dilution plating

Abstract

Environmental conditions and farm management practices have a considerable impact on soil biota, affecting nutrient cycling processes and ecosystem functioning. Understanding how management practices influence soil fertility and agricultural productivity is essential to improve the sustainability of agroecosystems. The effect of farming history on microbial soil properties was assessed by analysing soil samples from two organic and conventionally managed sites. C_{mic} *and* N_{mic}*, enzyme activities, bacterial community composition (PCR-DGGE) and total numbers of fungi and bacteria (soil dilution plating) were determined. Results suggested that organic farming practices did not have a clear positive effect on soil microbial biomass and activity; distinct differences in bacterial community composition were detected by PCR-DGGE but not by soil dilution plating. Findings indicate that practices commonly associated with conventional farming (application of mineral fertilisers or pesticides) have a less pronounced effect on the soil microbial community than other management techniques (e.g. manure application and crop rotation).*

Introduction

Soil biota plays an important role in maintaining soil fertility and productivity and improving the functioning of the soil ecosystem. Studying the response of the microbial community to agricultural disturbances is vital to our understanding on how management practices contribute to sustaining fertility and productivity to improve soil management systems (Wardle et al. 1999). The effect of different management regimes and perturbations on the soil microbial community, e.g. crop rotations, manure applications and tillage, has been studied in a wide range of soil and management systems, incl. conventional, low-input and organic farming. Most research suggests that organic practices have a positive, stimulating influence on the soil microbial community by increasing microbial biomass, enhancing diversity and improving soil functions like nutrient cycling (e.g. Watson et al. 2002). In comparison, there is little evidence of negative effects of mineral fertiliser and pesticide usage on soil organic matter, microbial diversity and activity (Fraser et al. 1988). This suggests that recognized beneficial management practices (e.g. green manuring, crop rotations, conservation tillage) have a bigger impact on the soil microbial community than the land-use system itself.

Materials and methods

Adjacent organic and conventionally managed sites of the same soil type (Udic Ustochrept, USDA) with similar fertility levels were chosen within the cropping farm at

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Lincoln University, New Zealand (43°38'S; 172°27'E) to compare soils with differing management histories with regard to soil biological properties and microbial community composition, and to identify fungal species that are indicative of the management system. The sites had been farmed under contrasting organic (ORG) and conventional (CON) management systems for 26 and over 100 years, respectively. ORG, previously been under a low-input 6-year rotation, was under a mixed herb-ley for 3 years at the time of sampling. The site had never received fertiliser, compost or manure, had not been grazed or subjected to inversion ploughing. CON had been commercially managed under an 8-year crop rotation and had been under pasture for 2 years at the time of sampling. During the rotation, residues were incorporated to a depth of 15 cm by ploughing. During the 8-year rotation, a total of 70 kg N and 16 kg P were applied per ha and yr. Top soil samples (0-15 cm) were collected in January, March and June 2002, sieved (4 mm) and stored at 4ºC. All analyses were carried out in triplicate: microbial biomass C (C_{mic}) and N (N_{mic}) (Sparling and West 1988), arginine deaminase activity (Alef and Kleiner 1987) (ADA), fluorescein diacetate hydrolysis (Adam and Duncan 2001) (FDA), total C and N (C_{tot}, N_{tot}). PCR-DGGE was performed on 16S rDNA fragments of triplicate DNA extracts using eubacterial primers F984GC and R1378; thermal cycling conditions were as described by Heuer et al. (1997). From each soil sample, spread plates were prepared in triplicate on four different media: Czapek Dox agar (CDA); Nutrient agar (NA); *Trichoderma* selective medium (TSM); King's medium B (KB). After incubation, cfu g^{-1} dry soil were estimated for bacteria and fungi. Selected fungal colonies were subcultured and identified. All numerical data were analysed by general linear model analysis of variance using GenStat on total or log_{10} transformed values where appropriate. Samples were considered significantly different when $p<0.05$ and least significant differences ($LSD_{0.05}$) were calculated.

Tab. 1: Mean values of three sampling dates in 2002 and levels of significance for soil properties in ORG and CON topsoil samples (0-15 cm). ***, p<0.001; **, p<0.01; NS, not significant.

Soil property	ORG	CON	Significance
C_{mic} (µg g^{-1})	494	596	***
N_{mic} (µg g^{-1})	50.1	47.6	NS
ADA (µg g^{-1} h^{-1})	2.86	1.91	***
FDA (µg g^{-1} h^{-1})	115	123	NS
C_{tot} (%)	2.77	2.93	**
N_{tot} (%)	0.242	0.243	NS

Results

ADA was significantly higher in ORG, while C_{mic}, C_{org} and microbial quotient were significantly greater in CON at all sampling dates. FDA and N_{mic} were significantly higher in CON in April and June, respectively; however, the differences were not significant when assessing overall trends (Table 1). Seasonal variation was similar for both soils. DGGE profiles of the bacterial communities revealed similar numbers of bands in both soils, while the banding patterns were distinctly different. Significantly higher numbers of fungi were recovered from CON on CDA ($p<0.001$) and TSM ($p=0.036$), while differences for bacteria were not statistically significant. The absolute differences in microorganism numbers between the two sites were minor (e.g. fungi on

CDA: $1.8x10^5$ cfu g^{-1} (ORG), $2.4x10^5$ (CON)) and likely to be of little practical significance with regard to soil ecology and function.

Characterisation of selected fungal isolates did not show major differences between the two soils although seasonal variations could be observed. From both soils, the following species were isolated: *Penicillium*, *Cladosporium*, *Gliocladium*, *Trichoderma*, *Mortierella*, *Botrytis*, *Paecilomyces*, *Coelomycete*, *Fusarium*, *Chrysosporium*, *Phoma*, *Alternaria*, *and Mucor*. While *Penicillium* and *Trichoderma* were most frequently isolated, no particular fungal species occurred predominantly in one soil. The small and inconsistent numbers of isolates suggests a random pattern of occurrence.

Discussion

The results suggest that past organic management did not have a major positive effect on soil microbial biomass and activity. The higher C_{mic} observed in CON samples were in accordance with our expectations, as ORG was a low-input area while CON had been grazed, cultivated and fertilised regularly. Crop rotations and fertilisation have a positive influence on the soil microbial biomass through greater return in crop residues. The overall similar levels of FDA observed for the soils in this study are most likely linked to inherent soil properties such as soil type and long-term management practices (cf. Dick 1997) that might affect chemical soil properties. The slightly higher FDA activity in CON is consistent with higher levels measured in other soils receiving mineral fertilisers and seems to be a positive response to repeated inorganic fertilisation.

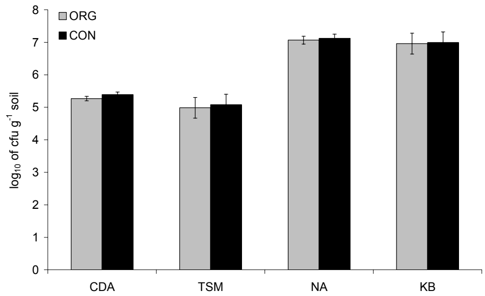

Figure 1: Bacterial and fungal cfu (log_{10}-transformed) in ORG and CON on CDA (fungi), NA (bacteria), KB (bacteria), TSM (fungi). Means of three sampling dates. n=27.

Soil dilution plating proved unsuitable for identifying key species indicative of the farm management system. Despite some differences in total numbers, no bacterial or fungal species were repeatedly isolated from either soil in large numbers. These findings are inconsistent with previous studies where organic management resulted in higher bacterial counts in soils (Fraser et al. 1988). However, most positive effects on microbial numbers in organically farmed soils are due to high organic matter amendments which did not occur in this study. In our study, microbial counts correspond to soil biological properties, which showed small differences. It is likely that the lower microbial numbers in ORG and the general lack of significant differences result from the fact that the two sites were providing comparable conditions for the microbial populations due to comparable chemical and physical soil properties, similar plant cover and both being in a restorative phase. This supports the theory that microbial numbers in soils are mostly influenced by changes in the soil environment and management techniques that cause such changes (Fraser et al. 1988). While the cfu assay suggested similarly sized and structured bacterial populations in the two soils, PCR-DGGE revealed clear differences between ORG and CON indicating distinctly different eubacterial communities. In contrast, the number of bands (i.e. species richness) was similar in both profiles suggesting a comparable number of species in both soils, despite significant differences in microbial biomass. This implies differences in species evenness, which is also suggested by the different intensities of the bands. The data showed how the various methods assess different characteristics of the soil biota. Microbial community composition was affected by the longer-term management, while the fraction assessed by soil dilution plating as well as microbial biomass and activity seemed to be influenced by inherent soil properties or management practices that were similar on the two sites.

Conclusions

Management practices such as manure application or crop rotations have a greater influence on microbial biomass size, activity and community structure and outweigh mineral fertiliser and pesticide usage. Thus differences observed in organic and conventionally managed soils should not necessarily be considered system effects, but be assessed as a collection of different management techniques. FDA seems an unreliable measure of microbial activity and soil quality due to linkages with inherent soil properties and mineral N. The relationship between microbial diversity and activity is not clear-cut and key fungal species indicative of one farming system could not be identified.

Acknowledgments

Lincoln University Analytical Services; Nick Waipara; Andrew McLachlan; Emily Gerard. Lincoln University and the New Zealand Fertiliser Manufacturers' Research Association for financial support.

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A New Approach to Humus Balancing in Organic Farming

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Key words: humus balance, methods, management assessment

Abstract

Humus balances provide a profitable approach for humus dynamics assessment in farming practice. Nevertheless, there is a clear demand for methodological adaptation. This article presents a new approach to humus balancing using reproducible algorithms for the estimation of balance coefficients. Humus balance coefficients for crops and organic fertilizers are estimated according to a bipartite algorithm. Humus demand is calculated on the basis of crop yields referring to the nitrogen household in the plant-soil system. Humus supply is derived from organic matter input with plant material and fertilizers. The new approach facilitates the adaptation of the method to new situations.

Introduction

The assessment of management impact on the humus dynamics of agricultural soils is of high interest in agronomical as well as ecological terms. For this reason there is a clear demand for adequate tools that facilitate humus dynamics assessment under practical conditions. Here humus balance methods have proved to be a profitable approach since they fulfil the criterion of applicability in practice far better than complex C-simulation models or measurement based approaches (Hülsbergen 2003). Models tend to require extensive input data that usually are not available under practical conditions. Humus balances on the other hand compare organic matter (OM) input (quantity and quality of organic fertilizers, crop residues and byproducts) to OM output (influence of crop-specific effects depending on site, yield and mineral N doses) without aiming at the prediction of absolut humus content changes. As a monocompartment model, humus balance considers OM as a whole with no division into specific and complex pools. The advantage of humus balancing is that only easily available management data are used. This implies that humus balances can help to define best-practice without the need for comprehensive assessment of actual humus content dynamics.

Yet, there have been serious doubts about the performance of humus balance methods, especially when applied in organic farming (Leithold et al. 2007). A major objection is the poor reproducibility of balance coefficients in most methods which prevents an adaptation of the respective methods to new situations. The marginal plausibility of balance results for organic farming systems underlines this methodological handicap.

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Materials and methods

We followed the basic scheme of humus balance methods presently established in Germany which is

humus saldo = humus supply (hs) – humus demand (hd).

“Humus saldo” reflects the net effect on humus content, “humus supply” refers to organic matter supply from plant residues and organic fertilizers and “humus demand” denotes the decrease of soil organic matter due to mineralization. The parameters ‘humus supply’ and ‘humus demand’ are attained by using humus reproduction coefficients (hrc) allotted to crops and fertilizers. The derivation of hrc was mainly based on empirical research in long-term field experiments. However, Leithold (1991) presented a mathematical approach for estimating hd coefficients on the basis of the nitrogen dynamics in the soil-plant system that was later on improved by Huelsbergen (2003). A corresponding reproducible procedure for the determination of hs coefficients to our knowledge does not exist.

For the new method we chose to develop one single algorithm that can be used to calculate hrc for any crop based on available yield data. To that effect, we adapted the approach of Hülsbergen (2003) and Leithold (1991) for the estimation of humus mineralization and combined it with a new algorithm for the calculation of organic matter supply contributing to humus build-up:

$$hrc = C_H - N_H * k$$

with

$$C_H = C_R \cdot h_R + C_{RT} \cdot h_{RT} + C_{EX} \cdot h_{EX} + C_{RE} \cdot h_{RE}$$

and

$$N_H = (N_{PB} - N_{dfa} - N_I * wp_I - N_{FERT} * wp_{FERT}) / wp_H + \Delta N_{min}$$

hrc = humus reproduction coefficient (kg C ha^{-1}).
C_H = C from organic input contributing to humus build-up (kg C ha^{-1})
N_H = mineralization of N from the humus pool (kg N ha^{-1})
k = factor for conversion of mineralized humus-N (kg N ha^{-1}) to mineralized humus-C (kg C ha^{-1})
$C_{R,RT,EX,RE}$ = C input from roots (R), root turnover during the vegetation period (RT) and root exudates (EX) or plant residues (RE) (kg C ha^{-1})
$h_{R,RT,EX,RE}$ = humification rate for a defined organic substrate input (factor)
N_{PB} = N in plant biomass as indicated by crop yield (kg N ha^{-1})
N_{dfa} = N derived from the atmosphere by symbiotic fixation (kg N ha^{-1})
$N_{D,Fert}$ = mineral N from atmospheric deposition (D) and fertilization (FERT) (kg N ha-1)
$wp_{D,Fert,H}$ = whole plant utilization rate for N from a defined source pool (factor)
ΔN_{min} = net change of mineral N in soil solution during cropping period (kg N ha-1)

Basically the algorithm generates humus reproduction coefficients estimating the supply of organic matter contributing to humus build-up on the basis of C input from plant biomass and organic fertilizers and calculates humus mineralization on the basis of N in plant biomass. Contribution of inputs to humus reproduction is estimated considering organic matter input from above-ground plant residues, roots, and exudates. The turnover of root material during the vegetation period is taken into account. Input quantity of the compartments is estimated based on crop specific shoot:root:exudate. Losses of C in turnover processes are taken into account applying substrate specific humification rates. The humification rate denotes the ratio between

OM input from a defined substrate and the proportion of that input that is actually humified, thus contributing to humus build-up. Humus mineralization is calculated by separating the contribution of each active N pool, including the humus pool, to plant nitrogen supply. The ratio between N supply from a defined pool and plant uptake of N from that pool is estimated by applying specific utilization rates (Leithold 1991). In our approach, utilization rates for N are modified dependent on site as well as yield level. The latter factor is included as an indicator of actual N use efficiency. For reasons of data availability, plant uptake of residual N as well as excessive mineralized organic matter N not taken up by a crop (e.g. in potato cropping) are taken into account by the net change of soil N_{min} over the cropping period.

Results

Up to now, hrc have only been calculated for selected crops and fertilizers in test runs of the approach. In the case of non-legume crops the calculation usually results in negative hrc, thus (theoretically) indicating a consuming impact on humus ressources. As for legumes, the contribution to humus reproduction depends on the kind of legume (forage or grain) as well as on utilization (harvested / mulched). Tab. 1 illustrates hrc generation for winter wheat, potatoes, grass/clover with 70% legumes (fodder and mulched ley), and field beans.

Tab. 1: Calculation of humus production coefficients (hpc) for winter wheat, grass/clover (harvested/mulched ley), and field beans.

Parameter	**Winter wheat**	**Potatoes**	**Grass/clover (Fodder)**	**Grass/clover (mulched)**	**Field beans**
yield (t FM ha^{-1})	**5.5 (grain)**	**2.8 (tubers)**	**60.0**	**60.0**	**4.5 (grain)**
$\Sigma(C_R,C_{RT},C_{EX},C_{RE})$ (t DM ha^{-1})	3.53	2.48	13.20	17.72	3.45
h	h_R = 0.3 ; h_{RT} = 0.2 ; h_{EX} = 0.05 ; h_{RE} = 0.2				
C_H (kg C ha^{-1})	*708*	*498*	*2645*	*3215*	*691*
N_{PB} (kg N ha^{-1})	125	156	469	469	302
N_{dfa} (kg N ha^{-1})	0	0	295	295	211
N_D (kg N ha^{-1})	20	20	20	20	20
N_{Fert} (kg N ha^{-1})	0	0	0	0	0
ΔN_{min} (kg N ha^{-1})	0	+50	0	0	0
wp	wp_I = 0.75 ; wp_{Fert} = 0.75 ; wp_H = 0.9				
N_H (kg N ha^{-1})	*140*	*206*	*176*	*176*	*84*
hrc (kg C ha^{-1})	**-610***	**-1676***	**+789**	**+1359**	**-194***

* assumption: all straw removed

In the example, beneficial site conditions (e.g. luvisol areas) and corresponding whole plant utilization rates for N are displayed.

Discussion

There may be some doubt about the inclusion of both C and N in the algorithm instead of expressing hpc as a function of only C or N. However, a bipartite approach was also used by Hülsbergen (2003). The reason is that there is neither a direct link between C in plant biomass and C mineralized from the SOM pool, nor between N input and humus buildup. Even though the approach for calculation of humus mineralization in principle allows for the assessment of cropping systems with fertilization, parameters cannot be easily calibrated. In the algorithm, SOM mineralization and mineral N supply from other sources are correlated negatively. Admittedly, the impact of mineral N supply on SOM mineralization is complex (Kuzyakov et al. 2000) and usually not regarded in models on SOM turnover (e.g. Petersen et al. 2005). Here, further investigations are necessary to correctly adjust the method. As for organic matter supply by roots and root exudates, the approach has to cope with the heterogenity of root biomass quantity. Still the application of generalized shoot/root ratios for each crop seems to be possible since the estimated values can offer sufficient accuracy.

Further attention has to be paid to the continuous adjustment of whole plant utilization rates for N as well as humification rates. Even though results from comprehensive investigations have been published facilitating the derivation of (tentative) values (Hülsbergen 2003, Klimanek 1997), parameter calculation has to be recognized as a sensitive possible source of error.

Conclusions

The approach presented in this paper considerably improves the methodologial performance of humus balancing by providing a reproducible approach for balance coefficient calculation. In doing so the adaptation of the instrument to new situations is facilitated. Still, further research efforts are necessary to continuously improve and adjust the instrument. It remains a challenge to simplify and generalize the complex context of management measures, site conditions and humus dynamics in order to provide adequate assessment tools for application in practice.

Acknowledgments

This research was funded by the German Federal Agency for Agriculture and Food / Federal Programme Organic Farming.

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Soil quality indicators in organic and conventional farming systems in Slovakia

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Key words: farming management system, organic system, conventional system, chemical, biological soil properties

Abstract

In this study we compare some chemical and biological soil properties using the organic and conventional systems. In 2003 and 2004 the soil characteristics were observed on the precise field experiment plots in Borovce (near Piešťany, in the western part of the Slovak Republic) where organic management has taken place since 1995. The soil representative is loam and clay, loam degraded Chernozem on loess. The chemical and biological soil properties were determined within two farming systems: organic and conventional. The lower values of soil reaction and the higher contents of organic matter and inorganic nitrogen in the soil were measured under organic treatment. Organic management also positively affected a number of the cellulolytic and ammonification bacteria as well as microbial biomass content, ammonification and nitrification activity. The earthworm population was more developed at the organic variant. During the years 2003 and 2004, after eight years of organic management utilisation, the tendency of increased biological activity in the soil under organic management was observed.

Introduction

Several studies show that organic farming leads to higher soil quality with higher microbiological activity than conventional farming, due to versatile crop rotations, reduced application of synthetic nutrients, and the absence of pesticides (Hansen et al., 2001 and Shannon et al., 2002). Drinkwater et al. (1995) reported higher pH, organic C and N, N mineralisation potential, and actinomycete abundance and diversity in organic fields than conventional ones. Different authors have indicated similar benefits in soil quality from organic management (Wander et al., 1994, Gunapala and Scow, 1998, Liebig and Doran, 1999 and Bulluck et al., 2002). Despite the recent interest in organic agriculture, little research has been carried out in this area in the Slovak Republic and only a small amount of data is available to assess the long-term effects of organic management. Since the management systems react differently in different soil - climatic regimes with respect to soil quality**,** the objective of this study was to evaluate the impact of organic production practices on soil quality in the western part of the Slovak Republic where organic farming management has been carried out since 1995. Several chemical and microbiological indicators of organically and conventionally managed soils were measured and the soil quality was compared within the precise field experimental plots on degraded Chernozem on loess.

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Materials and methods

The experimental plots are situated in an area with a continental character of weather (average annual temperature of 9.2 ^{0}C and the mean annual precipitation of 593 mm). A large variability of temperature and unequal precipitation are a characteristic of this area. The soil representative is loam and clay loam degraded Chernozem on loess (pH 6.68 – 6.73, humus content 1.8 – 2.0 %, good available potassium store, medium phosphorus content and high magnesium content). The chemical and biological soil properties were determined within two farming systems:

Organic system: All operations were undertaken in compliance with Slovak Law SR 421/2004. Crop rotation: alfalfa, winter wheat + intercrop, pea, winter wheat + intercrop, potatoes, spring barley + alfalfa underseeding. Phacelia and mustard were used as an intercrop mix. This type of crop rotation represents a typical crop rotation for the regional practice in this region in Slovakia. Farm yard manure fertilisation took place three times during the crop rotation to potatoes (dose 30 t/ha) and winter wheat after pea and alfalfa (dose 15 t/ha). Vermisol preparation was used to pea and spring barley and winter wheat (dose 50 l/ha) mainly for the quality of production improvement. The P and K fertilisation couldn't be undertaken as there was no permit available in the Slovak Republic. Within the system there was mechanical weed control but there was no chemical plant protection.

Conventional system: This system had the same crop rotation as the organic system. Farmyard manure fertilisation took place once during the crop rotation on the potatoes (dose 30 t/ha); Vermisol was applied to winter wheat after both forecops (dose 50 l/ha). The synthetic N fertilisers were used to pea, spring barley and to wheat and P and K mineral fertilisation was defined by the balance method. Chemical protection was used against pests and diseases.

The same varieties and soil tillage practices were used in both farming systems and nitrogen inputs from organic fertilisers in organic system were equal as this in conventional system from synthetic fertilizers. The systems simulated farming systems without animal husbandry. Farm yard manure applied into organic and conventional system was bought from nearby organic farm. Farm yard manure composition represented 22 % of dry matter, 17 % of organic compounds, 0.48 % of N, 0.11 % of P and 0.51 % of K. The soil samples were taken four times during the vegetation period, from the depth of 0.02 – 0.2 m. The air dried soil samples were used for the chemical analysis (pH/KCl, C_{ox}, N_t, N_{in}). The biological analyses were determined in the fresh soil samples.

Used methods: pH/KCl measured by Ion Analyser (JENWAY, VB), C_{ox} measured by analyser CNS-2000 (LECO, Corp. St. Joseph, MI, USA), N_t measured by analyser CNS-2000 (LECO, Corp. St. Joseph, MI, USA), inorganic nitrogen ($N\text{-}NH_4^+$ + $N\text{-}NO_3^-$) – ($N\text{-}NH_4^+$) measured by Spekol 11 (Carl Zeiss, Jena, SRN), ($N\text{-}NO_3^-$) izotachophoretic determination by analyser EA 100 (VILLA Labeco Spišská Nová Ves, SR). Ammonification activity = inorganic forms of nitrogen increase $N\text{-}NH_4^+$ + $N\text{-}NO_3^-$ after 14 days of aerobical soil cultivation. Nitrification activity = $N\text{-}NO_3$ increase after 14 days of aerobical soil cultivation. Microbial biomass C_{mic} defined by fumigation – extraction method. Cellulolytic bacteria number on mineral agar, ammonification bacteria number on agar No.2. The number of earthworms sorted by hand from the sonde, 0.25 x 0.25 x 0.3 m on a PVC sheet directly in the field, earthworms' biomass and average weight of one earthworm in the laboratory conditions.

The obtained results were statistically evaluated by non-parametric method by means of the Wilcoxon pair test.

Results and discussion

The two farming systems (organic and conventional) compared in Borovce, near Piešťany has emphasised interesting differences in soil quality after eight years of organic farming management utilisation. The soil pH was not statistically different between conventional and organic management (Table 1) although a higher soil reaction was discovered in the organic farming system. The organic management system and the use of organic residues and farmyard manure (FYM) have been shown to maintain soil organic matter at higher levels than inorganic fertilisation. This increase is particularly important in Slovakia, where the decline of organic matter content represents more than 59 % of the land area. Several studies have shown the similar results, that regular application of fertilizers for many years leads to an increase in soil organic C (Reeder et al., 1998 and Kundu et al., 2001). In general, the use of organic manures and compost enhances SOC more than application of the same amount of nutrients as inorganic fertilizers (Gregorich et al., 2001). Similar increases in SOC content due to addition of FYM were also observed by Swarup and Yaduvanshi (2000) in India.

Microbial biomass was higher under the organic system with the application of farm yard manure than the conventional management system. Microbial biomass is among the most labile pools of organic matter and it serves as an important reservoir of plant nutrients, such as N and P (Marumoto et al., 1982). Microbial biomass, in response to environmental changes, can therefore have important implications for nutrient bioavailability. The same results were also obtained by Melero, Porras, Herencia, Madejon, 2006. The number of cellulolytic and ammonification bacteria was significantly higher in the organic system in comparison with the conventional system, based on statistics. More intensively the processes of ammonification and also nitrification run under organic management. The data shows a higher activity of ammonification microflora decomposing nitrogen organic compounds and also nitrification microflora which oxidise a part of ammoniacal nitrogen. Biomass, the abundance of earthworms and the average weight of one earthworm were higher in organic plots as compared with the conventional plots but the differences were not statistically significant.

Tab. 1: Soil chemical and biological characteristics in organic and conventional system in the years 2003-2004

Indicator	Organic System	Conventional System
pH/KCl	6.73	6.68
C_{ox} (%)	1.297	1.225
N_t (%)	0.118	0.113
N_{in} ($mg.kg^{-1}$ dry matter)	15.3	11.0
Ammonification activity ($mg.kg^{-1}$ dry matter)	13.9	12.1
Nitrification activity ($mg.kg^{-1}$ dry matter)	13.9	12.0
Microbial biomass ($C_{mic}.g^{-1}$ dry matter)	700.6	677.8
Number of cellulolytic bacteria ($n.10^3$ $CFU.g^{-1}$ dry matter)	7.81	6.25
Number of earthworms ($ks.m^{-2}$)	39	34
Earthworms biomass ($g.m^{-2}$)	19.4	15.1

Tab. 2: Wilcoxon pair test (significance of differences between organic and conventional system)

Indicator	Number of no-zero differences	Test value	P-value
pH/KCl	12	0.204124	0.838252
C_{ox}	19	3.49149	0,00048043^{++}
N_t	19	3.49149	0,00048043^{++}
N_{in}	25	0.144338	0.885229
Ammonification activity	27	1.19257	0.233037
Nitrification activity	31	2.04211	0,0411404^{+}
Microbial biomass	27	0.721688	0.470484
Number of cellulolytic bacteria	33	2.62557	0,00865046^{++}
Number of ammonification bacteria	31	2.04211	0,0411404^{+}
Number of earthworms	19	0.338062	0.735313
Earthworms biomass	27	1.3568	0.174844
Average weight of one earthworm	24	0.452267	0.651073

$^{+}$ Significant for $P<0.05$, $^{++}$ Significant for $P<0.01$

Conclusions

The results indicated that organic management with addition of farm yard manure positively affected soil properties, increased organic matter content and bacteria community. Organic residues added to the soil promoted ammonification and nitrification activity and the amount of microbial biomass.

Acknowledgments

The results were obtained within the frame of the Project 2003 SP 27/028 OS01/028OD01 and 2006 UO 27/091 05 01/091 05 10. The authors thank Danica Palkovicova for her help with the field and laboratory work, Seán O` Donnell (BA Hons) for proof reading, and the anonymous reviewer.

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The importance of amino-N for humus formation studied by comparing amino-N input to the soil and soil total nitrogen content in long-term experiments

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Key words: soil organic matter, nitrogen fractions, amino acids, soil fertility

Abstract

Humus formation is thought to depend directly on carbon input. Referring to earlier studies we tested the role of amino-bound nitrogen (amino-N) input to the soil using data of 10 long-term experiments with different fertilization and crop rotation treatments. In 8 out of the 10 experiments there was a significant positive correlation between the amino-N input and soil total N content. This correlation was much stronger than the one of total N input and soil N content, indicating that amino-N was more important for soil N accumulation than total N input. Amino-N from farmyard manure seems to be more effective in this respect than amino-N from other organic fertilizers.

Introduction

Humus (soil organic matter) is usually considered as a product of soil life. Humus level and composition are of crucial importance for many biological, chemical and physical properties of soils. Humus analysis and management are usually based on its carbon content. This view, however, seems to be too restrictive. Among others, the findings of Sowden & Schnitzer (1967) and Scheller & Friedel (2000) indicate that amino acids are involved in the synthesis of humic substances in agricultural soils and that amino acid turnover is one of the main factors influencing the organic matter content in soils. When analysing a number of soil samples under arable, grassland and forest use, Friedel & Scheller (2002) observed that 28-50% of total nitrogen was determined as hydrolysable amino acid-N. Therefore, Scheller & Friedel (2000) claimed that amino acids play an important role in the formation of soil organic matter and humic substances. The objective of our investigation was to test the hypothesis that a higher input of amino-N (protein, peptide, amino acids) to the soil leads to a higher humus content, resulting also in a higher soil total nitrogen content. The evaluation was based on data from 10 long-term experiments with different fertilization and crop rotation treatments.

Materials and methods

Long-term experiments have been selected that include at least one organically fertilized treatment and treatments with mineral fertilization. Basic information of the trials is given in Table 1. Trial 3 is located in Switzerland, no. 5 in Sweden and all

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other trials in Germany. Further information and standard references of each experiment has been presented by Schuler (2007).

Tab. 1: Basic information on the selected experiments

No	Name	Period	Treatments
1	IOSDV* Berlin-Dahlem	1984-2003 (20 years)	Unfertilized; min**; FYM***; FYM + min; crop residues; crop residues + min
2	LTE Darmstadt	1981-1995 (15 years)	Min; FYM; FYM + bd**** preparations; each type at 3 rates
3	DOK trial Therwil	1978-1998 (21 years)	5 cropping systems fertilized with composted FYM + bd preparations; rotted FYM; FYM + min.; min solely; unfertilized
4	K trial Järna	1958-1985 (28 years)	Unfertilized; min at 3 rates; comp. FYM; the same plus bd spray preparations; fresh FYM; fresh FYM + min
5	Static Fertilization Experiment Bad Lauchstädt plus Legumes	1926-1982 (57 years)	Untertilzed; legumes; min; min + legumes; FYM at 2 rates; FYM at 2 rates + min; FYM at 2 rates + legumes; FYM at 2 rates + min + legumes
6	Static Fertilization Experiment Bad Lauchstädt	1903-1930 (28 years)	Unfertilized; min; FYM at 2 rates; FYM at 2 rates + min
7	IOSDV Puch	1984-2004 (21 years)	Unfertilized; min; FYM; straw; straw + legumes; slurry; straw + slurry; all the organic treatments were also combined with min
8	Fertilzer Combination Trial Seehausen	1967-1996 (30 years)	Unfertilized; min; FYM + min; high rate of FYM; high rate of FYM + min
9	IOSDV Speyer	1983-2003 (21 years)	Unfertilized; min at 2 rates; FYM; FYM + 2 rates of min; crop residues; crop residues + 2 rates of min
10	Static Soil Fertility Trial Thyrow	1937-1978 (42 years)	Mineral fertilzer at 2 rates; FYM at 2 rates; FYM at 2 rates + min; green manure; green manure + min; straw; straw + min

* IOSDV = international organic nitrogen long-term trial
** min = mineral fertilizer
*** FYM = farmyard manure
**** bd = biodynamic

Data of the fertilizer amounts and N contents have been taken from publications of the experiments. N contents of manure were available in each case. If N contents of other organic fertilizers were missing, standard averages taken from other references were used. The total and the yearly N input by different fertilizers were calculated for each treatment over a defined period. N input by wet deposition was assumed to be the same for all treatments of a trial and, therefore, was not considered. The amino-N input was calculated based on organic fertilizers only, as they are the largest input pool of amino-N. Analytical data for amino-N contents in manure, slurry, straw, beet leaves etc. were taken from different references listed by Schuler (2007). If legumes (in monoculture or mixture) were cultivated as green manure crops, the amino-N input by the crop residues was calculated with the data of residue amounts, their N contents and standard analytical data of their amino-N ratios taken from references listed by Schuler, 2007. In some cases missing data had to be estimated. For example, for pea roots the amino-N ratio of clover roots was used. Amino-N input by other crop residues and root exudates were assumed to be similar in all treatments of a trial and, therefore, were neglected. For each single trial, the relationship between either amino-N input (by organic fertilizers and, if applicable, by legume crop residues) or total N input and soil total N content was tested by Kendall's rank correlation (Sokal & Rohlf, 1995). For all trials the effect of fertilization was tested by calculating the surplus of soil N in a fertilized treatment compared to the respective unfertilized one. This procedure helped to compare N supply effects across different sites. Linear regressions were calculated for the N surplus of a treatment against the amino-N input.

Results

In 8 out of the 10 experiments (apart from no. 1 and 4) the amino-N input was significantly correlated with the N content of the soil; the correlation coefficients varied between 0.54 and 0.89 (Table 2). In all these cases the correlation between total N input and soil N was much weaker and in many cases statistically not significant. Therefore, it can be concluded that the amino-N sypply was more important for accumulation of soil N than the total amount of N applied by fertilizers.

Tab. 2: Correlation between either amino-N input or total N input and soil total N content (at the end of the observation period) in all experiments; Kendall's rank correlation *tau* and its probability p

No.	Site	Correlation between amino-N input and soil total N content	Correlation between total N input and soil total N content
1	Berlin-Dahlem	0.2981 (p = 0.2004)	0.0667 (p = 0.4225)
2	Darmstadt	0.7650 (p = 0.0020)	0.4119 (p = 0.0610)
3	Therwil	0.6708 (p = 0.0502)	0.0000 (p = 0.5000)
4	Järna	0.3118 (p = 0.1400)	0.3536 (p = 0.1103)
5	Bad Lauchstädt	0.7526 (p = 0.0003)	0.6260 (p = 0.0023)
6	Bad Lauchstädt	0.7454 (p = 0.0178)	0.7333 (p = 0.0194)
7	Puch	0.5444 (p = 0.0069)	0.3817 (p = 0.0420)
8	Seehausen	0.8944 (p = 0.0142)	0.8000 (p = 0.0250)
9	Speyer	0.5774 (p = 0.0151)	0.3000 (p = 0.1301)
10	Thyrow	0.8040 (p = 0.0006)	0.3146 (p = 0.1027)

There was no statistically significant relationship between amino-N input and the N surplus in fertilized compared to unfertilized treatments. This was observed with all treatments that have received organic fertilizers only, as well as with all farmyard manure treatments (data not shown). However, the linear regression for all organic treatments showed a much lower probability (p=0.158) than the one for manure treatments (p=0.071) which may be a hint that farmyard manure has a specific function among organic fertilizers.

Discussion

The rank correlation results support the hypothesis mentioned above, as a higher input of amino-N was more important for soil N accumulation (and humus formation) in most experiments than a high total N input. However, the wide range of correlation coefficients indicates that amino-N input had no exclusive effect, but interacted with other experimental details or site conditions. No simple reason can be identified, why amino-N had no significant effect in two trials. Apparently, the role of amino-N was basically independent from whether organic (trial no. 2, 3, 4) or conventional cultivation was practised, though an earlier study with trial 2 indicated an effect of biodynamic preparations on amino acid turnover in the soil (Scheller & Raupp, 2005). The origin of organic fertilizers, i.e. farmyard manure, slurry, straw, legumes, probably is of relevance for the amino-N effect on humus formation, as our results suggest (Schuler, 2007; data not shown). This aspect has to be considered in detail in further research, because of the growing trend, in each type of agriculture, to use residues of plant biomass fermentation as fertilizers. Due to restricted data availability, in our study some simplifications had to be made. In order to obtain more specific results, in further investigations the amino-N input by roots and other crop residues should be quantified. Furthermore, not only input but also a possible loss from soil of amino-N e.g. by mineralization or direct uptake by crops should be considered.

Conclusions

Soil organic matter management solely based on carbon replacement does not reflect current understanding in a sufficient way. The role of amino-N and its fate during composting (and other processes of organic matter decomposition) should be investigated in more detail. Methods for humus budgeting may have to be revised.

Acknowledgments

We are grateful for stimulating discussions to Dr. Edwin Scheller (1957-2006) who proposed this study.

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Changes in light fraction soil organic matter and in organic carbon and nitrogen in compost amended soils

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Key words: snap beans, soil organic matter, nitrogen, carbon, compost

Abstract

Organic vegetable growers can use compost to supply crops with nutrients and increase soil organic matter (OM), but little information is available about the transformations of compost OM over time in organically managed systems. This study examined light fraction soil organic matter (LFSOM) and organic carbon (C) and nitrogen (N) in organically and conventionally managed snap bean cropping systems (continuous beans (CB) and a fully phased beans/fall rye rotation (BR)) following three years of fertility treatments (1x and 3x compost, and 1x synthetic fertiliser, where 1x provided 50 kg ha^{-1} N). Light fraction C and N increased with compost amendment, with the C:N ratio significantly lower in composted plots than in synthetically fertilised plots. Rotation and weeding method played no role in the composition of LFSOM, or the percentage of LFSOM making up whole soil organic C or N. Light fraction N and C roughly doubled in the 1x compost plots over the three years, compared with synthetically fertilised plots, but was only 2.5 times higher in 3x compost plots. While the addition of 13 t ha^{-1} C increased whole soil C by 5.6 Mg ha^{-1}, tripling the amount of added C raised whole soil C by 9.9 Mg ha^{-1}. 1x and 3x compost increased whole soil N by 20 and 33%, respectively, compared with the 1x synthetically fertilised plots. The 3x compost treatment only, by reducing bulk density, improved soil physical properties.

Introduction

Soil organic matter has many important functions in promoting crop growth, including provision of nutrients, retention of water, connecting pore spaces and supporting plant-growth promoting organisms (Weil and Magdoff, 2004). When fertilising organic crops with compost, large quantities of organic matter are added to the soil influencing physical properties such as bulk density (Lynch et al., 2005), as well as pools of organic carbon. One densiometric fraction, the light fraction soil organic matter (LFSOM), represents a pool of organic matter intermediate to labile pools of fresh crop residues and recalcitrant pools of humic materials. LFSOM is considered a useful early indicator of changes in SOM due to management practice (Gregorich and Ellert, 1993), and has been used to describe the fate of compost amendments to soil (Lynch et al., 2005; Carter et al., 2004; Grandy et al., 2002). Fertility treatments affect the

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proportion of LFSOM in the soil, as well as its constituent proportions of carbon and nitrogen (Lynch et al., 2005; Grandy et al., 2002). Other cropping practices may affect LFSOM, including crop rotation (Grandy et al., 2002) and, over the long term, tillage (Murage et al., 2007). This study aimed at determining the effects of three years of fertility regime (synthetic fertiliser vs. compost rates), crop rotation, and weeding tillage on LFSOM and LF C and N.

Materials and methods

A long term organic rotations experiment was established in 2002. The layout consisted of three replicates at two sites, each comprising three strips, to which each was assigned a rotational sequence of continuous beans (CB), or one of the phases of a beans/fall rye two-year rotation (BR). Strips were divided into six plots. To each was assigned a treatment combination (Table 1) of fertiliser and weeding method. Compost had a mean C:N ratio of 19.8, with total nitrogen on a dry matter basis of 1.2%. The 1x compost rate delivered the equivalent of 50 kg N ha^{-1}: the same rate of N applied in synthetically fertilised plots. In herbicide-treated plots, herbicide applications followed commercial practices. Mechanical weeding was carried out twice per season. Treatments are summarized in Table 1. Bulk density cores and soil (0-15 cm depth) samples for organic matter analysis were taken after the completion of the crop rotation cycle, early in 2006. Total soil organic matter was separated into heavy and light fractions using a sodium iodide solution with a density of 1.7 g cm^{-1} in the manner described by Gregorich and Ellert (1993) and carbon and nitrogen were measured using dry combustion in a LECO CNS analyser. Analysis of variance was used to assess effects of rotation and fertility treatments, and calculations estimated the amount of applied compost C and N, and remaining whole soil C and N.

Tab. 1: Summary of treatments applied in the first rotation cycle (2003- 2005)

Treatment	Source of nutrients	Yearly N-P-K on Beans (kg/ha)	Yearly N-P-K on Rye (kg/ha)	Weeding method
F1x -M	Fertiliser	50-68-82	100-15-60	Mechanical
F1x-H	Fertiliser	50-68-82	100-15-60	Herbicide
C1x-M	Compost	50-28-26	50-28-26	Mechanical
C1x-H	Compost	50-28-26	50-28-26	Herbicide
C3x-M	Compost	150-84-78	150-84-78	Mechanical
C3x-H	Compost	150-84-78	150-84-78	Herbicide

Note: P and K rates are averages for the three years. For fertiliser, rates varied according to soil test. For compost, rates varied according to compost composition.

Results

Compost amendment affected the C and N content, and the C:N ratio of the LFSOM compared with synthetic fertiliser amendment (Table 2). In addition LF C and LF N as percentages of TOC increased with compost amendment (Table 3). Only the 3x rate of compost reduced soil bulk density. Weeding treatment and crop rotation did not significantly affect any of the parameters, though a significant rotation x weeding interaction existed for whole soil C:N showing it higher in mechanically weeded CB plots than in herbicide treated CB plots. In BR, weeding method did not affect whole soil C:N.

Tab. 2: Mean light fraction (LF) carbon (C), nitrogen (N) content and C:N in soil (0-15 cm) from different fertility treatments applied from 2003-2005.

Treatment	LF %C	LF %N	LF C:N
F1x	27.40	1.33	20.42
C1x	29.76	1.58	18.82
C3x	31.40	1.70	18.48
Standard error of mean	0.026	0.019	0.304
Significance			
Fertility application	***	***	***
Fertiliser vs. Compost	***	***	***
Rotation	ns	ns	ns
Weeding	ns	ns	ns

ns non-significant, *** significant for P<0.001

Tab. 3: Mean light fraction (LF) carbon (C) and nitrogen (N) expressed as percentatges of whole soil (0-15 cm) organic (O) C and N, and bulk density in fertility treatments over 2003-2005.

Treatment	LF-C as % of whole soil OC	LF-N as % of whole soil ON	Bulk density (g $(cm^3)^{-1}$)
F1x	7.40	6.33	1.30
C1x	13.47	11.86	1.30
C3x	18.86	16.71	1.24
Standard error of mean	0.070	0.076	0.015
Significance			
Fertility application	***	***	**
Fertiliser vs. Compost	***	***	~
Rotation	ns	ns	ns
Weeding	ns	ns	ns

ns non-significant, ~ significant for P<0.1 *significant for P<0.05, **significant for P<0.01, *** significant for P<0.001

Tab. 4: Carbon (C) and nitrogen (N) applied over three years, and changes to mass of whole soil C and N measured in 2006.

Treatment	Total C applied (Mg ha^{-1})	Total N applied (kg ha^{-1})	Whole soil C (Mg ha^{-1})	Whole soil N (kg ha^{-1})
F1x	0	150	31.6	1950
C1x	13	150	37.2	2340
C3x	39	450	41.5	2604

Discussion

Gains in LFSOM, C and N are expected when amending soils with composts, which are composed of organic matter in varying stages of transformation from labile fresh material toward humic materials. In this study, gains in LFSOM, C and N were not proportionate to compost application rate. This runs contrary to the results of another study which examined corn silage compost at two rates, one double the other, and found that soil C concentrations and total soil C both increased proportionately with compost rate, compared with a non-compost amended control (Lynch et al., 2005). Compost did not transform into more resistant heavy fraction soil organic matter (HFSOM) more quickly in the 3x compost rate than in the 1x compost rate, since HFSOM data showed equal increases in HF C and HF N between synthetic fertiliser and 1x compost as between 1x and 3x compost (data not shown). Other interactions are likely at work, which may be revealed with further study of crop residues returned to the soil during the period of study, crop products exported. Study of plant nutrient data may give insight into the mineralization of organic matter in the different treatments.

Conclusions

Compost application increased whole soil C and N, LFSOM, LF C, LF N, and the LF C:N ratio. Weeding method and crop rotation did not affect these parameters, except in the CB rotation, where mechanical weeding resulted in a higher C:N ratio than did herbicide. Compost amendment at the 3x rate decreased bulk density compared with both 1x compost and synthetic fertiliser. Though the SOM parameters increased with compost application, the increase was not a linear relationship with rate. This may interest growers whose cost of compost (fixed $ per ton) increases linearly with rate.

Acknowledgments

This work was supported by AAFC’s Matching Investment Initiative, Cardwell Farms Compost Products, Western Ag Innovations, La Ferme Michaud and Beatrice Allain.

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Effects of organic matter input on soil microbial properties and crop yields in conventional and organic cropping systems

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Key words: soil organic matter, crop yield, crop rotation, soil microbiology.

Abstract

Unlike conventional cropping systems, which are characterised by targeted short-term fertility management, organic farming systems depend on long-term increase in soil fertility and promotion of soil biodiversity. This study sought to investigate long-term effects of organic matter inputs on various cropping systems in a 10-year-old experiment. Results show that in the long-term high C and N inputs enhance microbial activity. Microbial biomass N and the potential nitrification rate were higher in cropping systems based on green manure than in those reliant on inputs from animal manure and mineral fertilizer. Soil microbiological properties were affected by the individual crops in the rotation. The high microbial activity with increased organic matter inputs did not transform to enhanced crop productivity.

Introduction

Crop production in organic farming systems relies to a large extent on soil fertility for nutrient supply. The soil fertility must be maintained via choice of crop rotation and (green) manuring practices. Fertility building by such means requires a long-term integrated approach, rather than the short-term and targeted solutions common in conventional agriculture. The fertility building in organic cropping systems has consequences for soil biological properties, which subsequently may influence N and C flows and emissions, including greenhouse gases (Mäder et al., 2002). The changes in organic matter input may affect crop yields and soil properties differently in different systems depending on mineral nutrient supply to the crops. These effects can only be properly studied in long-term experiments, where the fertility effects of various cropping systems are reflected in changes in soil properties and in crop responses. In this paper we explore the effects of different organic matter inputs on crop yields and soil microbiological properties in a 10-year old cropping system experiment in Denmark.

Materials and methods

A crop rotation experiment was initiated in 1996/97 at three sites in Denmark (Olesen et al., 2000), but only data from the site at Foulum is used in this paper (Table 1). Foulum is located in Central Jutland on a loamy sand with an annual rainfall of 704 mm. During the period 1997 to 2004 the experimental factors were 1) proportion of N_2-

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fixing crops in the crop rotation, 2) with (+CC) and without (-CC) catch crop, and 3) with (+M) and without (-M) animal manure. Two crop rotations (O2 and O4) with different proportions of cereals and nitrogen fixing crops in a four-year rotation were tested (Table 1). All crops in all rotations are represented every year in two replicates (blocks). The plots receiving manure were supplied with anaerobically stored slurry at rates where the NH_4-N amount corresponded to 40% of the N demand of the specific rotation based on a Danish national standard (Plantedirektoratet, 1997). The grass-clover was used solely as a green manure crop, and the cuttings were left on the ground. All straw was left in the field.From 2005 the design was changed to include a conventional cropping system (C4) with a crop rotation similar to the O4 rotation (Table 1). Conventional treatments (C4) replaced the previous -CC/-M treatments in O2 and O4 such that O2/-CC/-M was converted to C4/+CC and O4/-CC/-M was converted to C4/-CC. The crops in C4 received mineral fertiliser at recommended rates. A mixture of legume and non-legumes were used for the catch crops in O2 and O4, whereas non-legumes were used in the C4 catch crop treatment. From 2001 the cuttings in grass-clover in O2/+M was no longer mulched, but removed from the field. Manure application is based on the principles of recirculation, where nutrients in the cuts from the grass-clover are processed by anaerobic digestion and redistributed to the row crop and cereals in the rotation. In O4/+M treatments the manure application is based on import from conventional farms. Weeds were controlled by mechanical means in O2 and O4, whereas pesticides were used at recommended rates in C4 to control weeds, pests and diseases.

Tab. 1: Structure of the crop rotations.

	Crop rotation	O2	O4	C4
1st course 1997-2000	1	S. barley:ley	Spring oat[CC]	
	2	Grass-clover	Winter wheat[CC]	
	3	Winter wheat[CC]	Winter cereal[CC,1]	
	4	Pea/barley[CC]	Pea/barley[CC]	
2nd course 2001-2004	1	S. barley:ley	Winter wheat[CC]	
	2	Grass-clover	Spring oat[CC]	
	3	Winter wheat[CC]	S. barley[CC]	
	4	Lupin/barley[CC]	Lupin	
3rd course 2005-2008	1	S. barley:ley	S. barley[CC]	S. barley[CC]
	2	Grass-clover	Faba bean[CC,2]	Faba bean[CC,2]
	3	Potato	Potato	Potato
	4	Winter wheat[CC,3]	Winter wheat[CC,3]	Winter wheat[CC,3]

[CC]Catch crop in the +CC-treatments, [1] Triticale in 1999 and 2000, [2] Pea/barley in 2005, [3] S. oats in 2005.

Grain yields were measured at maturity using a combine harvester. Samples of total above-ground biomass in the grass-clover were taken in 1 m^2 sample areas in each plot at each cut. To determine total crop production, samples of total above-ground biomass were taken in 1 m^2 sample areas in each plot 1-2 weeks before maturity. Similar samples of total above-ground biomass were taken about 1 November to measure the above-ground biomass of catch crops and weeds. Total N in the grain and plant samples were determined on finely milled samples from each plot by the

Dumas method. Carbon content in plants was estimated under the assumption of 46% C content in plant DM biomass. Soil organic C and N were determined by dry combustion. Microbial biomass was determined by the chloroform fumigation incubation technique (Joergensen and Brookes, 1990). Nitrification potential was assessed using the method described by Hart et al., (1994).

Results

There were higher C and N inputs from aboveground material in the organic compared to the conventional systems, in particular affected by the catch crop (CC) treatment (Table 2). The organic system O2/+CC received significant C and N inputs from grass-clover and O4/+CC from crop residues and catch crops. This was reflected in a higher soil organic C content in the organic compared to the conventional treatments (Table 3). Microbial biomass N and nitrifier activity was highest in the O2/+CC and lowest in the conventional system (Table 3). The microbial population and activity, which increased with organic inputs in plots that will have spring barley in 2008, but showed no clear trend in the winter wheat plots. Annual grain yields were consistently higher in conventional compared to organic systems (Table 4). Grain yields obtained in the O4/+CC were comparable with yields from the O2/+CC. The low yields obtained for spring oats in the conventional system in 2005 were due to crop lodging.

Tab. 2: Annual C and N inputs in organic matter of manure and above-ground plant material (1997- 2006).

	Source	C4/-CC	O4/-CC	O4/+CC	O2/+CC
C input	Manure	0.0	0.3	0.3	0.2
(Mg DM/ha/yr)	Grass-clover	0.0	0.0	0.0	1.6
	Crop residues	2.1	2.4	2.9	2.4
	Catch crops	0.2	0.2	1.0	0.3
	Total	2.3	2.9	4.2	4.5
N inputs	Manure	0	18	18	15
(kg N/ha/yr)	Grass-clover	0	0	0	95
	Crop residues	42	40	61	44
	Catch crops	10	9	58	16
	Total	52	66	137	170

Tab. 3: Soil biological and chemical properties (+ *S.E; n =2*)

Soil Parameter	2008 crop	Treatment			
		C4 /-CC	O4/-CC	O4/+CC	O2/+CC
Organic C (%)	S. barley	1.95	2.10	2.09	2.28
	W. wheat	1.91	2.29	2.00	2.39
Microbial biomass N (µg N / g soil)	S. barley	32.1(2.3)	36.3(2.3)	36.0(4.0)	47.2 (0.8)
	W. wheat	27.2 (2.2)	32.7(1.3)	27.2*	29.2 (3.3)
Potential Nitrification (nmol NO_3 / g soil / h)	S. barley	10.6(0.3)	13.9(0.01)	15.5(1.6)	16.6(0.4)
	W. wheat	12.3(1.7)	16.3(1.9)	15.1(0.2)	17.9(0.2)

Discussion

The results suggest that increased microbial activity follows increased annual C and N inputs in cropping systems. This finding agrees with Raupp (1995), who reported higher microbial biomass in organic compared to conventionally managed soils. Catch crops significantly increase soil organic matter levels (Olesen et al., 2007), thus microbial activity and grain yield were as expected lower in organic system without catch crops. In line with the observations made by Acosta-Martinez et al., (2004), microbiological parameters, unlike organic C, were effected by crop type. The lower microbial population after the potato crop that preceded winter wheat suggests that potatoes had a negative effect on soil rhizosphere microbial populations. The generally higher nitrifier activity could be due to high residual N as the 2007 potato crop was affected by disease. Increased organic matter inputs enhanced microbiological properties, but did not necessarily translate to improved crop productivity. This is inevitable in organic systems where plant nutrient demand is rarely in synchrony with nutrient availability (Watson et al., 2002).

Tab. 4: Dry matter grain yields Mg DM ha^{-1} ($\underline{+}$*SE; n = 6*)

Crop	Year	Treatment			
		C4/-CC	O4/-CC	O4/+CC	O2/+CC
S. oat	2005	4.12	5.11	5.42	5.27
W. wheat	2006	7.05	5.19	6.08	6.16
	2007	6.86	3.50	3.32	4.00
S. barley	2005	6.25	4.92	5.19	4.86
	2006	5.74	4.38	5.14	4.77
	2007	4.64	3.13	4.53	4.51
Mean		5.78 (0.41)	4.37 (0.3)	4.95 (0.32	4.93 (0.25)

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The Potential Role of Organic Soil Fertility Management in the Kenya Highlands

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Key words: soil fertility, Kenya highlands, smallholders, legumes, organic farming

Abstract

Soil fertility degradation still remains the single most important constraint to food production in the Kenyan Highlands. It is estimated that 64% of the population resides in the highlands, with population densities in some areas of over 1000 persons/km^2. Use of inorganic fertilisers on smallholdings in the Kenya Highlands has been steadily declining since the 1960s, when heavy promotion and subsidization of fertilisers coincided with the release of improved maize varieties and the creation of co-operatives such as the Kenya Grain Growers Co-operative Union. Currently, their use continues to be constrained by their high cost, the low purchasing power of smallholders, and limited access to credit facilities. Farm sizes are getting smaller, and this promotes continuous cropping with limited scope for crop rotation and inadequate soil fertility replenishment. Soil fertility improvement can be achieved through organic farming techniques such as biomass transfer, re-activation of the 'N bulge', and phosphorus scavenging. Legume intercropping with maize – Kenya's staple food – as well as the implementation of short rain legume fallows are known to enhance maize yields in most cases.

Introduction

Kenya is a remarkably fine illustrative case of the causes and consequences of soil nutrient depletion. Countrywide, under increasing land pressure from a still burgeoning population, nutrient losses (e.g., from leaching and erosion) and off-takes from crop harvest removals often exceed additions from biological processes (e.g., nitrogen fixation) and application of organic and inorganic fertilizers (De Jager *et al*., 1998). Yields of key commodities have stagnated, not only in areas with marginal agricultural potential, but also in regions with relatively good production prospects. As it is in other Sub-Saharan African countries, it is increasingly difficult to concurrently satisfy short-term production needs and long-term demands for environmental sustainability. Forced by the need to produce more staple crops for a growing population and to grow cash crops to integrate into the monetary economy, farm households replaced once stable systems with intensive systems relying heavily on external inputs, or they moved into ecologically fragile areas. The use of inorganic fertilizer in Kenya dates back to early 1920s. At the time of independence in 1963, fertilizers were mainly used by large-scale farmers, most of whom were European. After independence, fertilizer use was advocated and small-scale farmers started using it. However, the implementation of Structural Adjustment Programmes (SAPs) resulted in increased prices for external inputs, while price levels of agricultural products decreased or

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remained stagnant, and only a limited growth in productivity was realised. These developments have forced farm households to exploit soil nutrient resources, leading to negative nutrient balances in most parts of this region (see table 1).

Current On-Farm Nutrient Balances in Kenya

Many studies have been carried out to quantify nutrient balances in different ecological zones (i.e. Smaling *et al*., 1997; De Jager *et al*., 1998 and Onwonga and Freyer, 2006). They have all shown that there are negative nutrient balances. A few cases give reason enough for considering alternative soil fertility management, e.g. the case of Kisii district, a densely populated area with high agricultural potential in the western region of Kenya. Soils in the area are predominantly well drained, deep, and, with the exception of phosphorus, rich in key nutrients (Smaling *et al*., 1997). Mean annual rainfall is high, exceeding 1000 mm. Major food crops are maize and beans, key cash crops are tea, coffee, and pyrethrum, while livestock and improved pastures are common farm components. Most significantly, given the high population density, little land is left fallow during the year. Where inorganic fertilizers are used, application rates are well below recommended levels. Annual nutrient depletions in the district have been estimated at 112 kg/ha of N, 2.5 kg/ha of P, and 70 kg/ha of K (Table 1).

Tab. 1: Farm Level Soil Nutrient Balances in Kenya (kg ha^{-1} a^{-1})

Soil Nutrient	Kisii District[1,2]	Kakamega District[1]	Embu District[1]	Nakuru District[3]
Nitrogen (N)	-112	-72	-55	-30
Phosphorus (P)	-3	-4	9	14
Potassium (K)	- 70	18	-15	11

Source: Smaling et al. (1997)[1], De Jager et al. (1998)[2] and Onwonga & Freyer (2006)[3]

Similar patterns are reported for Kakamega district, which can be compared to Kisii in population density and agroecological potential, and in Embu and Nakuru districts, where population density and agroecological potential are lower (Table 1). Purchasing mineral nitrogen fertilizer is hardly possible because of financial reasons. The main emphasis is given to supplying mineral P through diammonium phosphate (DAP).

Economic returns to food-crops in these districts tend to be insufficient to cover the costs of additional N fertilizers required to replenish lost nutrients (De Jager, 1998). Negative N balances underline that farmers do not cultivate enough legumes as an alternative to add N. Mainly a limited proportion of beans, cowpea, and soyabeans contribute to the N-balance. Because clover or alfalfa is an exception in the long rains and the short rains are scarcely used for N-fixing fallow plants, besides the negative N balance there also is a lack of humus-relevant biomass production. Low humus contents lead to an increased risk of leaching of mineral P as well as loss of soil fertility in general driven by erosion processes.

Opportunities for Organic Soil Fertility Management in Kenya's Agriculture

Agricultural systems productivity can be invigorated through nurturing soil organic matter build-up, which allows higher and more stable yields. The addition of soluble nutrients is not a viable option for Kenya's smallholders experiencing declining farm household incomes and poor output markets coupled with increasing food insecurity.

Furthermore, this strategy is not sustainable for soil fertility development. Low-external input sustainable agriculture (LEISA) has been viewed as an alternative remedy for these areas. More recently, one particular alternative that has gained interest is organic agriculture because of its comprehensive advantages. Traditional farming systems practised over time by smallholder households in these regions rely on the recycling of organic matter to maintain soil fertility. Subsequently, by adopting organic agriculture, which requires less financial inputs while placing more reliance on human resources, farmers could move towards more sustainable agricultural practices.

Legume intercropping is an organic farming strategy in the tropics aiming at replenishing soil fertility, improving soil structure, and suppressing weeds, while generally providing the benefit of a higher overall yield. Many studies have been carried out to evaluate the agronomic and economic benefits of legume-cereal intercrops in Kenya and other parts of the world (Rao and Mathuva, 2000; Mburu et al., 2003; Lelei, 2004 among others).

N deficiency is a major constraint on the productivity of the Kenyan smallholder farming systems. Green manure and forage legumes have the potential to improve the soil N fertility of smallholder farming systems through biological N-fixation. The effects of legumes on yields of associated major crops have been well documented. Maize has been studied extensively in association with pigeon pea (Rao and Mathuva, 2000), common bean (Lelei, 2004) and mucuna (Mburu *et al*., 2003). These studies all have indicated that maize grain yield was not negatively affected but sometimes enhanced by the legume intercrop, suggesting a balanced effect of competitive depression and N transfer from the legume. For example, maize-pigeon pea intercropping systems produced 17 to 24% higher maize yields than continuous sole maize (Rao and Mathuva, 2000).

The incorporation of green manure is another technique to strengthen soil fertility. Soil fertility is related to soil structure, which can be measured by aggregate stability. A study conducted on maize plots in rotation with cover crops showed aggregate stability values of 41.3%, 45.7% and 50.5% after biomass removal, mulch application, and incorporation of biomass respectively (Gachene *et al*., 1999). The cover crops used were *Mucuna pruriens, Vicia benghalensis* and *Crotalaria ochroleuca*. The soil aggregate stability of plots with incorporated biomass was not affected by the type of biomass added.

The application of biomass from a previously grown leguminous or non-leguminous crop can prevent soil erosion, reduce nutrient losses, stimulate microbial activity in the rhizosphere, improve soil structure, and raise the yields of subsequent crops (Schlecht et al., 2006). In the Kenya Highlands, six legumes have been identified as promising green manure crops for smallholder farming systems, namely purple vetch (*Vicia benghalensis*), velvet bean (*Mucuna pruriens*), perennial soyabean (*Neonotonia wightii*), Tanzanian sunhemp (*Crotalaria ochroleuca*), lablab (*Lablab purpureus* or *Dolichos lablab*) and lima bean (*Phaseolus lunatus*) (Kiama and Muriithi, 2001).

Conclusion and Recommendations

The steady fall in Kenya's stock of soil nutrients appears to be closely linked to soil fertility management practices such as monocropping and slash-and-burn methods, which are ill-suited to the relatively recent imperative of continuous cultivation under burgeoning population pressure. However, with appropriate soil fertility management practices, population pressure may not lead to nutrient depletion, but rather to improved soil quality and adequate yields.

Leguminous species have shown some potential for soil fertility improvement and soil conservation. Soil fertility improvement can be achieved through biomass transfer, short-term fallows, nitrogen fixation, re-activation of the 'N bulge' and P scavenging. Additionally, they have similarly shown potential for reducing soil erosion through five processes: interception of rainfall impact by tree canopy; surface runoff impediment by tree stems; soil surface cover by litter mulch; promotion of water infiltration; and formation of erosion-resistant blocky soil structure.

Because these systems require less financial input while relying more on human capital, there exists a huge potential, given the high population in these areas. The excess labour can be used for hauling biomass, mechanical weeding and composting, among other labour-intensive operations. In view of the aforementioned consideration, this review calls for more integrated soil management research beyond legumes so that farmers can always have fallbacks when one option is limiting. Agricultural extension agents should promote the use of legume intercrops to replace nitrogenous fertilizers and supplement human protein sources.

Acknowledgments

The Austrian Government is gratefully acknowledged for financially supporting this research through the "Organic Agriculture with Trees" (OAT) project.

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Nutrient management

A Conceptual Framework for Soil management and its effect on Soil Biodiversity in Organic and Low Input Farming

Koopmans, C.J.[1] & Smeding, F.W.[2]

Key words: Soil biology, soil management, biodiversity, sustainability, soil model

Abstract

Learning how to manage beneficial soil biological processes may be a key step towards developing sustainable agricultural systems. We designed a conceptual framework linking soil management practices to important soil-life groups and soil fertility services like nutrient cycling, soil structure and disease suppression. We selected a necessary parameter set to gain insight between management, soil life and soil support services. The findings help to develop management practices that optimise yields, soil fertility and biodiversity in organic farming.

Introduction

Learning how to manage beneficial soil biological processes may be a key step towards developing sustainable agricultural systems. Organic farming aims at optimising production while maintaining a rich biological diversity of the soil (Davis and Abbott, 2006).

Farmers have an ongoing economic interest in soil ecosystem services like nutrient cycling and soil aggregate formation. Little knowledge exists however, about the relationship between specific soil management practices influencing soil biodiversity and these services. It may be true that environmental variables like soil type and climate determine to a large extent the soil community (Davis and Abbott, 2006). However, individual practitioners have many opportunities to influence this community in regard to optimising biological fertility at their individual farms.

In this paper we present a the conceptual framework linking soil services, soil management and its effects on soil biodiversity. The study focuses on the question: if we want to achieve certain soil ecosystem services, which soil life is then important and with which soil management practices can we obtain the desired soil life? The conceptual framework is a mind map that enables the evaluation of the effects of farming practices on soil biodiversity parameters. This study contributes to national research programs concerning the Biological indicator-system for soil quality (BiSQ) (Rutgers et al., 2005).

Materials and methods

The study included the elaboration of two typologies of both soil (ecosystem) services as well as (organic) soil management practices. With the typology as a starting point, interactions were explored, based on literature (e.g. Bloem et al., 2005) between important soil services and soil management practices like nutrient cycling, soil

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structure formation and disease suppression. Soil biodiversity is involved in these interactions. Parameters of soil biodiversity (based on BiSQ) were selected, that are supposed to be essential for linking management to soil services. The result was a conceptual framework based on experimental data, literature and expert judgement, that links soil management practices, soil life groups and soil services like soil fertility. Subsequently the framework was used to evaluate and understand the impact of type of manure on soil biodiversity and soil services, as an example of one of the most important soil management practices

Results and Discussion

Figure 1 presents the link between the services an agricultural soil can perform, the most important soil management practices by farmers and effects of these practices on soil biodiversity and productivity. The soil practices in our study focus primarily on the soil fertility service and all services linked to soil fertility like nutrient cycling, soil structure and disease suppression.

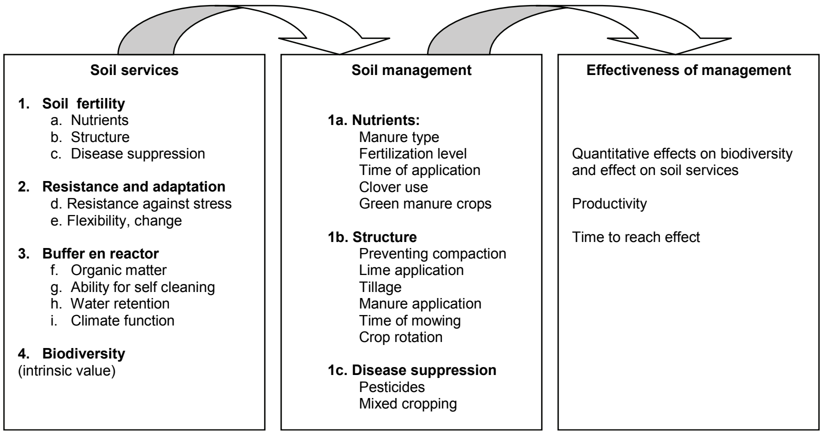

Figure 1: relates soil services to certain soil management practices and the effect of the soil management on soil biodiversity.

Linking soil management practices and services can be considered as a new management tool. The choice of services reflects the local use of the soil by farmers (Rutgers et al., 2005).

In the conceptual framework of figure 2 the central question is: how to obtain a particular soil service? The framework clarifies the most important relations to soil life and requirements in terms of soil management practices. Therefore the framework consists of three important squares which are related to each other: soil management (including tillage), soil life and soil ecological services.

Additional to the three squares, the circle includes the management effects that are mediated by crop development i.e. the root system. As indicated by many authors soil management can impact soil life directly or through plant growth and especially root production.

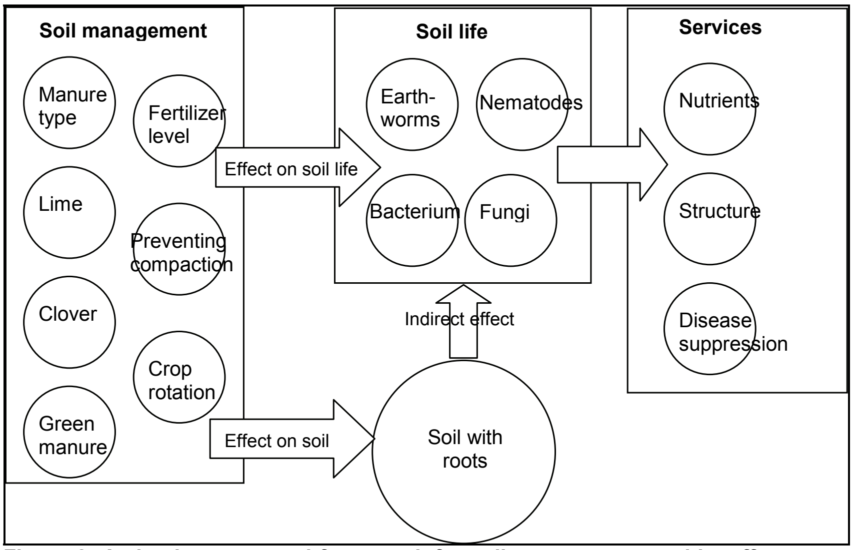

Figure 2: A simple conceptual framework for soil management and its effect on soil biodiversity and soil services.

The value of the elaborated approach is primarily the link between soil management practices and soil (ecosystems) services that represent the farmers profit and external demands (e.g. clean drinking water). Second: a conceptual framework can help the practitioner to better understand the soil-life black box. In this respect decision support is important because in practice different soil management practices are always taken simultaneously. The framework can show whether soil practices synchronise in their effect on soil life or work in the opposite direction. The framework is able to give an estimate of the impact of different management practices.

The soil food web structure and the life support services of soil organisms can be indicated by a selection of parameters (table 1). With this standardised parameter set based on the BiSQ (Rutgers et al., 2005) it is possible to determine the effects of management on these biodiversity parameters which should be measured.

An example of the application of the framework is presented by Zanen et al. (this issue). That study shows that soil management practices like organic amendments allowed in organic agriculture, alter soil life (i.e. nematode population) and change soil indicated by organic N mineralization potential. Other studies (Koopmans et al., 2006) suggest that changes in the response of crop roots due to different organic inputs altering the composition of the soil community over time.

Conclusions

This study shows that important soil services, soil management practices and soil biodiversity indicators can be linked in a framework to develop sustainable agricultural systems that manage beneficial soil biological processes. This may be a key step towards understanding the biological mechanisms behind soil biodiversity. The findings could be useful to support management practices that optimise yields, soil fertility and biodiversity in organic farming.

Tab. 1: Parameters of the dataset of the soil biodiversity framework.

Area	Parameter	Unit
Biological	Bacterial biomass	µg C/g soil
	Thymidine incorporation	pmol/g soil/hr
	Leucine incorporation	pmol/g soil/hr
	Fungal biomass	µg C/g soil
	Active Hyphae	%
	Pot. N mineralization	mg N/kg/week
	Pot. C mineralization	mg C/kg/week
	Bacterial feeding nematodes	n/100 g soil
	Fungal feeding nematodes	n/100 g soil
	Plant feeding nematodes	n/100 g soil
	Nematodes predators	n/100 g soil
	Earthworm biomass	g/m^2
	Lumbricus rubellus	n/m^2
	Aporrectodea calliginosa	n/m^2
	Lumbricus terrestris & Aporrestodea longa	n/m^2
Physical	Structure crumb	% in 0-10 cm
	Structure round	% in 0-10 cm
	Structure angular	% in 0-10 cm
	Plant roots 10 cm	n/400 cm^2
	Plant roots 20 cm	n/400 cm^2
Chemical	Organic matter, clay, pH, Ct, Nt, Pt, Pw, P-Al, K2O	divers

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Improving Soil Structure and Nitrogen Use Efficiency by GPS-controlled Precision Tillage Technology in Organic Farming

Zanen, M. [1] & Koopmans, C.J.[2]

Key words: soil structure, GPS-controlled traffic systems, nitrogen use efficiency.

Abstract

A field experiment was conducted to determine the effects of tillage technique (GPS-controlled traffic system and traditional tillage) and level of fertilization (farmers' practice or phosphate equilibrium) on yield, soil structure and nitrogen use efficiency. Manure inputs could be seriously reduced without yields being diminished during the first three years of the intensive crop rotation. Results suggest that an improved soil structure under GPS-controlled precision tillage enhances nitrogen use efficiency.

Introduction

Organic agriculture should play a leading role and set an example for sustainable soil management. This implies greater nutrient use efficiency and fewer inputs. GPS-controlled precision tillage using the same traffic lanes every year offers the opportunity to improve soil structure (Vermeulen & Klooster, 1992). Our hypothesis is that the improved soil structure of the beds will provide better aeration and rooting for the crop and access to necessary nutrients. This would mean that nitrogen use efficiency would improve in GPS-controlled precision tillage systems. In this study we evaluate the effects of a GPS-controlled precision tillage system using permanent traffic lanes in combination with low manure input on soil structure, nitrogen use efficiency and crop yield in an intensive crop rotation.

Materials and methods

During a period of four years on site field experiments were conducted at an organic vegetable farm in Langeweg (N. Br), the Netherlands (4° 38' East, 51° 39' North). The soil of the experimental field was characterized as clay loam (2.6% organic matter, 23% clay, pH-KCL 7.4). In 2003 the experiment was set up with two tillage treatments (GPS-precision and Traditional) and two fertilization treatments (Farmer's practice (FP) and Phosphate Equilibrium (PE), defined as P_2O_5 removed at harvest = P_2O_5 input with manure) in a split-plot arrangement (Tab. 1). The experimental design was a randomised complete block with four replications and 6,3 m x 25 m plot size. In each experimental year one crop was studied, following the intensive vegetable rotation of the farm: spinach (2003), carrot (2004), potato (2005) and grass seed (2006). During each growing season, soil structure was determined visually. Soil structure was rated as a percentage of crumbly and angular structures at a relevant depth, using a modified method according to Shepherd (2000) as described in Koopmans & Brands (1993). Nitrogen use efficiency was calculated in 2004 (spinach) and in 2006 (potato) as the N-application rate with fertilization divided by the total N amount taken up by

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the leaves and tubers, excluding roots. The data were analyzed by analysis of variance (ANOVA) using tillage treatment as main plots and fertilization levels as subplots. Significant effects were separated by the least significant difference (LSD) at P = 0,05.

Tab. 1: Tillage and fertilization treatments of the field experiment in Langeweg

Tillage system	Fertilizer application	N	P_2O_5	K_2O
		Kg ha^{-1} year^{-1}		
Traditional	Farmer's practice (FP)	128	53	150
Traditional	Phosphate equilibrium (PE)	62	26	72
GPS precision	Farmer's practice (FP)	128	53	150
GPS precision	Phosphate equilibrium (PE)	62	26	72

Results

In the first year, significant (P<0.05) higher yields were obtained in spinach using GPS-precision techniques (Fig.1).

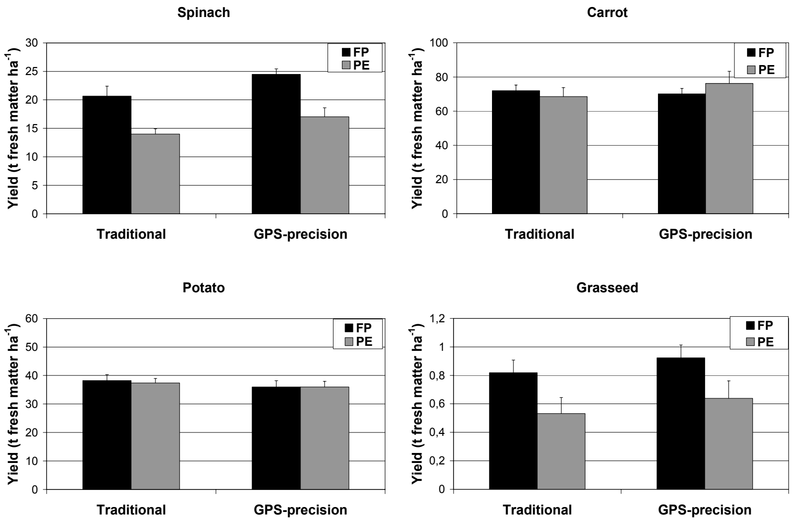

Figure 1: Yields of spinach (2004), carrot (2005), potato (2006) and grass seed (2007) in management practices Traditional (FP and PE) and GPS-precision (FP and PE). Errorbars indicate standard error of the mean (SE).

In spinach (2004) yields at FP fertilization level were significantly higher (P<0.001) than yields at PE fertilization level. Interestingly there was no significant difference between yields in plots with GPS-precision techniques with PE fertilization level and traditional tillage with FP fertilization level, indicating a higher nutrient availability in GPS-precision plots. In carrots (2005) and potatoes (2006) no significant differences between treatments were observed. Grass seed yield (2007) in the PE fertilization treatment significantly diminished (P<0.001) compared to the FP treatment. No effect of tillage strategy was observed. Results in grass seed confirmed the earlier observation in spinach in which there was no yield difference between GPS-precision tillage at PE fertilization level and traditional tillage at FP fertilization level.

Soil quality

Visual determination of soil structure clearly showed the effect of GPS-precision tillage on soil quality in 2004 and 2007. The percentage of angular elements at 0-15 depth in spinach and at 0-10 cm depth in grass seed was significantly higher (P=0.02) using traditional tillage as compared to GPS precision tillage (Tab.2). In carrots no angular elements were found. The percentage of crumble elements in the ridges was significantly higher using precision tillage. In potato, after traditional harvest of the carrots under suboptimal soil conditions, soil structure was diminished in all treatments and soil clods in all plots were characterized as 100% angular elements.

Tab. 2: Percentage of angular soil elements per soil layer per year. Values are mean, n=4.

	Angular elements (%)			
	0-10 cm depth	0-20 cm depth	0-20 cm depth	0-10 cm depth
	Spinach	Carrot	Potato	Grass seed
	2004	2005	2006	2007
Traditional				
FP	31	0	100	43
PE	38	0	100	45
GPS precision				
FP	6	0	100	19
PE	2	0	100	6
Tillage system	*	NS	NS	*
Fertilization	NS	NS	NS	NS

* Indicate significance at P ≤ 0.05.

Nitrogen use efficiency

In the first year of the experiment nitrogen use efficiency of spinach was significantly higher (P<0.001) with PE fertilisation (87%) as compared to FP fertilisation (44%). Two years later, in 2006, similar results of nitrogen use efficiency were found in potato. Nitrogen use efficiency was significantly higher (P=0.006) with PE fertilisation (255%) as compared to FP fertilisation (145%). However, there was no difference in yield of potatoes grown with PE fertilisation and yield of potatoes grown with FP fertilisation.

Discussion

The results of this study support the hypothesis that tillage techniques using GPS-precision can enhance soil structure, resulting in lower manure input needs and higher nitrogen use efficiency. Lowering the amount of fertilizer towards phosphate equilibrium, meant that nitrogen input was seriously reduced. Strikingly, this reduction had no significant effect on yield reduction of spinach, carrot and potato. Visual determination of soil structure showed the negative effects of traditional tillage on subsoil structure which is in agreement with earlier studies on the effects of subsoil compaction (Van den Akker and Schjönning, 2004). Furthermore, in 2005 and 2006 it showed the negative effects of conventional harvest under suboptimal conditions of the soil. If carrots and potatoes had been harvested by using traffic lanes, there would have been less soil compaction and this could have resulted into higher yields and N utilization coefficients of the crops. The higher nitrogen use efficiency at lower fertilisation levels stretches the possibilities for reducing inputs in organic agriculture.

Conclusions

The study shows that manure inputs could be reduced to phosphate equilibrium without lowering yields in three out of four years of an intensive crop rotation on a clay loam soil in the Netherlands. Our results in spinach and potato suggest a higher nitrogen use efficiency due to a better soil structure after GPS-precision tillage. The results also make clear that this promising new technology only can improve soil structure and result in higher yields on the long term, when all tillage is done from the same traffic lanes, including harvest.

Acknowledgments

We thank the organic farm Biotrio De Nieuwe Weg for their work on the trial and availability of the land. Coen ter Berg helped us with sampling of the trial over years. The authors gratefully acknowledge funding from the Dutch Ministry of Agriculture, the Rabobank and Louis Bolk Institute.

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Season-long supply of plant-available nutrients from compost and fertiliser in a long term organic vs. conventional snap bean rotations experiment

Owen, J.[1], LeBlanc, S.[2] & Fillmore, S.A.E.[3]

Key words: compost, plant nutrients, ion exchange membranes, seasonal changes

Abstract

In Canada, stockless organic vegetable cropping systems may use compost for fertility. However, information to guide growers about when nutrients become available in the soil over the growing season is lacking. Detailed analysis of plant nutrient supply was conducted over three years in a multi-site rotations experiment using two cropping sequences. The experiment compared conventional fertility treatment (synthetic fertiliser (1x N)) with organic treatments (annual compost amendment at a low (1x N) and a high rate (3x N)). Plant-available soil nutrients were captured using sequential two-week burials of ion exchange membranes. Ions were eluted and quantified. Variation in nutrient supply over time, and effects attributable to crop rotation and fertility regime were evaluated with analysis of variance and of principal components. Results showed season-long supply of plant nutrients was more affected by year than fertility regime or rotation, even in composted plots where large residual effects were expected. Synthetic fertiliser and 1x compost resulted in very similar seasonal plant nutrient supplies. While 3x compost caused some significant changes, the gains in plant nutrient supply was modest enough to suggest little or no advantage in this one respect to warrant the cost of amending at greater than the 1x rate.

Introduction

Plant nutrient supplies available for crop growth in organic systems are often comparable and sometimes exceed those found in conventional systems, yet synchronizing the availability of those nutrients may be more difficult (Berry et al., 2002). Because composition of compost is notoriously variable, and mineralization of organic matter in the soil is mediated by a host of factors such as temperature, moisture, soil chemistry and microbial communities (Magdoff and Weil, 2004), predicting the timing and quantity of nutrient supply in the soil becomes difficult. While beneficial effects of compost are well documented (Rosen and Allen, 2007) growers in Canada still often rely on rules of thumb about nutrient availability in the first year to determine application rates. This study used ion exchange membranes to evaluate season-long plant nutrient availabilities in soils amended with two rates of compost, compared with soils amended with synthetic fertilisers, over three years in a continuous bean cropping system, and a fully phased snap bean/fall rye rotation.

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Materials and methods

This research was conducted over three years of a long term organic-versus-conventional rotations experiment, with three replicates at a research farm site and three at a commercial farm site in Bouctouche, New Brunswick, Canada. Each replicate comprised three strips, to which each was assigned a rotational cropping sequence (continuous beans (CB), fully phased beans/fall rye two-year rotation (BRB or RBR)). Strips were divided into plots to which were assigned one of three yearly-applied fertility treatments (synthetic fertiliser, low (1x) rate compost, high (3x) rate compost). Compost was a commercial organic certified mix of forestry, fishery and farmyard waste (Cardwell Farms Compost Products, Penobsquis). It had a carbon to nitrogen ratio of 15.2, with total nitrogen on a dry matter basis of 1.5%. The 1x compost was applied at a rate calculated to deliver the equivalent of 50 kg N ha^{-1}: the same rate of N applied in synthetically fertilised plots. N, P and K amendments in synthetically fertilised plots were based on regional crop production guides. Amounts of nutrients added in each treatment are summarised in Table 1.

Anion and cation exchange membranes were used to monitor supply of plant-available ions in the soil solution of bean plots. The membranes, Plant Root Simulator™ probes (Western Ag Innovations, Saskatoon), were buried vertically in the soil, each exposing an area of 17.5 cm^2 of ion-exchanging surface to the soil at approximately six to thirteen cm below the soil surface. Four pairs of anion and cation probes were buried on the crop row in each plot to form composite samples to account for soil heterogeneity. Each pair of probes was shielded from interference by plant roots by a length of pvc pipe hammered into the soil. Probes were buried for sequential two-week periods, for 6, 7 and 8 burials in 2003, 2004 and 2005, respectively. Each new set of probes was inserted directly into the holes left by the previous set. In the laboratory, ions adsorbed to the membranes were eluted and quantified by colorimetric or inductively coupled plasma techniques. Because burial dates varied from year to year according to the cropping season, seasonal curves of nutrient supply were developed for each year, and from these curves, predicted values were generated for a specific set of dates. Principal components were computed for seasonal totals of plant nutrients supplied in bean plots, and presented in biplot form.

Tab. 1: Three-year totals of plant nutrients (kg ha^{-1}) applied as synthetic fertiliser, low rate (1x) or high rate (3x) compost to plots in continuous beans (CB), Beans-Rye-Beans (BRB) and Rye-Beans-Rye (RBR) crop sequences.

		Nutrients applied (kg ha^{-1})						
Treatment	Crop Seq.	N	P	K	Ca	Mg	Fe	Al
Synthetic fertiliser	CB	150	210	215	0	0	0	0
	BRB	200	140	215	0	0	0	0
	RBR	250	70	215	0	0	0	0
Compost 1x	CB, BRB, RBR	150	107	93	271	60	88	*
Compost 3x	CB, BRB, RBR	450	321	279	813	180	264	*

* not analysed

Results and discussion

Extended burials of ion exchange membranes provide an opportunity to measure the nutrient supply rate in soils over time while accounting for short term dynamic interactions of nutrients within the root zone (Qian and Schoenau, 2002). In this study sequential burials captured season-long plant nutrient supplies over three years. Compost application, particularly at the 3x rate, was expected to increase the supply of nitrogen and other plant nutrients. Supply rates tended to be similar between the synthetic fertiliser and the 1x compost treatment (Figure 1). NO_3-N supply was greatest in the synthetic fertiliser treatment, and decreased significantly with increasing compost amendment, likely because the addition of massive amounts of organic C in the compost treatments over the years immobilised N. Potassium supply increased significantly with increasing compost, though potassium supplied at the 3x compost rate was only about 65 kg ha^{-1} greater than that applied as synthetic fertiliser (Table 1). The modest differences in nutrient supplies between 1x and 3x compost treatments was surprising, suggesting that while organic matter increased (data not shown) this did not translate into gains in nutrient supply proportionate to the inputs.

Biplot analysis (Figure 2) revealed clear clusters of fertility treatments by year. Nutrient supplies were least in 2003, but despite high inputs of compost, did not increase incrementally by year in compost amended plots. In 2004, nutrient supply exceeded nutrient supply in 2005, suggesting that year effects play a defining role in nutrient supply. Mg and K were affected in much the same way by fertility treatments, independent of Fe, Al and P which formed another tight cluster. In acid soils, such as those of this study, inorganic P precipitates as Fe/Al-P secondary minerals and may become adsorbed to Fe/Al oxides (Tisdale et al., 1993). The association of Fe, Al and P with the 1x and 3x compost treatments in 2004 is therefore likely related as well to an increase in pH found in composted treatments (data not shown). Ca and N supply were most affected by 1x compost and synthetic fertiliser treatments. Overall, the average nutrient supply among all treatments was best represented by 1x compost in the CB rotation in 2005, with total season supplies (mg ion cm^{-2} per 12 weeks) of: NO_3-N, 2287; NH_4-N, 41; P, 70; K, 2063, Ca, 8397; Mg, 1613; Al, 224; and Fe, 259 mg ion cm^{-2}. Other factors likely contributed to the year effects, including crop uptake, and crop residues returned to the soil, which would have differed by crop, and possibly by treatment as well. These important relationships will be explored at length elsewhere.

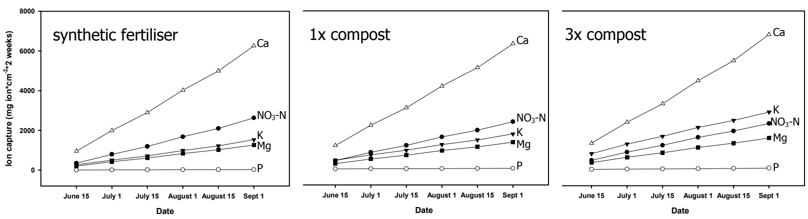

Figure 1: Cummulative supply of plant nutrients in soils amended with synthetic fertiliser, 1x compost and 3x compost, over three years and two cropping sequences.

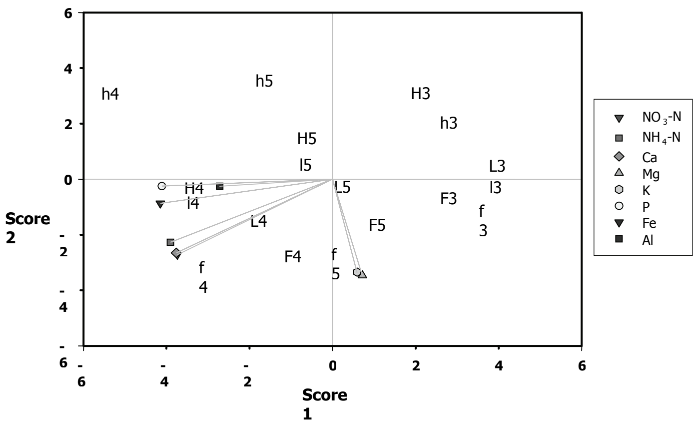

Figure 2: Biplot of principal components of fertiliser amendment/crop sequence on seasonal total plant nutrient supplies (caps refer to Continuous Beans; lower case to Beans/Rye; 3, 4, 5 to 2003 to 2005; letters l, h, f to low (1x) and high rate (3x) compost and synthetic fertiliser)

Conclusions

Compared with synthetic fertiliser, compost application resulted in less NO_3-N, and greater amounts of K and Ca over the course of the season. Nutrient supply was more affected by year than by any other factor, with the effect of year resulting in lower nutrient supplies in 2004 than in 2005 despite any residual contributions of previous years' compost applications. Applying 3x compost increased Ca and K supplies, but other gains were not enough to warrant the considerable associated costs.

Acknowledgments

This work was supported by AAFC's Matching Investment Initiative, Cardwell Farms Compost Products, Western Ag Innovations, La Ferme Michaud and Beatrice Allain.

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Elemental Contaminants in Fertilizers and Soil Amendments Used in Organic Production

Baker, B.[1] & Tracy, D.[2]

Key words: fertilizers, soil amendments, elemental contaminants.

Abstract

Elemental contaminants in fertilizers pose a threat to human health and the environment. Organic agriculture can take measures to protect the public and the environment from the long-term effects of these contaminants, also known as heavy metals. Arsenic (As), cadmium (Cd), and lead (Pb) were identified as the top priority metals that need attention. Fertilizers and soil amendments used in organic production were randomly selected, and the laboratory results for the levels of As, Cd, and Pb compared against six different standards based on different models. Organic farmers are advised to avoid using fertilizers that may degrade the average levels found in soils in the United States. Standard-setting bodies are advised to prohibit the use of fertilizers and soil amendments that have As, Cd, and Pb that will result in the accumulation of those elements in the soil when applied at average loading rates on an annual basis.

Introduction

Heavy metals occur naturally in soils. They can also be accumulated through conventional agricultural practices and are found in a variety of industrial by-products, some of which are combined with fertilizers and soil conditioners. The elemental contaminants known as heavy metals pose a threat to food safety and can harm the environment, whether they come from synthetic or natural sources. The Organic Materials Review Institute (OMRI) has identified and characterized the concerns raised by the application of heavy metals found in the fertilizers and soil amendments permitted for use in organic production. The purpose of this study was to determine the levels of heavy metals in a representative sample of organic fertilizers, and to predict how many fertilizers and soil conditioners would meet various standards that limit heavy metal contamination.

Materials and methods

OMRI staff used the data submitted by our listed suppliers for product review. Staff drew the files of 50 products at random that had been submitted at some point. To be considered valid, analytical results needed to be clearly linked to and identified with the submitted product. The product needed to comply with organic standards. The sample needed to have been taken within the previous five years. Of the 50 selected, 32 products had valid results of analyses on file for As, Cd, and Pb using EPA's Strong Acid Digest/ Inductively Coupled Plasma (ICP) methods.

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As, Cd, and Pb were selected as the highest priority elemental contaminants based on a consensus of experts consulted. Other contaminants might also be of concern, but were beyond the scope of this study.

The analytical results were then compared with six different scenarios:

1) OMRI's Maximum Concentration of Contaminants Contained in Synthetic Micronutrient Products (OMRI, 2002).

2) The Association of American Plant Food Control Officials' (AAPFCO) Statement of Uniform Interpretation and Policy (SUIP) (AAPFCO, 2006). AAPFCO standards base heavy metal limits on phosphorus or micronutrient content. Limits for compost and manure based products were set based on phosphate content.

3) The US Environment Protection Agency's (EPA) standards set for metals resulting from the land application of sludge, also known as the 503s (US EPA, 1994).

4) The Washington State Department of Agriculture's limits established for metals loading in fertilizers expressed in lb/acre/yr (WSDA, 2006). For the WSDA limits, products were viewed based on the loading rates on their label. For compost, an annual loading rate of 2 tons/acre (approximately 4.5 metric tons/ha) on an 'as-is' basis was used. If dry weight was reported, then an annual loading rate of 1 ton/acre (2.24 metric tons per hectare) was used.

5) The No Net Degradation (NND) limits are based on the US Geological Survey and other researchers' estimates of average background levels of heavy metals in soils in North America. (Lepp, 1981; Shaklette and Boerngen, 1984; Gustavsson et al., 2001).

6) The European Union (EU) limits for metals when sewage sludge is used in agriculture. (EU, 1986). The Annex IB Lower Limit Value was used.

Table 1 lists limits of the different scenarios examined. Data from the sampled products were entered into an Excel spreadsheet and analyzed using the different model standards.

Tab. 1: Limits of the Different Scenarios (ppm)

Scenario	Arsenic (As)	Cadmium (Cd)	Lead (Pb)
OMRI [1]	10	20	90
AAPFCO[2]	13	10	61
503s[3]	41	39	300
WSDA[4]	149	40	290
NND[5]	7.2	0.4	19
EU[6]	--	20	750

[1] OMRI 2002. Table 3.
[2]Association of American Plant Food Control Officials SUIP 25, Column 2,
[3]US EPA, 1994. Table 3 of 40 CFR 503.13,
[4]Washington State Department of Agriculture, 2006. WAC 16-200-695 and RCW 15.54.800.
[5]Shaklette, et al., 1984; Lepp, 1981; and Gustavsson et al., 2001.
[6]European Union Council Directive 86/278

Results

The results are summarized in Table 2. The highest As levels were found in dehydrated poultry litter and rock phosphate. Conventional broiler production in the US uses As as a parasiticide. It is a known impurity in many rock phosphate deposits. Rock phosphate also had the highest level of Cd, exceeding the limit for all but one of the standards. In the case of rock phosphate, the source of contamination is believed to be natural impurities. The highest Pb level was 66.6 ppm, found in compost made from municipal green waste. Demolition material, such as lumber coated with lead paint, is a common contaminant at such facilities.

Tab. 2: Summary of Results of the Random Selection of Fertilizers and Soil Conditioners Used in Organic Production

Parameter	Arsenic (As)	Cadmium (Cd)	Lead (Pb)
Average (ppm)[1]	9.6	8.5	12.8
# (%) Positive[2]	19 (58%)	18 (55%)	20 (61%)
Maximum (ppm)	53.6	96.6	66.6
# >OMRI 2002 (%)	4 (12%)	2 (6%)	0 (0%)
# >AAPFCO (%)	2 (6%)	0 (0%)	1 (3%)
# >503s (%)	0 (0%)	1 (3%)	0 (0%)
#>WSDA (%)	0 (0%)	1 (3%)	0 (0%)
#>NND (%)	5 (15%)	11 (33%)	4 (12%)
#>EU (%)	--	2 (6%)	0 (0%)

[1]Average of the positive samples.
[2]Number of samples exceeding the limit of detection reported by the laboratories.

Some of the fertilizers in the sample exceeded average soil background levels for all three of the contaminants. Because Cd has a relatively low average background level, the percentage of fertilizers that exceed background level was the greatest, accounting for about a third of the randomly selected products.

Discussion

When the various scenarios were applied to the selected fertilizers, The No Net Degradation standard was the most precautionary, as expected. However, it would also be the most restrictive in terms of what fertilizers and soil conditioners could be used. Of the remaining standards, none was consistently more protective. The risk assessment models did not have a consistent estimate of the risks posed by the different elemental contaminants. The loading rate model was the most permissive with Pb, but was stricter with Cd and As.

Most of the experts noted that soil contamination is a function of both the loading rate and the background level. Thresholds for each of the priority contaminants should be established at two levels: the lower threshold based on a no net degradation policy that requires monitoring for increases in soil levels over time, and the higher threshold based on a loading rate that predicts levels of contamination in soil monitored on an annual basis and expected to increase to a level toxic to plants.

Conclusions

As, Cd, and Pb were found in most fertilizers and soil conditioners that were randomly selected. The levels found were within the thresholds of most of the regulatory limits and would not be expected to result in soil degradation. Poultry litter, rock phosphate, and compost made from municipal green waste were found to be the most likely kinds of fertilizers and soil conditioners to exceed regulatory limits and threaten soil degradation. We believe that organic farmers should be made aware of the long-term consequences of applying soil amendments that are contaminated with heavy metals and take precautions to not cause long-term degradation.

Acknowledgments

The authors acknowledge Eric Sideman of the Maine Organic Farmers and Gardeners Association, Will Brinton of Woods End Laboratories, Zea Sonnabend of the Ecological Farming Association, Rose Koenig of the University of Florida, and Joseph Heckman of Rutgers University.

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Management Strategies and Practices for Preventing Nutrient Deficiencies in Organic Crop Production

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Key words: Amendments, crop rotation, organic crop production, rock phosphate, nutrient deficiencies

Abstract

*Field experiments are underway in Canada to determine the influence of management practices (crop diversity, green manure, legumes) and amendments (*Penicillium bilaiae*, rock phosphate, elemental S, gypsum, manure, wood ash, alfalfa pellets) on crop yield. In the alternative cropping systems study established in 1995, crop yields for organic system without any chemical input were 30-40% lower than the conventional system with high inputs. But, lower input costs plus price premiums for organic produce normally more than offset lower yields, resulting in favourable economic performance and energy efficiency. Legume, green manure and compost manure helped to replace nutrients lacking in the soil and improved crop yields. In the organic system, amount of P removed in crop exceeded that of P replaced and this can be a major yield limiting factor. In amendments experiments, there was small effect of granular rock phosphate fertilizer and/or* Penicillium bilaiae *in increasing soil P level and crop yield in the application year. Other findings suggested the use of elemental S fertilizer, gypsum, manure, wood ash or alfalfa pellets to improve nutrient availability, and yield and quality of produce. In conclusion, integrated use of management practices and amendments has the potential to increase sustainability of crop production as well as improve soil quality plus minimize environmental damage.*

Introduction

Maintaining soil fertility, controlling weeds and developing appropriate crop rotations are important production issues facing organic agriculture in the Canadian prairies (Jans, 2001). Crops with taproots can absorb nutrients from deeper soil depths (Entz et al., 2001a), and nutrients become available in surface soil after crop residues are returned. This can improve the economic productivity when surface soil has low fertility. Rotation of fibrous and taproot crops in a cropping system can therefore improve the cycling and crop use of nutrients.

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In organic farming, synthetic fertilizers/chemicals are not applied to increase crop production. Any nutrient(s) limiting in soil can cause substantial reduction in crop yield. In the Canadian Prairie Provinces, most soils under organically farmed systems are deficient in available N for optimum yield (Watson et al., 2002). There are many organically farmed soils low in available P, and some soils contain insufficient amounts of S and K for high crop yields (Entz et al., 2001b). The N deficiency in soil on organic farms can be corrected by growing N-fixing legume crops in the rotations. However, if soils are deficient in available P, K, S or other essential nutrients, the only alternative is to use external sources to prevent their deficiencies. Manure/compost can provide these nutrients. But often there is not enough manure to apply on all farm fields, and the cost of transporting manure to long distances is uneconomical in remote areas. On such soils, rock phosphate fertilizer, elemental S fertilizer, gypsum, alfalfa pellets or wood ash may be used to correct deficiencies of these nutrients. The information on the feasibility of these products in preventing nutrient deficiencies under organic farming is lacking.

Materials and methods

Alternative cropping systems experiment

The on-going field experiment was established in 1995 on a Dark Brown Chernozem (Typic Boroll) loam soil at Scott, Saskatchewan to compare input level and cropping diversity under various alternative cropping systems. The 54 treatments were combinations of three input levels [organic – ORG (no input of fertilizers and other chemicals under conventional tillage), reduced – RED (reduced input of fertilizers and other chemicals under no-till) and high – HIGH (recommended input of fertilizers and other chemicals under conventional tillage)], three cropping diversities (low diversity – LOW, diversified annual grains – DAG and diversified annual grains and perennial forage crops - DAP) and six crop phases including green manure (GM), chem-fallow or tilled-fallow (F). Data collection focuses on crop yield, nutrient concentration and uptake, potential for soil degradation, soil quality, pest dynamics, economic performance, energy efficiency as well as indicators of environmental well being and biodiversity.

Rock phosphate and other amendments experiments

A number of field experiments are underway to determine the influence of *Penicillium bilaiae* on the release of available P from rock phosphate fertilizer in preventing P deficiency on P-deficient soils, elemental S fertilizers and gypsum in preventing S deficiency on S-deficient soils, and compost manure, wood ash or alfalfa pellets in preventing deficiencies of N, P, K, S and other nutrients in soils lacking in these nutrients for organic crops. Data collection includes yield, produce quality, and nutrient uptake of crops, nutrient accumulation and quality of soil, and greenhouse gas (GHG) emissions.

Results and discussion

Alternative cropping systems

The results to date demonstrated that crop yields for the ORG were 30-40% lower than for the production systems with the HIGH input. But, lower input costs plus price premiums normally more than offset lower yield in organic agriculture. Net energy production was greater for conventional than organic, but energy output to input ratio was greater for the ORG system. This indicated favourable economic performance and energy efficiency of organic systems. Legume crops and green manure helped to replace N in organic systems. Summer fallow also helped to replace N and some other nutrients in organic systems, but there is risk of erosion and deterioration of soil quality especially on tilled fallow. The findings also suggest that application of compost manure can provide N, P, K, S and other nutrients lacking in the soil.

Extractable P in the 0-90 cm soil was higher with HIGH input than with ORG. In the organic system, the amount of P removed in crop exceeded that of P replaced. This resulted in low extractable P in the surface soil and extremely low in the subsoil layers, and this can be a major yield limiting factor for high crop production in organic systems. This indicates that there may be little potential for taprooted crops to bring P from deeper soil to the surface at this site (Malhi et al., 2002). This also suggests that if the whole soil profile is low in available P or other nutrients, it may not be possible to sustain high crop yields under organic systems without external nutrient additions.

Nitrate-N in the 0-240 cm soil was greater at HIGH input than at ORG input. The nitrate-N data in different soil layers suggested some downward movement of nitrate-N in plots receiving HIGH input. Our findings related to ORG input are in agreement to earlier observations by Kolbe et al. (1999) that properly managed organic crop production may considerably reduce potential risk of nitrate leaching in soil because of decreased input of N to the soil-plant system. Nitrate-N soil was higher in rotations that included GM/F than in rotations with continuous cropping, suggesting that if N fertilizer is applied at high rates and crop frequency is low, there is a potential for leaching of nitrate-N in the soil profile, increasing risk of ground water contamination.

Rock phosphate and other amendments

In the rock phosphate experiments, there was a significant but small increase in crop yield from granular rock phosphate in the year of application on a P-deficient soil. The results suggest that it is unlikely that the addition of rock phosphate will produce any economic returns for organic producers in the year of application, but it may provide economic yield benefit in the long term. Application of *Penicillium bilaiae* alone increased crop yield, but its application in combination with rock phosphate did not increase the crop performance over *Penicillium bilaiae* applied alone on P-deficient soils. Composted livestock manure in the alternative cropping experiment showed greater potential in restoring soil P than other strategies such as rock phosphate application. In the previous on-going experiments, granular rock phosphate was not very effective in correcting or preventing P deficiency in crops, most likely due to large particle/granule size. In future experiments, we are planning to also broadcast and incorporated into the soil a finely-ground rock phosphate fertilizer to increase interaction between P particles and soil microorganisms to increase P release and its availability to crops.

The addition of wood ash, without concurrent addition of N, showed increase in seed yield and economic returns of barley and field pea in Alberta, and alfalfa forage yield and protein content in Ontario. The main yield benefit most likely resulted from improvement in the availability of P and/or other nutrients from wood ash. In addition to correcting/preventing nutrient deficiencies and improving yields of crops grown on soils deficient in these nutrients under organic farming systems, wood ash has other potential benefits, such as reduction in soil acidity (which may last for several years), improvement in soil tilth, increased microbial biomass and reduced weed infestation. The results of other experiments suggest that elemental S fertilizer and gypsum may have the potential to correct/prevent S deficiency and improve yields of crops grown on S-deficient soils under organic farming systems. In growth chamber, application of alfalfa pellets to soil was found effective in increasing crop growth.

Conclusions

Crop yields for organic systems were 30-40% lower than the conventional production systems with high inputs, but lower input costs plus price premiums normally more than offset lower yield in organic agriculture. Legume crops, green manure, compost manure and other amendments (elemental S fertilizer, gypsum, manure, wood ash or alfalfa pellets) could prevent nutrient deficiencies in soil on organic farms. The findings suggest that integrated use of management practices and amendments has the potential to increase sustainability of crop production and net returns to producers as well as improve soil quality and prevent soil erosion by returning more crop residues to the soil plus minimize environmental damage by leaving less nitrate-N in the soil.

Acknowledgements

The authors thank Saskatchewan Agriculture and Food, Agriculture Development Fund, The Canada-Saskatchewan Green Plan, TOLKO Industries Ltd. and NOHFC/TBARA for financial assistance, and L. Sproule, D. Gerein, D. Leach, SARDA staff and TBARS staff for technical assistance.

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Potential of Oil Palm Empty Fruit Bunch (EFB) as Fertilizer in Oil Palm (Elaeis guineensis L Jacq.) Nurseries

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Key words: organic agriculture, oil palm seedlings, empty fruit bunch, cow dung, fertilizer

Abstract

Oil palm is one of the major oil crops in the world. Oil palm empty fruit bunch (EFB) could serve as an alternative and cheaper organic fertilizer in oil palm farms. This study investigated the value of composts of different forms of EFB for raising oil palm in the nursery. The experiment, which covered the pre-nursery (< 3 months) and nursery stages (3-13 months) used different EFB: cow dung ratios (100:0, 90:10, 80:20, 70:30 and 60:40) as compost as well as cow dung only and mineral fertilizer (NPKMg 12-12-17-2). The composts were added to the soil at the rate of 4.8 g N /plant. The experiment was laid out in a randomized complete block with three replicates. Data were collected on dry weight, nutrient concentrations, and soil pH changes. Oil palm seedlings under the application of unsoaked oil palm EFB and cow dung (60:40) were significantly ($p < 0.05$) higher in dry weight (18.0 g / plant) than those from the mineral fertilizer and control treatments (15.7 and 10.5 g / plant respectively) in the nursery stage. Composts of unsoaked EFB and cow dung (ratio 60:40) was more suitable for raising oil palm seedlings in the nursery than other treatments used.

Introduction

Development of organized organic agriculture system is still young in most developing countries. However, sourcing and adoption of sustainable organic inputs and resources by practitioners are essential for lasting development in this area. Application of mineral fertilizers is the most common means of improving soil fertility among farmers. However, the positive effects of mineral fertilizers on soil for crop production last only for a short time. In the long run, mineral forms of N fertilizers (urea and ammonium sulphate) can lead to decreasing base saturation, acidification, and a drop in soil pH (Phicot *et al.*, 1981). Ogedengbe (1991) observed a cationic imbalance in the soil of the Okomu oil palm plantation, Benin, Nigeria and linked this to the problem of intensive application of mineral fertilizer. Another complication is the fact that the commonly used mineral fertilizers are becoming scarce and not usually available to most farmers. This situation has triggered the problem of underfertilization on many farms. As a result, crop performance has been reduced. Organic fertilizers have the potential to correct almost all negative impacts of mineral fertilizers on soil. Efforts targeting increases in agricultural production should be backed up with environmentally friendly fertilizer application practices that should guarantee safety and sustainability of the soil natural resources.

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Oil palm (*Elaeis guineensis* L Jacq.) is a crop of national economic importance in Nigeria. Mineral fertilizers (urea and NPKMg 12-12-17-2) are the conventional fertilizers in raising oil palm. However, oil palm empty fruit bunch (EFB) and cow dung (from oil palm/ livestock integration), usually available year-round, seem to be underutilized. These materials, if composted and used as organic fertilizer in toil palm production, could increase yield and also eliminate problems associated with intensive mineral fertilizer application. Thus, this investigation focussed on determining effective combinations of oil palm EFB and cow dung in composting for raising oil palm in the nursery.

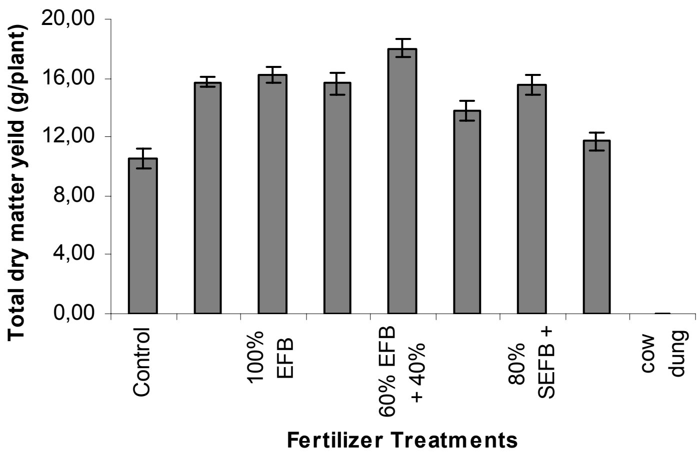
Materials and methods

Geminated oil palm (var. 'Tenera' was used. Pre-nursery stage (0 – 3 months after planting) took place in the greenhouse, whereas the plants were exposed to prevailing environmental conditions during the nursery period (3 –13 months after planting). The experiment was laid out in a randomised complete block design with three replicates. 2 kg of rain-washed river sand was used to raise the plants at the pre-nursery stage, while at the nursery, the soil was made up to 5 kg per bag. Treatments investigated were: (1) Control (no application), (2) Mineral fertilizer, (3) 100% Unsoaked Empty Fruit Bunch (UEFB), (4) 80 % (UEFB)+ 20 % cow dung, (5) 60 % (UEFB) + 40 % cow dung, (6) 100% Soaked Empty Fruit Bunch (SEFB), (7) 80 % (SEFB) + 20 % cow dung, (8) 60 % (SEFB) + 40 % cow dung and (9) Cow dung. Conventional mineral fertilizer was applied at 7 g urea / 5 L water per 100 seedlings (Hartley,1988) as fertigation in the pre-nursery as well as N-P-K-Mg (12-12-17-2 compound fertilizer, 14 g per plant [Onwubuya, 1982]) in the nursery. This was applied twice (2nd and 8th months) during the nursery period. The compost treatments were applied once at a rate equivalent to 4.8 g N /plant one week before planting. Dry matter yield was determined. The most recently matured leaf (Mengel and Kirkby, 2001) of the pre-nursery treatment plant was used for nutrient analysis in the pre-nursery stage, while at the nursery stage total plant shoot was used. Soil and plant material analyses were conducted using standard methods. Means of dry matter yield were compared using the treatment error ($p<0.05$).

Results

The un-soaked EFB: cow dung – 60: 40% compost treatment performed significantly ($P<0.05$) better than other treatments in total plant dry matter yeild at 10 months in the nursery (Fig. 1). At the end of this period, no plant on the cow dung compost treated soil survived.

Manganese concentration in the oil palm plants at the end of the pre-nursery stage ranged from 52 – 1126 $mgkg^{-1}$ (least in control and 100% UEFB and highest in cow dung treatments). Iron concentration at this stage ranged 906 – 3332 $mgkg^{-1}$ (least in mineral and highest in cow dung treatments). At 10 months in the nursery, manganese concentration in the plants ranged from 196 - 1204 $mgkg^{-1}$ (least in soaked EFB: cow dung – 80: 20% and highest in mineral fertilizer treatments respectively). Also, iron ranged 1704 – 2418 $mgkg^{-1}$ (least in 100% soaked EFB and highest in mineral fertilizer treatments respectively). Soil pH at the end of the 10 months in nursery ranged 5.4 – 7.1 (least in mineral and highest in control treatments respectively). See Table 1.



Bars indicate treatments' error ($p<0.05$)

Figure 1: Effects of oil palm empty fruit bunch (EFB) compost on oil palm dry matter yield at 10 months in the nursery

Tab. 1: Effects of oil palm empty fruit bunch (EFB) compost treatments on nutrients concentration in leaves of oil palm seedlings and soil pH

Stage	Pre-nursery		Nursery		
Treatments	Mn	Fe	Mn	Fe	Soil pH
	mg/kg				
Control	52	1219	382	1785	7.1
Mineral fertilizer	72	906	1204	2418	5.4
100% UEFB	52	1848	252	2351	6.7
80% UEFB + 20% cow dung	69	2257	215	1796	6.8
60% UEFB + 40% cow dung	57	2282	233	1928	6.6
100% SEFB	65	2530	211	1704	6.6
80% SEFB + 20% cow dung	53	2683	196	2103	6.7
60% SEFB + 40% cow dung	59	1891	214	1659	6.8
Cow dung	1126	3332	-		6.0

Discussion

Unsoaked oil palm EFB plus cow dung (60 : 40) resulted in significantly higher dry matter yield than the conventional mineral fertilizer and control (no fertilizer) treatments at the end of the nursery stage. Generally, nutrient concentrations in the leaves of the plants ranged from optimum to excessive as a result of the treatments (von Uexkull, 1992; Hartley, 1988). The plants treated with cow dung compost died shortly after the 3rd month in the nursery. Manganese toxicity was suspected as the cause, arising from the high Mn concentration and the marginal leaf necrosis observed at the prenursery stage. Hochmuth *et al.* (2004) reported that Mn, which is an immobile nutrient in plants, could be toxic to plants when the concentration in the plants' tissue is very high (above 500 mg / kg). This means that the very high concentration of Mn in the plants treated only with cow dung compost could have resulted into the death of those plants. Thus, it seems inadvisable to use compost of only cow dung for raising oil palm seedlings in this type of soil.

Highest soil acidity caused by the mineral fertilizer treatment is a negative consequence in this tropical soil. Soil acidity is usually enhanced by rapid decline in soil organic carbon content (Bagayoko *et al.*, 2000). However, adequate compost application to soil could arrest this situation, as was observed in this investigation.

Conclusions

The overall results of this investigation indicated that composting a combination of oil palm empty fruit bunch with cow dung led to better performance of oil palm seedlings. Thus, this treatment could be used as an alternative to mineral fertilizer for raising oil palm seedlings. Soaked or unsoaked EFB and cow dung (60:40) composts seemed to enhance plants' performance better than other EFB composts. Composted soaked EFB and cow dung in the ratio 60:40 performed better in the oil palm pre-nursery, while unsoaked EFB and cow dung (60:40) compost performed better in the oil palm nursery than other EFB composts used in this investigation. However, sustainable integration of oil palm and livestock is essential for getting sufficient cow dung for this compost combination.

Acknowledgments

Support from DAAD for the laboratory analytical aspect of this project granted to the first author at University of Hohenheim, Germany is appreciated.

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Use of a mixture of biotite- and apatite-rich rock powder in a soil with inherent low soil fertility

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Key words: Potassium, Phosphorus, Rock Powder, Ryegrass, Clover

Abstract

Long-term fertility of organically managed soils is challenged by repeated removal of plant nutrients through cash crops. The use of selected rock powders may contribute to maintain soil fertility. A pot trial with Italian ryegrass and white clover was used in order to study the potential of a biotite-rich and of an apatite-rich rock powder to maintain and improve the nutrient supply of organically managed soils.

Introduction

Motivated by the high price of soluble K-fertilizer during the 1st World War, a number of field trials showed that biotite-rich rock powder has a long lasting ability to improve crop yields on K deficient soils (Solberg 1928). Only a few studies have followed those early works (e.g. Bakken *et al.* 2000). Due to its bulky weight and volume, rock powder is not competitive relative to low price soluble K fertilizer. However, its use can be of interest on organically managed farms in order to counteract the continuous removal of nutrients through sale of cash crops, which is challenging the long term fertility of soils with moderate nutrient reserves on farms without animal manure (Løes *& Øgaard*. 1997). It may also enable the conversion to organic management of poor sandy soils, which is usually discouraged even in the case of animal production. Even the most easily weathering rocks release nutrients very slowly, however this does not need to be a drawback since slow nitrogen supply often retards the initial growth rate of organically managed crops.

This work is a contribution to the study of the potential of biotite-rich rock powder (**biotite-Rp**), alone or in combination with igneous apatite-rich rock powder (**apatite-Rp**), as source of potassium (K), phosphorus (P) and other plant nutrients. Igneous apatite is less soluble but has lower heavy metal content than sedimentary phosphates. A working assumption is that if a rock powder can increase the nutrient uptake by plants grown on a very deficient soil, it is also likely to be able to maintain soil fertility in areas where nutrients removed by crops can neither be compensated by the weathering of local soil material, nor by large supply of organic amendments. Both nutrient uptake by plants grown in pots and artificial rock weathering were studied (Speetjens 2007). Selected results from the plant trial are presented here.

Materials and methods

A finely ground biotite-Rp (biotite gneiss, K content 1.3 % by weight, 50 % grain size 0,36 mm) was added alone, or together with low-grade igneous apatite-Rp (apatite

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norite, P content 2.2 %, 50 % grain size 0,38 mm), to the top 10 cm of three-litre pots filled with a sandy soil known to be extremely deficient in plant nutrients, from a an eolian deposit ("Elverum sand") poor in organic matter. The low dose (**LB,** 13 ton ha^{-1}) of biotite-Rp was merely sufficient to raise the index for easily plant available potassium to what is considered the exhaustion levels by repeated cropping of unfertilized sandy soils. The high biotite-Rp dose (**HB**) was five times as much. Apatite-Rp was added in low dose (**LA**, 9.8 ton ha^{-1}) or high dose (**HA,** 29 ton ha^{-1}).There were three controls: limed fertilized (**K1),** non-limed fertilized (**K2**) and limed unfertilized (**K3**). The latter two received moderate doses of potassium sulphate and calcium phosphate. Liming raised the soil pH to the same level as the large application of biotite-Rp. In an additional treatment, calcium phosphate was added to HB (**HB-P**). As plants, in particular clover, showed symptoms of micro-nutrients deficiency, a solution containing Cu, Zn, B, S and Mo was added to all pots once.

Pots were planted with either Italian ryegrass or white clover plants which had germinated on an organically certified soil, in order to ensure vigorous seedlings and infection of clover roots by symbiotic bacteria. Ryegrass pots were fertilized repeatedly with low doses of ammonium nitrate, while clover plants received no nitrogen application. Treatments were replicated four times. Plants were harvested consecutively three (clover) or four times. At the end also stubbles (ryegrass) and stolons (clover) were collected, and the N, K, P, Mg, S and Ca content of each sample was analysed.

Results

Application of rock powder always significantly increased the total dry matter yield of ryegrass (sum of 4 harvests + final stubble), compared to the unfertilized control. Clover showed a similar trend (sum of 3 harvest + final stolons), although the total yield increase was statistically significant only when a large dose of apatite-RP was added in addition to biotite-Rp (Figure 1). HB combined with a moderate application of calcium phosphate raised the dry matter yield of both species to the same level as the next best fertilized control, which indicates that biotite-RP was a good source of K. As expected, K and Mg uptake increased with application of biotite-Rp, and even more so when pots were moderately fertilized with calcium phosphate (data not shown). Unexpected was though the effect of biotite-Rp on the total amount of P taken up by the plants. Low biotite-Rp dose raised the amount of P absorbed by the plants. This can be attributed to the small amount of P (0.09 %) present in the biotite-Rp, but the amount of P taken up was significantly reduced when more biotite-Rp was applied (Compare LB with HB on Figure 1). For ryegrass this was true also when apatite-Rp was added (compare LB-HA with HB-HA in Figure 1).

Application of apatite-Rp did not increase the total P uptake, but for one case with white clover (compare HB with HB-HA in Figure 2). However, it significantly increased the uptake of S by ryegrass (not shown). A similar, although not statistically significant increased S uptake was found in white clover. Unexpectedly, addition of apatite-Rp increased the uptake of K (data not shown). Clover benefited well from the combined application of HB and HP, which raised the biomass production to 70 % of the "best" fertilized control (K1 = 100 %, K3 = 42 %).

Total nitrogen uptake by clover (sum of 3 harvest + final stolons) was always increased (Table 1). Due to the very low N content of the soil this indicates a strong positive effect of the rock powders used, on biological fixation. This will obviously benefit also grasses and herbs present in a clover-grass leys. As mentioned, N fertilizer was applied to ryegrass only.

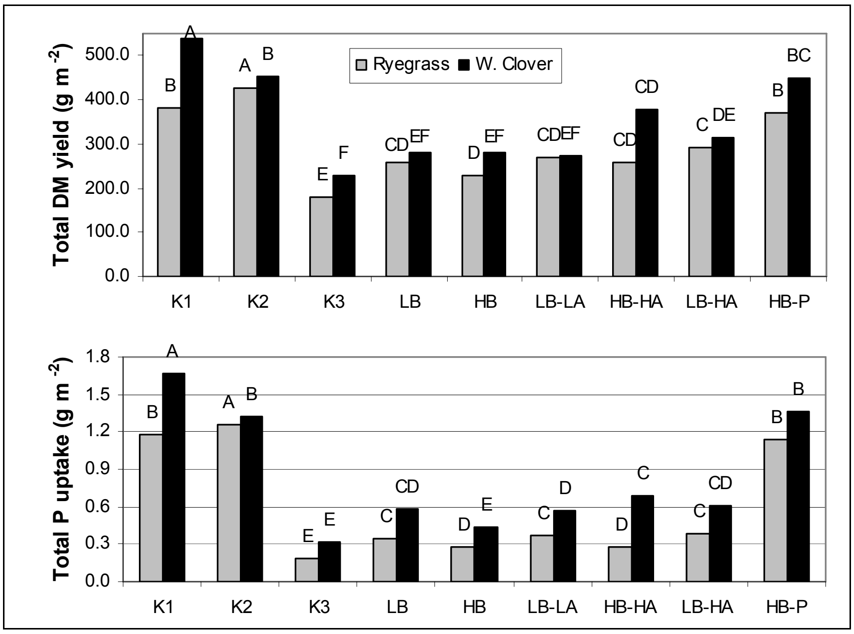

Figure 1: Dry matter yield and P uptake (g m^{-2}), sum of four ryegrass harvests + final stubble, or three white clover harvests + final stolons. See text for explanation of treatments. Within the same plant species, treatments with the same letter are not statistically different (P>0.05)

Tab. 1: N uptake by white clover. Treatments as in Figure 1. Treatments with the same letter are not statistically different (P>0.05)

Treatment	K1	K2	K3	LB	HB	LB-LA	HB-HA	LB-HA	HB-P
N (g m^{-2})	19.0a	13.7bc	5.3e	9.0d	8.5d	8.7d	11.9c	9.6d	15.3b

Discussion

The weathering trial indicated that the small amount of P present in biotite-Rp was more soluble than P contained in the apatite-Rp. This can explain the positive effect of a moderate biotite-Rp application on the amount of P taken up. One would then expect an even higher P uptake when the biotite-Rp application was increased from LB to HB, while the results show that P uptake was lowered. A raise in pH (aq), from 5.9 to 6.7 in the soils with low and large biotite-Rp dose, respectively, can be a reason for the negative effect of increasing the biotite-Rp dose on the P uptake. However, other mechanisms may have played a role. For example the weathering trial showed that contact with biotite-Rp reduced the amount of soluble P extracted from apatite-Rp using a 0.01 M citric acid solution. A possible reason for this can be the precipitation of phosphates reacting with iron. Although the large biotite-Rp dose is not practicable in common farming, this result shows that the use of biotite-Rp can pose some problem on P-deficient soils. On the other hand, plant growth on the HB-P treatment indicates that where P is not severely deficient, the biotite-Rp tested in this trial can effectively improve the K and Mg supply available for plants.

Given the extremely low P level in the soil, we expected a positive effect of apatite-Rp on P uptake. However, the lack of a positive effect on ryegrass is in good agreement with many field trials under conventional management. It is thus most interesting that, when supplied with a large dose of biotite-Rp, white clover took clear advantage of a large dose of apatite-Rp. In general white clover took up much more P than ryegrass, and in real field situation this will benefit ryegrass as well, through decomposition of white clover residues. A higher microbial activity than in the test soil used in this study, a lower pH and the presence of mycorrhiza may improve the apatite-Rp ability to supply P in organically managed soils. Application to composting heaps has been suggested as a way to increase bio-availability of rock phosphate (Sekhar & Aery 2001). This opportunity should be tested further.

Increased uptake of Mg (present in large amount in the biotite-Rp) and of S (present in small amount, most in apatite-Rp) were also important, with positive consequences on the nutritional values as well as on yield mass. For example, ryegrass and white clover grown on HB-P had equally high yields as one of the fertilized controls, but a lower K/(Mg+Ca) ratio, which is preferable for cattle nutrition.

Conclusions

The results confirm the hypothesis that the selected rock powders can improve the supply of elements that are essential for growth of plants, suggesting that they can help sustaining soil fertility. However, some unexpected and complex results exemplify the need for more knowledge of the weathering and chemical reactions when rock powders are added to soils. They also indicate that applications of biotite-Rp in large quantity should be handled carefully. Most important, the results show that clover can take advantage of apatite-RP better than ryegrass, but there is still a scope to search for techniques that can improve the bio-availability of igneous phosphate rocks.

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Soil Fertility and Biodiversity effects from Organic Amendments in Organic Farming

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Key words: soil biology, soil microbial biomass, soil quality, manure, compost

Abstract

After a completed rotation of seven years, soils of the Manure as a Chance (MAC) trial were analysed for the effect of organic amendments on soil physical, chemical and biological properties. Yields suggest significant differences due to different organic amendments after seven years. In treatments receiving farm yard manure and bio waste compost yields increased over time. Soil properties indicate changes in soil carbon, nitrogen mineralization en plant feeding nematodes due to different organic amendments. No significant changes in microbial and fungal biomass were found.

Introduction

Organic farming strives for a balance between a reasonable good yield, a high produce quality and a limited environmental impact. Inputs include plant residues and plant based composts, animals manures from various origin and stages of decomposition and additional fertilizers like rock dust (Anonymous, 2005). Soil fertility and especially soil biological fertility is promoted within organic farming for reasons of nutrient cycling, structure improvement or biodiversity (von Fragstein, 2006). Very little research has been done to facilitate farmers to make choices between available amendments and improve soil fertility within the legal framework of organic farming. In this study we evaluate the effects of eight (out of thirteen) different organic amendments applied within the legal framework of organic farming in the Netherlands. Effects on crop and soil fertility are evaluated in terms of yield and in terms of physical, chemical and soil biological properties.

Materials and methods

Starting in 1999, the fertilisation trial Manure As a Chance (MAC) in Lelystad, The Netherlands (5° 30' East, 52° 32' North), examines the effects of thirteen different organic amendments on crop yield. In 2006, after one rotation was completed and amendments had been applied for seven years, effects of eight selected amendments on soil fertility and crop yield were compared. Only data from 2006 are used in this paper. The on site farm experiment was set up as a randomised complete block with four replications and 7m x 9m plot size. The soil was characterized as a sandy calcareous marine deposit (1.6% organic matter, 9% clay, pH-KCL 7.6). Mean annual precipitation is 780 mm. Except for fertilisation, all other elements of cultivation are the same in all treatments and follow normal organic farming practices. The intensive vegetable rotation, common in Dutch organic farming systems, includes red cabbage, potatoes, beet, carrot, parsnip, broccoli, pumpkin and cauliflower in 2006. The legal framework limited the manure or compost additions: 1)The manure or compost

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addition is limited by a maximum of 100 kg N ha^{-1} $year^{-1}$. 2)The manure or compost addition is limited by a mean net legal maximum of 80 kg P_2O_5 ha^{-1} $year^{-1}$. 3). The compost addition is limited by a legal maximum of 6000 kg dry matter ha^{-1} $year^{-1}$.

Tab. 1: Selected treatments of the organic amendment experiment MAC and average application of active nitrogen, P_2O_5 and organic matter in kg.ha^{-1} $year^{-1}$.

Level	Amendment	Active nitrogen*	P_2O_5*	Dry matter*	OM*
1	Deep stable manure (FYM)	67	66		4930
1	Cattle slurry (CS)	67	35		1530
1	Mineral fertiliser (MIN)	67	43		0
1	Biowaste and slurry (GFT+CS)	67	69		2910
2	Chicken manure (CM)	47	80		1680
2	Plant compost 1 (NC)	24	80		7870
3	Biowaste compost (GFT)	9	57	6000	1490
3	Plant compost 2 (GC)	8	48	6000	1770

* amendments are applied two years in three.

Yield of cauliflower was assessed in 4 rows per plot, 5 plants per row. Soil samples (0-10 cm depth) per plot were taken in November 2006 and analyzed for their total N, total C, organic C and POM-C contents. For physical characterization the pH in water, bulk density and earthworm pores according to Koopmans and Brands (1993) were determined. Microbial and fungal biomass, N mineralization, nematodes and basal respiration were determined according to Mulder et al. (2005). Data were analyzed by analysis of variance (ANOVA). Significant effects were separated by the least significant difference (LSD) at P = 0,05.

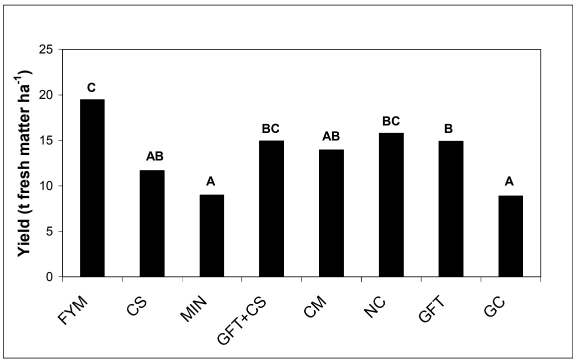

Figure 1: Yields of cauliflower in the MAC trial in 2006 (p<0.001).

Results

After seven years the use of FYM resulted in the highest yields (Fig.1). The GFT and GFT+CS treatments showed similar yields indicating that a higher nitrogen availability in the GFT+CS treatment did not result in higher yields. The results confirm a trend observed in the past seven years in which yields in the MIN treatment diminished, yields in the CS and CM treatments remained at the same level and yields in the FYM and GFT treatments increased if compared to averages of all treatments. Soil physical, chemical and biological properties were affected by the amendments. NC resulted in the highest C-total content, CM in the lowest (Fig.2). Nitrogen mineralization was relatively low in all treatments. Significantly lower values were found in MIN and GFT (Fig 2.).

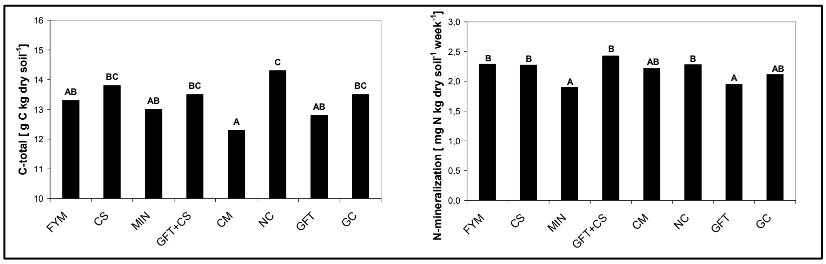

Figure 2: Total soil carbon and potential anaerobic nitrogen mineralization in soils of the MAC trial with different organic amendments (significant at P<0.05).

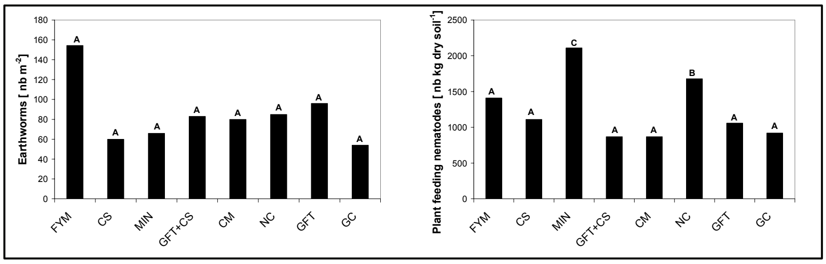

Figure 3: Number of earthworms and plant feeding nematodes in soils of the MAC trial with different organic amendments (significant at P<0.05).

No significant effects were found on the biomass of bacteria, fungi and earthworms (Fig. 3). However, earthworm pores, counted at 20 cm depth were significantly higher in the FYM as compared to the other treatments (data not shown). Amendments mainly had an effect on the number of plant feeding nematodes with MIN and NC resulting in the highest numbers (Fig 3.).

Discussion

The results show that organic amendments affect yields and soil fertility properties within a time frame of seven years. The lasting effect of FYM and the GFT+CS treatment in terms of yields and mineralization is especially pronounced and confirms earlier findings (Koopmans and Zanen, 2007). Soil mineralization and nematode population are among the soil properties that are most easily affected by fertilizer choice. However, fertilizer choice and crop production may interfere, resulting in a change of soil biodiversity through for instance root production.

Conclusions

The study shows that organic amendments used within the legal framework of organic farming may impact soil fertility and biodiversity indicators within seven years. Further research is required to understand the biological mechanisms behind this. The findings help to gain insight into the relationships between soil management, soil biodiversity and soil support services like soil fertility to optimise yields, mineral-use-efficiencies and soil structure formation in organic farming.

Acknowledgments

We thank the organic farmer Jan van Geffen for his work on the trial and allowing us to make use of his land, Coen ter Berg and Luc Steinbuch for their help with fertilization and sampling of the trial over the years. The authors gratefully acknowledge funding from the Dutch Ministry of Agriculture Nature and Food Quality, the IONA foundation and the Louis Bolk Institute.

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The effects of different cattle manure levels and branch management methods on organic production of *Cucurbita pepo* L.

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Abstract

To study the effects of different manure levels and two branch management methods on organic production of Schneider squash, a field experiment was conducted during 2005 and 2006. Treatments were four manure levels (10, 15, 20, 25 ton ha^{-1}) and two branch management methods (with and without a wood pole), which were allocated to main plots and subplots, respectively. Results showed that the crop performed better in branch management without a wood pole than with a wood pole. Results showed that in the first year, manure level had a significant effect on fruit and seed yields. However, these traits were not significantly affected by manure levels in the second year. For both years, there were no differences in seed numbers due to manure levels. Seed oil content was slightly increased when the manure level was increased from 10 to 25 ton ha^{-1}.

Keywords: Schneider squash, manure, seed oil, yield, organic production.

Introduction

In recent years the safety and health of food has becoming a major concern due to overuse of chemicals for food production and its negative impacts on human health and environment (Gliessman 1998; Pimentel 2005). For this reason, cultivation of medicinal plants and other food plants with medicinal properties have been expanded (Berenyi 1998). *Cucurbita pepo* is an important oilseed plant that is used in food and also in cosmetics and health items (Aruyi et al. 2000; Younis & Al-Shihry 2000; Bombardelli et al. 1997; Murkovich et al. 1996). Murkovich et al. (1996) worked on a hundred lines of this species and found 39.5-56.5 % oil and 21-67.4 % linoleic acid content. Aruyi et al. (2000) reported that the ranges of oleic and linoleic acids in the seeds were 75.98-81.84 and 12.1-16.54 %, respectively. The purpose of this experiment was to study the effects of different manure levels and branch management methods on yield, oil and protein content of *C. pepo*.

Materials and methods

This study was conducted for two growing seasons of 2005-2006 on the Research Farm of the Faculty of Agriculture, Ferdowsi University of Mashhad, Iran. The experiment was in the form of split plot based on a randomized complete block design with three replications. Cattle manure levels of 10, 15, 20, 25 ton ha^{-1} were applied in the main plots, and branch management method (with and without a wood pole) were allocated to the subplots. The nutrient content of the cattle manure used was 2.11, 0.73, and 1.88 % N, P and K, respectively. The original nutrient content of the soil was 755, 42 and 465 ppm N, P and K, respectively. No chemical fertilizers or biocides were applied and weeds were controlled by hand. In the second year no soil tillage

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was conducted and seeds were planted on the same place and the same date as the first year. However, based on the results of the first year in which the superiority of plants without a wood pole was confirmed, this treatment was not continued for the second year. Therefore, in this year only the effect of manure was investigated, and the experiment was analyzed with levels of manure only. For analysis of variance (ANOVA) Minitab software Ver. 13 was used and means were compared using Duncan's multiple range tests at 5% probability level.

Results and discussion

Results of combined analysis of the experimental data showed that the effect of manure application on fresh fruit yield was significant; however, manure application did not affect seed dry weight and seed number (not shown). With increasing application of cattle manure to 25 ton ha^{-1} an increasing trend was observed in the yield of fresh fruit (Fig. 1). However, in the second year, application of manure did not affect yield. Averaged over two years, an increasing trend in fruit yield was observed from 10 to 20 ton ha^{-1} cattle manure, but no significant difference was observed between 10 and 15 ton ha^{-1}.

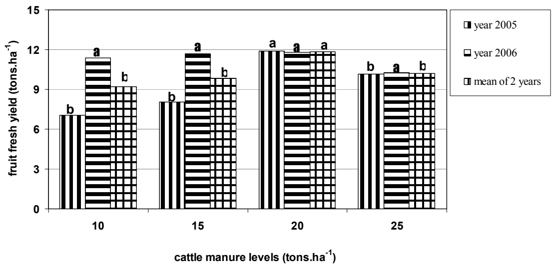

Figure 1: Effect of cattle manure levels on C. pepo fresh fruit yield. Similar letters indicate no significant differences between means within a year (p<0.05).

In general, the effect of cattle manure level was inconsistent, and a reduction of yield at 20 ton ha^{-1} seems to be unusual. However, it may be postulated that the effect of cattle manure on this species is achieved up to 20 ton ha^{-1}, and a further increase may have had a detrimental effect, possibly due to plants dying off. It also could be assumed that higher levels of cattle manure might have caused water to be stored in the root zone and hence leading to the spread of root pathogens. Visual investigation showed die-off of more plants at the highest manure level (25 ton ha^{-1}), which could have been associated with this effect. There is evidence (Bombardelli et al. 1997; Khorrami Vafa, 2006) that a well-drained soil is suitable for this species. This could be an indication of the sensitivity of plants to a high level of water in the root zone. On the other hand, it has also been reported (Aruyi et al. 2000) that application of high level of nitrogen fertilizers caused fresh vegetative growth and hence low yield of fruit. Therefore, the low yield at 25 ton ha^{-1} cattle manure could be associated with higher water level in the root area and also availability of more nitrogen, which changes the proportion of vegetative to generative growth.

Figure 2 shows that with increasing the cattle manure level from 10 to 20 ton ha^{-1} in the first year seed yield was increased, but there was no further increase from increasing the level of manure to 25 ton ha^{-1}. However, in the second year there were no significant differences among the seed yields.

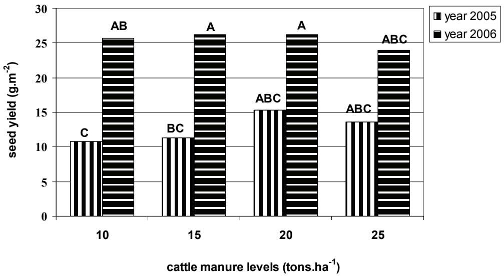

Figure 2: Interaction between cattle manure levels and year of experiment on C. pepo seed yield. Means followed by the same letters do not differ significantly (p<0.05).

From comparing Figures 1 and 2 it appears that the trends of change in fruit and seed yields are somehow similar. In general, the response of both components to cattle manure was higher in the second year compared with the first year. This is not unusual because more nutrients are released in the second year (Kuepper 2000). However, lack of response to fertilizer levels seems unclear. In other words, the reason there were no differences between fruit or seed yield at 10 ton ha^{-1} and other manure levels is unusual.

With an increase in the amount of manure, oil percent showed a decreasing trend (Fig. 3). This decrease was 5 percentage points from an application of 10 ton ha^{-1} of cattle manure to 25 ton ha^{-1}. This has also been confirmed elsewhere (Aruyi et al. 2000). Also, the effect of cattle manure on protein content was negligible, an increase of 1 percentage point unit was observed going from 10 to 25 ton ha^{-1} (Fig. 4). As a general trend, nitrogen fertilizer has been reported to increase protein content (Levitte 1980; Khorrami Vafa 2006).

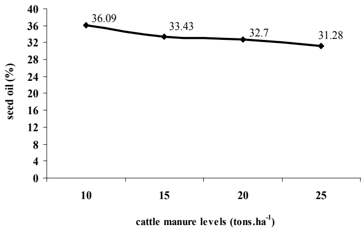

Figure 3: Effect of cattle manure levels on *C. pepo* seed oil content

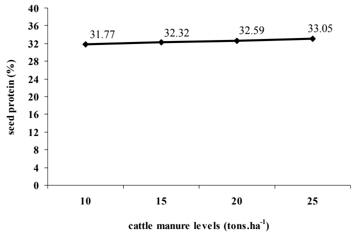

Figure 4: Effect of cattle manure levels on *C. pepo* seed protein content

Conclusion

The effect of cattle manure on fruit and seed yields are similar; when the rate of cattle manure was increased to 20 ton ha^{-1} an increasing trend was observed, but a further increase in cattle manure either did not change the yield or a slight reduction was observed. Therefore, an optimum amount of manure seems to be 20 ton ha^{-1}. The effect of cattle manure, as expected, was higher in the second year than in the first year; this was more pronounced for seed yield than for the fresh fruit yield.

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Inoculation affects nitrogen balances of composts and growth, yield and microflora of *Phaseolus* beans

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Key words: Compost, Inoculation, Effective Microorganisms, Quality, Crop growth,

Abstract

The impact of organic matter and two types of inoculums on composting and subsequent growth of common beans was evaluated under tropical field conditions. The composts were made of commonly available organic matter with different C:N ratios, and inoculums consisting of cattle manure slurry, Effective Micro organisms or a mixture of both were added. The mixture of cattle manure and Effective Microorganisms increased N availability and reduced C: N ratios of compost than when applied individually. Legume green matter enhanced compost quality and growth yields. The nodulation and mycorrhizal populations of roots of beans were increased by a mixture of inoculums and using diverse materials in the compost. The usefulness of inoculums such as EM, which is available in all continents is presented on the basis of this study .

Introduction

Composting is a very common source of manures in organic farming due to the non use of cropping land for its production and the possibility of using different sources as its components (Diaz, 2007). The application of partially decomposed material also helps providing nutrients more rapidly, while long term experiments show its benefits in producing high yields in organic farming (Herencia et al, 2007).

Composing requires inoculation and is carried out using animal manures, old compost or forest soils (Diaz, 2007). Many inoculants have been developed and Effective Microorganisms (EM), consisting of Lactic acid bacteria, yeast and phototrophic bacteria in a mixture maintained at a low pH has proven to be useful for compost (Jenkins and Daly, 2005), although Mupondi et al (2006) report its non effectiveness when compared to feedstock materials in composting pine bark, which has a high C:N ratio. Thus, studies determined the impact of EM and feedstock material (cattle manure) used individually or in combination on nitrogen (N) and C:N ratios of compost made with green manures, weed and straw, which are common material in the tropics and the impact of these composts on growth, root microbes and yields of common beans (*Phaseolus vulgaris* L), as N is the most difficult nutrient to manage in organic farming (Gaskell and Smith, 2007).

Materials and methods

Experiments were carried at the University of Peradeniya, Sri Lanka from January – May, 2006. The compost piles were made with equal parts of rice straw, leaves of *Gliricidia sepium, Tithonia diversifolia* and common weeds, in equal proportions (1 kg fresh material) Four replicates of each pile were made and N and C:N ratios determined by conventional methods (Anderson and Ingram, 1993). The inoculums

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used were cattle manure CM (250 g in 1 l water) activated EM (100ml in 1 l water), a mixture of CM and EM (250 g CM and 100ml EM in 1 l water) with water as a control and 500 ml of each inoculum were added to the respective compost piles and covered for a period of 40 days with mixing at 10 day intervals. At 40 days samples were analysed for N and C: N ratios and the respective composts added to separate plots of 1 x 1m, replicated 4 times within a Randomized Block design. Uniform seeds of beans (Var. Top Crop) were planted at a spacing of 10 x 15 cm, 5 days after the addition of composts, and maintained organically, At the R1(flowering) stage, 4 plants were carefully uprooted, plant height recorded, nodule numbers counted and root length determined by the grid technique. Mycorrhizal infection was determined by the grid line intersect method as described by Ambler and Young (1977). Fresh pod yields were recorded and the data analyzed statistically using a GLM procedure.

Results and Discussion

Legume green manure (Gliricidia) increased N contents and reduced the C: N ratios of preinoculated compost (Table 1), highlighting their value in composting when compared to non legume green manures. This is due to the greater N content in this material. The use of all components developed the best composts, highlighting the usefulness of material diversity in obtaining quality compost for organic farming

Tab. 1: N and C: N ratios of different compost materials (dry matter basis)

Composts	**N mg.g-1**	**C:N ratio**
Straw + Gliricidia + Weeds **(C1)***	5.84	26.5
Straw + Tithonia + Weeds **(C2)**	3.65	36.8
Straw + Gliricidia + + Tithonia + Weeds **(C3)**	4.16	30.4
LSD (p=0.05)	0.007	0.003

C1, C2 and C3 notations will be used in all tables to identify compost types

Microbial solutions (cattle manure or EM) increased N availability and lowered the C: N ratio of all composts, the use of a mixture had the most significant impact on these measured parameters (Table 2). EM had a greater beneficial effect in enhancing N availability of all composts, thus reducing the C: N ratios to a greater extent than CM. This clearly implied the importance of using an inoculant with known microbes for composting, rather than using ad hoc feedstock material, which could have different effects on the basis of microbes present. However, the use of inoculants such at EM must be carried out as per instructions to obtain the maximum beneficial effects.

Inoculation increased growth and yields of beans and the root microflora (Table 3). The impact of the three types of inoculum were EM + CM>EM >CM, highlighting the benefits of using both types of solutions. If one inoculum was to be used, EM which contains a known mixture of microbes had a more beneficial effect in enhancing growth, nodulation, mycorrhizal infection and yields of beans. The use of all plant material for compost also had a beneficial effect in terms of promoting yields, which is the most important factor in small holder farming systems and this could be attributed to the better quality of the material, especially when inoculated with EM and CM, which stimulates the roots and the rhizosphere.

Conclusions

Compost with legume leaves or preferably with a diverse range of material inoculated with EM and CM was of the highest quality and the most beneficial in terms of plant growth, yields and microbial populations of the roots. This clearly suggested the importance of using a range of inoculum and also the value of EM as a compost processing material. EM, which is now available in over 125 nations worldwide and made with the local microbes, would be a useful additive in composting within organic farming systems, as it is available at a relatively low cost. Thus tropical and even temperate organic farming systems could easily develop good compost by using EM with other feedstock inoculum for obtaining quality compost for successful cropping.

Tab. 2: N and C:N ratios of composts at 40 days after inoculation (dry matter basis)

Inoculation	C1 Compost		C2 Compost		C3 Compost	
	N mg.g^{-1}	C:N ratio	N mg.g^{-1}	C:N ratio	N mg.g^{-1}	C:N ratio
CM	4.14	25.4	2.11	34.2	3.12	25.6
EM	4.36	21.5	2.21	33.9	3.59	24.8
CM + EM	4.99	20.8	2.65	30.6	4.01	20.5
Water	2.42	26.8	1.42	35.8	2.24	29.5
LSD (P=0.05)	0.24	0.05	0.33	0.02	0.18	0.01

LSD (P=0.05) for compost comparisons N = 1.04; C:N ratio = 0.13; Interaction Significant at P=0.05

Tab. 3: Growth, root microbial infection and yields of beans as affected by different composts and inoculations

Composts	Inoculum	Shoot height (cm)**	Total root length (cm)	Nodules .plant^{-1}	%Root infection (Mycorrhiza)	Yield. g.plant^{-1}
C1	Cattle manure slurry (CM)	25.6	258	16	22	421
	Effective Microorganisms (EM)	26.4	284	24	27	511
	EM + CM	30.5	324	35	31	567

	Water	21.5	205	10	12	224
C2	Cattle manure slurry (CM)	20.6	289	22	34	367
	Effective Microorganisms (EM)	22.6	314	31	36	451
	EM + CM	24.5	338	46	45	472
	Water	20.6	266	18	18	215
C3	Cattle manure slurry (CM)	26.6	315	26	32	494
	Effective Microorganisms (EM)	30.4	342	40	41	699
	EM + CM	32.5	390	51	47	781
	Water	36.2	284	42	20	267
LSD (p=0.05)	Compost	0.004	0.014	0.009	0.021	0.018
	Inoculum	0.009	0.001	0.020	0.008	0.007
	Interaction	*	*	NS	*	*

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Nitrogen management

Nitrate leaching and energy efficiency of stockless arable systems compared with mixed farming and a non-organic system on fertile soils in Northern Germany

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Key words: nitrate leaching, energy efficiency, stockless organic farming, conventional farming

Abstract

Previous studies based on either small-scale plot experiments or modelling approaches, indicate a lower risk of nitrate leaching and a higher energy efficiency in organic than in conventional farming systems. Because there is still a lack of data measured at the farm scale, which also take farm type and farming practices into account, a comparison between an N-intensive non-organic, two organic all-arable crop rotations and a typical rotation of a mixed organic farm was carried out over a three-year period at a highly productive site in Northern Germany. Comparing the all-arable crop rotations, the organic systems had 70% lower potential yields than the regional typical conventional crop rotation. In spite of 60% lower input of fossil energy an N-intensive organic crop rotation showed 20 percent lower energy efficiency than a comparable conventional. In the present study, the higher N inputs and higher N surplus in the conventional system did not lead to significantly higher nitrate leaching than in the organic all-arable crop rotations. Comparison of an organic all-arable crop rotation with the corresponding mixed farming system showed significantly higher potential yields, higher energy efficiency and lower nitrate leaching in the organic mixed farming system. Management of the grass/clover (mulching versus feeding) had the strongest influence on nitrate leaching and energy efficiency in the organic systems. The decision to undertake stockless instead of mixed organic farming should not only be based on economic reasons, but also take the important aspects of energy and nitrogen efficiency into account.

Introduction

Several studies have shown that that changing from conventional to organic farming can represent a way to reduce negative impacts to the environment, for example nitrogen (N) losses (Hansen et al., 2000) and the input of fossil energy both per unit land and per unit product (Dalgaard et al, 2001). In contrast to this, some studies on farm nitrogen budgets (e.g., Scheringer et al., 2001) and field measurements indicate a substantial risk of nitrate leaching on specialised organic farms. This indicates that it is not the simple case of conversion to organic farming alone which guarantees a reduction of all negative impacts to the environment. Factors such as farm type, cropping method, soil and climatic conditions strongly affect the relative performance of organic farming systems from both an agronomic and an environmental point of view. Also in organic agriculture there is currently a trend towards specialized farming systems. Until the early 1990's, organic farming in Europe was represented mostly by

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mixed farms with livestock since a tight nutrient cycle with a high share of forage legumes and nutrient recycling through livestock was regarded as a prerequisite in nitrogen (N)-limited organic farming systems. Recently the growing market for organic cereals, field grown vegetables and the conversion of all-arable farms to organic standards created the context for an increasing specialisation towards all-arable stockless organic farms. These farms have followed up the intensification and specialisation as observed in conventional agriculture. Cereals and other cash crops are grown in short rotations (3-4 years) with a minimum proportion of forage legumes. Studies comparing the relative performance with respect to yields and environmental effects of organic mixed and all-arable farms are scarce. Comparisons of organic and conventional all-arable cropping systems under favourable soil and climatic conditions are scarce as well. Since most studies based their conclusions on results from small-plot field trials or on farm nitrogen budgets, especially comparative studies based on measured data at a farm scale are lacking. For this reasons N- and energy-fluxes of different conventional and organic cropping systems were compared in a farm-scale study on highly productive arable soils at Kiel University's experimental farm Lindhof in Northern Germany that has been sub-divided in an organic and a conventional farm unit.

Materials and methods

During the conversion from conventional to organic farming, different crop rotations were implemented at the field scale at the experimental farm Lindhof (Kiel university) in Northern Germany The site is characterised by Luvisols and Cambisols as soil types, a mean annual air temperature of 8,7°C and a mean annual precipitation of 774 mm. Over a three-year period (1999/2000- 2001/2002), organic and conventional crop rotations were analyzed for productivity, nitrogen balances and nitrate leaching. At Lindhof one non-organic and three organic crop rotations which represent 4 farm systems where established in 1994. The three organic crop rotations differed with regard to legume content and farm type. Each of the following crop rotation was carried out on four fields representing four replications: (1) non-organic, (2) stockless organic with a crop rotation content 50% legumes, (3) stockless organic with 30% legumes and (4) mixed organic 50% legumes. The non-organic crop rotation was oilseed rape – winter wheat – sugar beet – winter wheat. Average annual N input was 186 kg ha^{-1}. In the organic all-arable farming systems grass/clover was mulched while the mixed farming system was characterised by harvesting and feeding grass/clover to a small herd of suckler cows as well as manure application to non-legume crops. Only the harvest years 1999-2001 were considered, in order to minimize the risk that organically managed fields that had been converted to organic standards in 1994, were still affected by residual effects of conventional practices, such as high levels of soil nutrient supply. The farm scale of the experiment ensured that crops were managed as on commercial farms, and that yields were comparable to practical conditions. To compare the at field level determined yields of the different crops, it was necessary to transform them to comparable standards. The yields of the all-arable crop rotations were transformed to grain equivalents (GE) using values for standardised fresh matter contents from the official tables of the German Federal Agency for Agriculture and Nutrition. To compare yields of the all-arable crop rotation with those of the mixed farm system (Table 2), yields were transformed into metabolisable energy (ME) using data of the official German feedstuff evaluation tables. The energy input was determined as sum of direct and indirect fossil energy inputs. Leaching of nitrate was determined with ceramic suction cups, of which 300 had been installed on the farm area. Leachate was sampled weekly during the three winters and analyzed for NO_3 concentrations. The volume of drainage water was calculated by a general water balance model. Nitrogen fixation was estimated on subplots as difference of the absolute measured N-amounts of crop and crop residues (root, stubble and litter) between the considered legume and a similar managed non-N-fixing reference crop. For statistical analyses, the untransformed data was subjected to analysis of variance (ANOVA).

Results and discussion

Some agronomic and environmental characteristics of the analyzed all-arable farming systems are given in Table 1. Yields (in grain equivalents) of the conventional system were much higher than of the organic all-arable systems. This may be attributed to a higher nutrient input, a target-oriented use of plant protecting agents, and the absence of a non-yielding mulched grass/clover ley in the conventional system. In spite of the significantly higher N input and N surplus of the conventional system, nitrate leaching did not differ significantly from the organic crop rotations. The observed range in nitrogen leaching was from 20.1 to 23.6 kg NO_3-N ha^{-1}. Related to the average drainage (253 mm in 3 winters), NO_3-N loads were below the EU threshold value of 50 ppm NO_3 in drinking water, which is equivalent to the leaching of 28.6 kg N ha^{-1}. The relatively high N losses via leaching in the organic all-arable systems were due to inefficient utilization of mineralized N from the grass/clover mulch.

Tab. 1: Yield of grain equivalents (GE), N input, N balance, N leached, fossil energy input, and energy efficiency of all-arable farming systems during the experimental period 1999/2000-2001/2002

Farming system	Crop rotation	Yield [GE ha^{-1}]	N input [kg ha^{-1}]	N balance [kg ha^{-1}]	Leached NO_3-N [kg ha^{-1}]	Energy input [GJ ha^{-1}]	Energy efficiency [GE GJ^{-1}]
1. Conventional	1.1 Sugar beet						
all-arable farm	1.2 Winter wheat	107.5 a[1)]	186.0	47.5	23.6 a	15.57 a	6.65 a
	1.3 Winter oilseed rape	(100%)	(100%)	(100%)	(100%)	(100%)	(100%)
	1.4 Winter wheat						
2. Organic	2.1 Grass/clover mulched						
all-arable farm	2.2 Oats	31.8 b	88.5	12.1	21.2 a	6.07 b	5.28 b
50% legumes	2.3 Grain legume	(30%)	(48%)	(25%)	(98%)	(39%)	(79%)
	2.4 Winter wheat/potato						
3. Organic	3.1 Grass/clover mulched						
all-arable farm	3.2 Oats	29.8 b	67.0	17.5	20.1 a	4.50 c	6.58 a
33 % legumes	3.3 Winter rye	(28%)	(36%)	(37%)	(85%)	(29%)	(99%)

1) same letters in one column are not significantly different $P \leq 0.05$

Furthermore, the relatively high average input of mineral fertiliser-N of 186 kg ha^{-1} into the conventional system was the main reason for the much higher input of fossil energy compared to the organic systems. As productivity in the conventional system was also much higher, energy efficiency was not lower. Table 2 shows the same characteristics for the organic all-arable and mixed farming systems with 50% legumes. Utilisation of grass/clover herbage in animal production and higher yields of non-leguminous crops due to the application of manure led to 50% higher energy yields and 30% higher energy efficiency in the organic mixed farming system. Nitrate leaching was significantly lower in the mixed farming system than in the all-arable system even though total N input was higher. Harvesting the grass/clover herbage resulted in higher nitrogen fixation and lower leaching losses in the following winter.

Tab. 2: Metabolisable energy yield, N input, N balance, N leached, fossil energy input, and energy efficiency of organic all-arable and mixed farming systems during the period of 1999/2000-2001/2002

Farming system	Crop rotation	Yield [GJ ME ha^{-1}]	N input [kg ha^{-1}]	N balance [kg ha^{-1}]	Leached NO_3-N [kg ha^{-1}]	Energy input [GJ ha^{-1}]	Energy efficiency [GJ GJ^{-1}]
2. Organic all-arable farm 50% legumes	2.1 Grass/clover mulched 2.2 Oats 2.3 Grain legume 2.4 Winter wheat/potato	36.3[1] b[2] (100%)	88.5 (100%)	12.1 (100%)	21.2 a (100%)	6.07 b (100%)	5.90 b (100%)
4. Organic mixed farm 50% legumes	4.1 Grass/clover harvested 4.2 Oats 4.3 Grain legume 4.4 Winter wheat/potato	55.4 a (153%)	137.2 (155%)	11.1 (92%)	11.4 b (62%)	6.96 a (115%)	7.87 a (133%)

[1] mean of entire crop rotation, all values are averages per year, [2] significant at $P \leq 0.05$

Conclusions

Under the sites growth conditions, stockless organic farming was not advantageous in terms of nitrate leaching and fossil energy efficiency. Farming system had a decisive impact on agronomic and environmental performance. In terms of nitrate leaching and fossil energy efficiency mixed farming with livestock was advantageous. The decision to undertake stockless instead of mixed organic farming should not only be based on economic reasons, but also take energy and nitrogen efficiency into account.

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Legume catch crops for reducing N leaching and substituting animal manure

Askegaard, M.[1] & Eriksen, J.[2]

Key words: soil fertility, catch crop species, residual effect.

Abstract

Organic cereal production on coarse sandy soil is a challenge because of low soil fertility and a general limitation on the use of animal manure. The possible exclusion of conventional animal manure in organic crop production increases the challenge further. Two factorial experiments were carried out aiming at investigating the potential of legume catch crops with respect to residual effects and effects on N leaching. Legume catch crops were compared with non-legume catch crops in systems with spring barley as the main crop each year. Grain yields were determined and N leaching losses measured by means of installed ceramic suction cups. The legume catch crops, especially white clover and red clover, showed large residual effects in succeeding spring barley, and clover was efficient in reducing N leaching losses. A clover catch crop had the potential to replace animal manure but attention should be paid to the risk for poor growth in soil recently cropped to clover.

Introduction

Animal manure (AM) is an important nutrient source in organic agriculture. However, in Denmark a significant part of applied AM, especially on organic arable farms, is imported from conventional farms. It is widely debated whether this import of conventional AM should be prohibited, and if that happens it will become urgent to compensate for the missing nutrients through import from alternative sources. In grain production there is a special focus on the nitrogen (N) supply. For the compensation of conventional manure there is a need to focus on increased utilization of N_2 fixation in legume plants and on catch crops, which reduce the N-leaching losses and thus improve the N nutrition of subsequent crops. The most commonly used catch crops in Denmark are non-legumes such as ryegrass. A field experiment "organic crop rotations for grain production" on coarse sand has shown large effects of ryegrass catch crops in reducing nitrate leaching (Askegaard et al., 2005). However, there is a need to study the effects of catch crops other than ryegrass, and legume catch crops may become valuable because they both fix atmospheric N_2 and take up nitrate-N from the soil solution (Thorup-Kristensen et al., 2003). The potential of legumes as catch crops was investigated on a coarse sandy soil (<5% clay), which represents about 25% of the agricultural soil in Denmark. One objective was to test the possibility of replacing a cropping system based on ryegrass catch crops plus AM with a system relying on clover catch crops only. Another objective was to test the residual effects of legume catch crop species.

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Materials and methods

The experiments were carried out at Jyndevad Research Station, Denmark, on irrigated coarse sand. Spring barley (*Hordeum vulgare* L.), harvested at maturity, was sown in all plots after spring ploughing each year, and the catch crops were undersown at the beginning of stem elongation. All straw was chopped and left on the soil. During autumn the plots with no catch crops were kept bare by means of two shallow harrowings; the plots with catch crops were left undisturbed.

Legume catch crops as a substitute for animal manure (Experiment I): The treatments established in barley in 2001 in 144-m^2 plots with four replicates were: 1) no catch crop with AM (CC_{no}/AM); 2) perennial ryegrass (*Lolium perenne* L) catch crop with AM (CC_{grass}/AM); and c3 clover catch crop (mixture of red clover (*Trifolium pratense* L.) and white clover (*Trifolium repens* L.) without AM (CC_{clover}). The combination of treatment and plot was maintained during the experimental period. Each spring, 70 kg total-N ha^{-1} in conventional pig slurry was injected into the spring barley seedbed in the two AM treatments. Potassium (K) was applied to the treatment with clover catch crop in an amount corresponding to the K content of the AM treatments. The experiment was discontinued after harvest in 2003 because of poor clover development. Leaching of nitrate-N was measured using porous ceramic cups installed at 1-m depth. Samples taken every one to four weeks were analysed for nitrate-N. The estimated accumulated annual leaching was calculated from 1 April to 31 March.

Residual effects of legume and non-legume catch crops (Experiment II): The experiment was established in spring 2001 and replicated on an adjacent area in the 2002/03 season, where slurry (70 kg total-N ha^{-1}) was injected into the seedbed of spring barley. Nine plots with catch crop species/mixtures and four plots without catch crops were randomly established in three blocks in 48-m^2 plots. The catch crop species were: white clover; red clover; Persian clover (*Trifolium resupinatum* L.); black medic (*Medicago lupulina* L.); kidney vetch (*Anthyllis vulneraria* L.); rye/hairy vetch mixture (*Secale cereale* L./*Vicia villosa* L.); ryegrass; chicory (*Cichorium intybus* L.); and fodder radish (*Raphanus sativus* L.). Rye/hairy vetch and fodder radish were first sown after harvest of spring barley. Spring barley was sown the following spring for measurement of the residual effects. Four reference N-fertilizer treatments (0, 40, 80 and 120 kg N ha^{-1}) were applied in spring to the plots without a previous catch crop. In the catch crop treatments the succeeding spring barley was unfertilized.

Apart from N fertilizer application to the reference plots in exp. II and application of K to the clover as a KCl salt in exp. I, the treatments were managed according to the Danish certification standards for organic farming.

Results

Experiment I: In 2001, when a grass-clover catch crop preceded barley in all treatments, the application of AM to the treatments with no catch crop and ryegrass catch crop increased grain yields (Table 1). The effects of the clover catch crop and the ryegrass catch crop plus AM on grain yields in 2002 and 2003 were at similar levels and significantly higher than in the treatment with AM application and no catch crop.

The annual flow-weighted mean NO_3-N concentration (nitrate leaching per volume of drainage) in the CC_{no}/AM treatment was between 13 and 16 mg L^{-1}. This was significantly higher than the values for the catch crop treatments, which were between 5 and 8 mg NO_3-N L^{-1}. The WHO guideline for drinking water is a maximum of 11.3 mg NO_3-N L^{-1}.

Tab. 1: Effects of three catch crop treatments on annual N leaching and grain yields of a succeeding spring barley. Values with the same letter are not significantly different within the column (P<0.05).

[1]Treatment	Leaching kg nitrate-N ha^{-1}		Grain yield t DM ha^{-1}		
	2001/02	2002/03	2001	2002	2003
No catch crop, with animal manure (AM)	100^{a}	96^{a}	3.8^{a}	2.4^{b}	2.2^{b}
Ryegrass catch crop, with AM	55^{b}	23^{b}	3.6^{a}	3.2^{a}	3.2^{a}
Clover catch crop, without AM	60^{b}	31^{b}	2.2^{b}	3.1^{a}	2.7^{ab}

[1]The treatments were carried out each year.

Experiment II: Catch crop treatments significantly affected grain DM yields of the succeeding spring barley (Fig. 1). The yield levels following the non-legumes were similar to the treatment with no catch crop and no N fertilizer, whereas the residual effect of white clover on grain yields corresponded to 120 kg N fertilizer ha^{-1}.

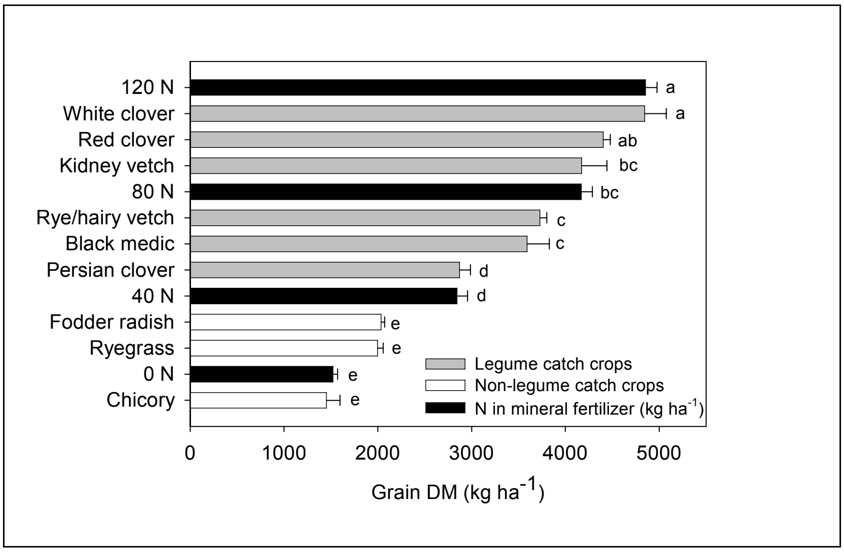

Figure 1: Effect of catch crop species and mineral N fertilizer application on spring barley grain yields. Values with the same letter are not significantly different (P<0.05).

Discussion

The significant difference in residual effects between legumes and non-legumes was caused by the low fertility status of the coarse sandy soil. This low fertility is the result of a coarse soil texture and high autumn/winter precipitation that is typical for the site. In the comparison of grain yields from barley getting nutrients by feeding on clover residues or on spring applied AM only, the larger yield response following a clover catch crop indicates that more N was captured and made available to plants through N_2-fixation than the allowance in AM.

In the present experiment the clover catch crop was as effective as the ryegrass in reducing N leaching. In another experiment on the same site a ryegrass catch crop reduced N leaching more than clover, but the clover was still efficient (Askegaard and Eriksen, 2008). The reason for the relatively good effect of clover on N leaching could be better timing between clover NO_3-N uptake after harvest of the main crop and onset of the NO_3-N leaching losses, which normally start early in the autumn on this soil type (Askegaard and Eriksen, 2008).

The spring barley system based on clover catch crops undersown each spring as the sole N source was not stable, as the clover exhibited poor growth after a few years. This could be due to the simple variation between years or more likely the build-up of clover cyst nematodes in the soil, which can be significant with repeated sowing of white clover in the same field (Søegaard and Møller, 2005).

Among the tested legume species, the largest residual effects originated from the two most common legumes in ley production, white clover and red clover. It needs to be emphasized that only one variety per species was included in this experiment.

Conclusions

Clover catch crops significantly increased yields and reduced the loss of nitrate-N to the environment. It appears that clover catch crop has the potential to replace AM as a nutrient source for spring barley on the coarse sandy soil. Among the tested clover species, white clover and red clover had the largest residual effects, which corresponded to the effect of 100-120 kg N ha^{-1} in mineral fertilizer. A possible drawback with clover as a catch crop is the poor establishment in recently clover-cropped soil, a subject that is currently under investigation.

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Winter grazing as an alternative to mulching or mowing grass clover swards

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Key words: grassland, grass/clover, forage quality, wheat, nutrient management

Abstract

Management factors like the type of defoliation and seed mixture influence yield and forage quality of grass clover mixtures. In comparison to harvesting, grazing is less cost intensive. For economical reasons a maximum duration of grazing period is required. Grazing over winter can cause pasture damages. This problem is of minor relevance for grass clover grown on arable land in the last production year, which is ploughed in the following spring. This study compares different grass clover mixtures concerning yield, forage quality and suitability for winter grazing.With this background, tall fescue exerted more significant effect on the dry matter yield than perennial ryegrass. White clover showed significant superiority over all the other tested species, with regard to protein and energy contents. Otherwise, swards with red clover and alfalfa had a significantly higher legume contents and produced higher dry matter and N yields than the other swards. Plots grazed in different periods over winter showed a clear significant loss of grazable matter. The highest loss of dry matter which also was accompanied by a decrease in crude protein and energy content was observed in mixtures with Lucerne. Under mulching systems and early grazing high nitrate losses were measured. After ploughing, the early grazing systems resulted in lower spring wheat yields than grazing in January or cutting systems.

Introduction

Yield and forage quality of grass legume mixtures are affected by management factors like the type of defoliation system and the selection of seed mixture (Loges, 1998). In addition to use for silage and mulching of grass clover, a mixed harvesting and grazing system is also possible and typical. Compared with harvesting, pasture is cheaper (Jakob, 2003). From the economical point of view, applying extended grazing period, as long as possible, is always encouraged. By winter grazing costs for housing and forage conservation can be decreased.

On permanent pastures winter grazing can lead to problems, especially in maritime climates. Excrements can affect nutrient entries to ground and surface water (Buchgraber, 2006). A high stocking density brings irreversible sward damages.

These problems can be avoided or reduced, by practicing winter grazing only on grass clover swards that will be ploughed anyway in next spring.

The main objective of this study is to compare different grass forage legume mixtures regarding their yield ability, forage quality and ability for winter grazing.

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The possibility to support extensive cattle or sheep with grass legume mixtures by winter pastures was the main subject of the investigation.

Materials and methods

The current study is based on a multifactorial experiment carried out from 2005 to 2007, on the organic farm "Hof Ritzerau" in northern Germany. Grass clover swards with two different grass species (perennial ryegrass (*Lolium perenne*), tall fescue (*Festuca arundinacea*)) and three different forage legume species (white clover (*Trifolium repens*), red clover (*Trifolium pratense*) and lucerne (*Medicago sativa*)) were established and used for harvesting, mulching and as a mixed system with different grazing dates (Tab. 1).

Tab. 1: Levels of the different studied factors included in the experiment

factor	level	description
1. grass species	1.1 perennial ryegrass, Indiana *Lolium perenne* (PR)	most important grass species in northern Germany
	1.2 Tall fescue, Kora *Festuca arundinacea* (TF)	wintergreen, deep rooting grass species
2. legume species	2.1 White clover, Klondike *Trifolium repens* (WC)	typical forage legumes
	2.2 Red clover, Amos *Trifolium pratense* (RP)	
	2.3 Lucerne, Daisy *Medicago sativa* (LC)	
3. defoliation system	3.1 harvesting	3 cuttings
	3.2 mulching	3 cuttings
	3.3 mixed system	2 cuttings…
	3.3.1 grazing in October	… + grazing in October
	3.3.2 grazing in December	… + grazing in December
	3.3.3 grazing in January	… + grazing in January

At every date of use, plants were sampled for evaluating yield and eventually the rest of grazing. Forage quality parameters like crude protein (CP) and metabolizable energy content (ME) were measured by NIRS. In winter, nitrate leaching was measured using suction cups. The following spring wheat was harvested by a combine harvester.

Data were statistically analysed using the mixed procedure of SAS analysis. The students t-test ($P<0.05$) was used for mean comparison.

Results

To illustrate the productivity and quality parameters of the mixtures, first the sum of three applied cuttings per year are shown. The dry matter yield ranged significantly between 10 and 15 t ha^{-1} among three tested legume species (Tab. 2). Red clover and Lucerne produced higher yields than white clover. Regarding the yield composition, both the grass species and the legume species exerted significant effects on the legume portion. Tall fescue suppressed legumes more than perennial ryegrass. White clover was more negative affected than red clover and lucerne. It was also observed that a high legume portion was important to achieve a high crude protein content from the sward. This may explain the reason behind the very low protein content produced from the mixtures including white clover and including tall fescue. Both grass species had higher energy contents than red clover and lucerne fractions. Single energy content of white clover fractions was higher than those of grass species. Because of that a higher legume portion produces higher energy content only in mixtures with white clover.

Tab. 2: Yield and selected forage quality parameters in cutting systems.

seed mixture	WC PR	WC TF	RC PR	RC TF	LC PR	LC TF
yield [t ha^{-1}]	9.1^{b*}	9.7^{bc}	14.7^{a}	13.3^{ab}	14.2^{a}	13.2^{ab}
legume portion [%]	39.8^{c}	24.1^{d}	61.3^{ab}	49.1^{ac}	65.9^{a}	55.5^{ab}
crude protein [%]	15.8^{b}	14.7^{b}	18.5^{a}	16.4^{ab}	18.9^{a}	18.2^{a}
energy [MJ ME kg^{-1} DM]	10.6^{a}	10.2^{b}	10.1^{b}	10.1^{b}	9.3^{c}	9.1^{c}

To evaluate whether grass legume swards are suitable for winter grazing the stock of the third growth in October and January was taken (Tab 3). The dry matter yield in October was affected by legumes as in annual harvesting. From October to January the difference between the mixtures was decreased. No more differences between mixtures were recognized. In forage quality all mixtures, except white clover with perennial ryegrass, had crude protein content losses. The same mixture had the least losses of energy from October to January. Red clover and Lucerne mixtures had high energy losses. Especially, mixtures with Lucerne had the significantly lowest energy contents, lower than 10 MJ ME kg^{-1} DM.

Tab. 3: Yield and forage quality parameters in grazing the third growth in October and January.

seed mixture	WC PR	WC TF	RC PR	RC TF	LC PR	LC TF
yield Oct. [t ha^{-1}]	23.0^{b*}	27.1^{b}	47.2^{ab}	52.8^{a}	65.7^{a}	72.8^{a}
yield Jan. [t ha^{-1}]	20.2^{a}	17.7^{a}	18.8^{a}	35.5^{a}	32.4^{a}	31.4^{a}
crude protein Oct. [%]	24.8^{c}	18.9^{d}	31.5^{a}	27.7^{b}	33.1^{a}	32.8^{a}
crude protein Jan. [%]	27.8^{a}	13.7^{c}	26.3^{a}	17.9^{bc}	23.6^{ab}	20.9^{b}
energy Oct. [MJ ME kg^{-1} DM]	16.5^{a}	15.9^{b}	16.2^{ab}	15.1^{c}	15.2^{c}	15.0^{c}
energy Jan. [MJ ME kg^{-1} DM]	15.8^{a}	12.6^{b}	12.1^{b}	12.0^{b}	9.1^{c}	9.0^{c}

Tab. 4: Nitrate leaching and spring wheat yield after different defoliation systems on perennial ryegrass red clover mixture.

defoliation system	Harvest	Mulch	Grazing in Oct.	Grazing in Dec.	Grazing in Jan.
leaching [kg NO_3^--N ha^{-1}]	12.2^{a*}	20.6^{a}	30.8^{a}	9.1^{a}	14.5^{a}
spring wheat yield [t ha^{-1}]	3.7^{a}	3.5^{ab}	3.0^{b}	3.4^{ab}	3.8^{a}

* Means within the same column allowed by the same letters are not significantly different at 0.05 level of probability.

Under perennial ryegrass red clover mixtures differences in nitrate leaching under different defoliation systems was not statistical affected, but under mulching system and early grazing high losses were measured (Tab. 4). At the same time, after ploughing the sward, early grazing leaded to lower spring wheat yield than after the harvesting and the January grazing systems.

Discussion

In silage use systems, red clover and Lucerne had advantages against white clover; however lucerne mixtures had extreme large energy losses over winter. They are not able to support cattle or sheep in the late winter time (GfE, 2001). Tall fescue was detrimental to harvesting systems. In winter it was without any advantages compared to perennial ryegrass.

In northern Germany, the mixture perennial ryegrass with red clover is widespread. That's why influence of defoliation system on nitrate leaching and spring wheat yield is only shown after this mixture. The high nitrogen losses between 20 and 30 kg ha^{-1} under mulching and early pasture cause low wheat yields in next year. Later pastures prevent nitrogen losses and increase wheat yield.

Conclusions

Mixed systems with harvesting and winter pasture should prefer grass legume mixtures with perennial ryegrass and red clover. This mixture provides a high yield in summer and low material losses in winter.

Compared to cutting and grazing, mulching systems are without advantages and induce high costs. For arable farms it would be better to replace legume grass yield with organic fertilizers from a neighboured cattle farm.

Winter grazing on arable land is an alternative to grazing on wet permanent grassland, but cattle should come to arable land as late as possible without damaging permanent grassland, so nitrogen losses can be minimised and spring wheat yield is not decreased by a winter pasture in January.

Acknowledgment

The scientific investigations are kindly sponsored by the owner of “Hof Ritzerau“, Günther Fielmann.

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Nitrogen balances in Dutch organic greenhouse production

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Key words: greenhouse, modelling, nitrogen balance.

Abstract

The organic greenhouse production in the Netherlands is limited with regard to the number of growers, but plays an important role in EU organic greenhouse production. In the high-technology greenhouses a high production level is realized but nitrogen balances of this production system have been questioned. In order to document and improve the nitrogen balance, the production of seven greenhouses was monitored and soils were repeatedly analysed. The model "Bemestingsrichtlijn biologische kasteelten" (Fertilization Guide Organic Greenhouse Production) has been developed to simulate nitrogen availability and to fine-tune manure applications to crop demand. In the course of four years the overall nitrogen surpluses decreased sharply, but due to the observational character of the research no statistical analyses can be made. Part of the high surpluses in the first years can be explained by initial investments in soil organic matter. Calculation of the dynamic balance gives more possibilities to fine-tune farmers' fertilization strategies. Growers that followed the model-based advise for manure application, realized a substantial reduction of nitrogen surpluses.

Introduction

Although limited in number of growers, the Dutch organic greenhouse production is an important factor in Dutch and EU greenhouse production. Part of it is performed at a high technology level, resulting in correspondingly high nitrogen inputs and high production. The nitrogen balances of these production systems are undocumented so far. In a four-year monitoring project, the organic greenhouse production and fertilizer strategies of seven greenhouses were followed. During the project, a model was developed, tested and applied, aimed at the reduction of nutrient surpluses (nitrogen, phosphorus and potassium) of this production system. In the following text we focus on nitrogen only.

Materials and methods

Seven Dutch organic growers with intensive year-round cultivation of greenhouse crops participated in this monitoring project. From each greenhouse, one compartment was monitored from 2002–2005. During this period sweet pepper was cultivated most (43%) followed by tomatoes (39%) and cucumbers (18%). Total fresh- and dry mass of fruits, leaves and stems was determined throughout the growing period for each crop. Dry matter samples were analysed for nitrogen content. The total uptake of nitrogen for each crop was calculated. All compost, manure and additional organic

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fertilizer applications were registered, and total and mineral nitrogen contents were analysed if unknown. Additional organic fertilizers were applied as side dressings (e.g. feathermeal pellets or beet vinasse) during the growing season. During the growing seasons, soil mineral N was measured at approximately one-month intervals (8-11 measurements per year). Additionally, in 2004 (two growers) and 2005 (seven growers) a compartment of each greenhouses was divided in two parts with different fertilization strategies, one receiving fertilizers according to the current growers' practice, the other receiving fertilizers according to the outcome of the model calculation. Data were analysed in two ways:

1. Calculation of the input-output balance, defined as the difference between total N-input (N-contents of organic fertilizers) and total N-output (N-contents of harvested products and above-ground crop residues).

2. Calculation of the dynamic balance, defined as the difference between total mineral nitrogen, becoming available during the growing season (including N-mineralization of soil organic matter, organic fertilizers and above-ground crop residues), and total N-uptake by crops (including harvested products and above-ground crop residues). Available nitrogen was estimated, using model calculations of the "Bemestingsrichtlijn Biologische Kasteelten" (Fertilization Guide Organic Greenhouse Production). This model has been developed to support Dutch organic greenhouse production (Voogt, 2005).

Results

For all crops, the input-output and dynamic balances for nitrogen were calculated (Cuijpers et al., 2007). There was a large variation between the growers and between years and crops (data not shown). This, together with the limited number of participants (n = 7) complicates interpretations of the results.

For further analysis of these data, the average of the input-output balance and dynamic balance of all crops within one year is given (table 1). A clear declining trend is visible in the input-output balance, but must be nuanced by two factors. First, the character of the research was observatory, not experimentally, which impedes statistical analysis. Second, nitrogen surplus might be crop-dependent and each year the 7 growers cultivated a different ratio of sweet pepper, tomato and cucumber. In the dynamic balances the variation among the growers and among the years is too big to conclude that the surplus has diminished over the years.

Tab. 1: Total nitrogen crop uptake and nitrogen surplus in both input-output balance and dynamic balance (between brackets: lowest and highest value). Data given in kg ha^{-1} , n = 7

Year	Total crop uptake	Surplus Input-output balance	Surplus Dynamic balance
2002	**763** (452/1263)	**711** (215/2667)	**274** (-47/596)
2003	**638** (371/1012)	**460** (254/747)	**448** (182/684)
2004	**781** (382/1179)	**151** (-507/681)	**213** (-236/584)
2005	**765** (584/976)	**78** (-389/898)	**173** (-61/497)

In table 2, the improvements, achieved by application of the fertilization model are shown for both input-output balance and dynamic balance. In 2005, three out of seven growers adapted their fertilization strategies completely to the model strategy. In the other greenhouses the use of the model reduced nitrogen surplus in both input-output balance and dynamic balance, with exception of one grower. In this greenhouse compartment the model-directed manure strategy seemed to show nitrogen shortage and side-dressings were applied above the recommended amount. No yield effect was recorded due to reduced nitrogen applications.

Tab. 2: Reduction of applied and available nitrogen (kg/ha) as a result of the use of the fertilization model

Grower	Reduction in N-application Input-output balance	Reduction in N-availability Dynamic balance
A (2005)	0	0
B (2005)	0	0
C (2005)	176	17
D (2005)	1079	321
E (2004)	482	298
E (2005)	104	168
G (2005)	-301	-327
N (2004)	582	349
N (2005)	0	0

Discussion

In the input-output balances the input data can be considered as reliable. However, the output data are influenced by some methodological uncertainties. Calculation of the nitrogen quantities in fruits and other plant material is based on irregular measurements during the growing season. The amount of leaves, fallen or cut during growing cycles, were partly measured, partly estimated. Crop residue dry matter was based on measurements of only five plants at the end of the cropping period, as were nitrogen contents. All these factors increase the possible variation in outcome.

The dynamic balances contain more uncertainties than the input-output balances. The mineralization of organic matter and thus the release of nitrogen is calculated according to Janssen (1984) by means of the parameter *Initial Age* (IA), which is based on the C-turnover rate. The IA of organic inputs were based on incubation tests that were carried out on 42 different organic fertilizers in 2002 and 2004. The IA of soil organic matter was calculated based on incubation tests, carried out in 2002 and 2004) (data not shown).The model setup uses soil organic matter with an IA which is (in this case) derived from incubation experiments and it uses actual and historical manure applications. An overlap exists between IA of soil and historical manure applications. This was arbitrarily corrected, as was corrected for (a) length of growing period of the crops and (b) mineralization of nitrogen from fallen or cut leaves during growth. Even given these uncertainties, the dynamic balance offers more possibilities to fine-tune farmers' fertilization strategies and to gain insight in soil processes with environmental importance, like leaching or denitrification.

The average-year results of the in-out balances (table 1) show a clear decline in nitrogen surpluses, although the results must be interpreted carefully as was stated before. The decrease can partly be explained by unusual high applications of compost (200 tons ha^{-1} or more) and manure at the beginning of this 4-year period, motivated by the growers as an investment in soil organic matter. This is supported by a measured increase of soil organic matter (data not given). Such an application is done only once or twice, and will result in a long-term effect of increased nitrogen release out of soil organic matter. This will diminish the need for manure application in the following years. Modelling the soil organic matter dynamics with the NDICEA model (Van der Burgt et al., 2006) indicates that a yearly application of 50 tons ha^{-1} of compost will maintain soil organic matter in a range around 6%, a level which is considered to be sufficient. Interpreting the data, it should be taken into account that N-losses by denitrification, or by leaching were not part of the balance calculations. For situations with significant over-irrigation it could have the effect that the soil mineral N is reduced, both by higher denitrification rates and N leaching, stimulating the growers to additional side dressings.

Conclusions

Although observational data are not statistically analysed, the sharp decline in nitrogen surplus in the input-output balance is convincing and can be explained. The high nitrogen input in the first years is not lost; it is part of the build-up of soil organic matter.

The dynamic balance is a much more interesting instrument for analysing nitrogen balances than the input-output balance, even knowing the uncertainties linked to the dynamic balance and the more complicated way to construct it. Together with a (still to be validated) model, this can be a promising decision-support instrument for greenhouse growers to meet future challenges in further improvements of nitrogen balances.

Acknowledgments

We honestly thank all participating growers for their kind cooperation and for sharing their knowledge, and we thank the Dutch government for financing this research and development project.

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Mineral nitrogen in the course of a cash crop and two livestock rotations - first results from the long-term monitoring Trenthorst

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Key words: crop rotation, mineral nitrogen, production system, long-term monitoring

Abstract

The long-term monitoring Trenthorst, situated near Lübeck in a temperate maritime climate on loamy soils, was established in 2003 and compares two cash crop and three livestock farming systems. We studied the soil mineral nitrogen contents of one cash crop and two livestock farms, specialised in dairy cows and goats/oilseeds resp., with the hypothesis that the livestock farms show a more even course of Nmin in the rotation and a higher rotation mean. The rotation average of Nmin in the cash crop farm was not lower than the ones in the livestock farms. But in the course of the rotations differences became evident: compared to the livestock farms the cash crop farm showed higher Nmin-values after the first rotation year (mulched vs. cut grass clover) but lower values in the fourth and fifth year of the rotation. As a precise nitrogen supply via manure as in the livestock farms is impossible in a self-sustaining cash crop farm, the excess of nitrogen at the beginning and the lack of it towards the end of the rotation could not be balanced. A way to improve this might be the use of green manure crops for biogas production and the application of the residues as manure. But as no full rotation period has yet passed, a longer study period is necessary to confirm the results.

Introduction

The long-term monitoring Trenthorst was established in 2003 and comprises the six-year crop rotations of two cash crop and three livestock farms, specialised in dairy cows, pigs and goats and oilseeds respectively. Central aims of the experiment are 1) the comparison of a wide range of organic farming systems under practical farming conditions (in contrast to field experiments) with respect to the development of soil nutrient contents, plant- and grain nutrient contents, yields and biodiversity 2) the analysis of nutrient cycles in different farming systems 3) the comparison of different preceding crops, respectively, rotation positions of winter wheat and winter rape. To ensure sufficient options for a comparison of the farming systems, most crops are included in more than one rotation, and the first crops and the last crops in three rotations are identical. Two farms do not have a fixed crop rotation and as no full rotation period has passed yet, they are not included in this paper. To compare the nitrogen supply in the three remaining crop rotations (one cash crop and two livestock) we analysed the development of the soil mineral nitrogen content (Nmin) at the beginning of the growing season, as this is the parameter in the nitrogen cycle most directly related to yields and grain quality. We hypothesized that 1) the livestock farms show a more even course of Nmin contents in the rotation and a higher rotation average 2) winter wheat has a better nitrogen supply in the dairy cow than in the cash

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crop farm and 3) this leads to higher winter wheat yields and grain nitrogen contents in the dairy cow farm.

Materials and methods

The experimental farm Trenthorst is situated near Lübeck (53°46' N, 10°31' E) in a temperate maritime climate (Ø annual precipitation 739 mm, Ø annual temperature 8.8 °C) on loamy soils. The agricultural area of 480 ha is divided into five independent farms. Details of the three farms with an established stable crop rotation are given in table 1. The soil properties on these three farms are similar, although the fields of the goat farm tend to be less homogenous and to have heavier soils than the other two farms. Schaub et al. (2007) give a detailed description of the site conditions and study setup. In the cash crop farm, grass clover is mulched three times per year and the straw mostly incorporated into the soil. The livestock farms harvest grass clover and straw for forage, respectively bedding, and use only the manure of their own livestock. Nitrogen is transferred from grassland to the crop rotation via manure.

On each arable field, four or eight representative monitoring points were established, where all parameters have been measured annually since 2003. The results from these monitoring points are regarded as replications, as each farm consists of six arable fields and each crop is grown only once per farm and year. Data were analysed by univariate ANOVA and Tukey-HSD-test in SAS 9.1 (SAS Institute 2003). The Brown-Forsythe-test was used to test for homoscedasticity and Welchs ANOVA was used where necessary.

Soil samples were taken in three depths (0-30 cm, 30-60 cm and 60-90 cm) each year, before the start of the growing season in February or March, and the nitrate and ammonium content were determined.

Tab. 1: Crop rotation, area and livestock of three farms in the long-term monitoring Trenthorst

Farm	Arable/ grass-land [ha]	Stocking rate [LU*ha^{-1}]	Live-stock	Position in crop rotation / = mixed crop * = grass clover undersown					
				1	2	3	4	5	6
Cash crop	31/-	-	-	Grass clover[2]	Winter wheat	Oat	Pea	Winter rape	Triti-cale*[3]
Dairy cows	64/39	0.97	80 cows + calves	Grass clover	Grass clover	Winter wheat	Oat/ Field bean	Pea/ Barley	Triti-cale*
Goats	60/50	0.19	50 goats + lambs + young cattle[1]	Grass clover	Winter rape	Pea/ False flax	Winter wheat[4]	Lin-seed	Triti-cale*[3]

1 = replacement animals of dairy cow farm 2 = White clover in 2005 3=Spelt wheat in 2003 and 2004 4=Summer wheat in 2003 and 2005

Results

Averaged over the years 2003 to 2006, only two differences in the course of the N_{min}-contents in the three crop rotations were noted: the cash crop farm had a higher N_{min}-

content than the goat farm in the second year of the rotation and a lower value than the dairy cow farm in the fifth year of the rotation. Nevertheless the course of the N_{min}-contents resembled the pattern that can be observed when one considers only the years after 2004 (Figure 1). From 2004 to 2005 the manure management on the dairy cows farm changed considerably: the cows, which until then had been kept as suckler cows, moved into the new cubicle house and were milked, the cows no longer had access to pasture and instead of solid manure slurry was produced. Averaged over the years after 2004, the cash crop farm had significantly higher N_{min}-values than the livestock farms in the second year of the rotation (after grass clover). In the third rotation year the three farms were on the same level, but in the fourth and fifth rotation year the cash crop farm showed significantly lower values than the dairy cow farm. In the last year of the rotation the N_{min}-contents of the dairy cow farm decreased to the level of the cash crop farm. Averaged over the entire rotation and the years 2005 to 2006, the N_{min}-contents of the three farms did not differ.

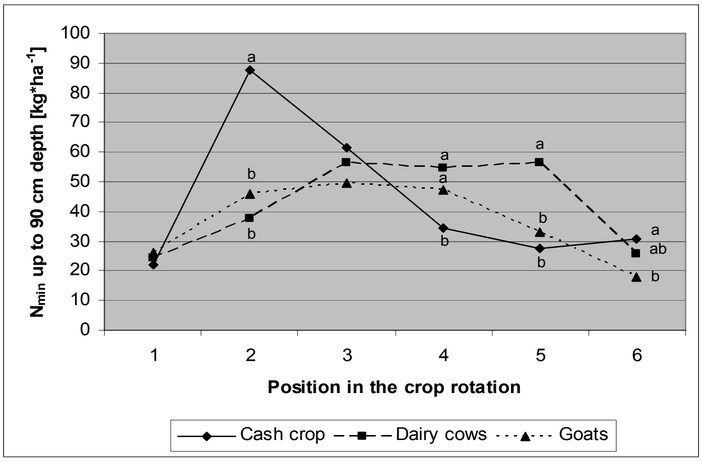

Figure 1: N_{min} in the course of three crop rotations in the long-term monitoring Trenthorst, means of the years 2005 and 2006 (different letters within position: significant difference (p=0,05))

The N_{min}-contents under winter wheat were significantly higher in the cash crop farm than in the dairy cow farm in the years 2004 and 2006 and averaged over the years 2003 to 2006. Nevertheless this higher N_{min}-value did not result in higher yields or grain protein contents: in 2005 and 2006 the winter wheat yields on the cash crop farm were numerically higher than on the dairy cow farm, but on average the dairy cow farm had a higher winter wheat yield. The wheat grain nitrogen content on the cash crop farm was numerically higher than on the dairy cow farm, but only in 2005 this difference was significant.

Discussion

Since only four years of the six-year rotation period can be analysed up to now and major changes in the dairy cow farm management took place after the first two study years, a longer study period is necessary to verify the findings.

The comparatively smooth course of the N_{min}-contents in the livestock farms can be explained by the harvesting of the grass clover as forage. This removes nitrogen and prevents a nitrogen accumulation as in the cash crop farm where grass clover is mulched (Loges et al. 2000). The distribution of farmyard manure leads to a more even nitrogen supply during the rotation. As this is not possible in a self-sustaining cash crop farm, the N_{min}-contents decrease earlier than in a livestock farm, although they are higher after the first year of the rotation. This high N_{min}-content after grass clover implicates an increased risk of nitrate leaching, especially on sandy soils. The use of clover grass for biogas production could remove the excess nitrogen and provide a cash crop farm with "transportable" nitrogen to fertilize crops at the end of the rotation. Stinner et al. (2005) reported a 10 % reduction of the average N_{min}-contents in the rotation and thus a decreased leaching risk when grass clover and intercrops were used for biogas production instead of being mulched.

The similar rotation average of N_{min} in the cash crop and the dairy cow farm is in accordance with findings of Schmidt et al. (2006), who reported a similar N availability in a stockless mulch and a livestock rotation. In contrast Entz et al. (2005) found higher available N in a grain-forage rotation compared to a green manure rotation. This might be due to the higher proportion of forage crops (50 % vs. 33 % in Trenthorst) in the rotation.

The higher N_{min}-contents under winter wheat in the cash crop farm in comparison to the dairy cow farm are somewhat surprising. The second year of grass clover apparently cannot compensate for the nitrogen removal via forage in contrast to the mulching of grass clover.

Conclusions

In comparison with the livestock farms, the cash crop farm showed higher N_{min}-values after the first rotation year (mulched vs. cut grass clover), but lower values in the fourth and fifth year of the rotation. The rotation averages of N_{min} were similar in the cash crop and the dairy cow farm. As no full rotation period has yet passed, a longer study period is necessary to confirm the results.

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Autumn sown catch crop understoreys as strategy to reduce nitrate leaching in winter cereals

Loges, R., Mauscherning, I., & Taube, F.[1]

Key words: intercropping, catch crops, winter cereals, nitrate leaching

Abstract

Under conditions with wet mild winters due to high nitrate leaching risk growing systems with high nitrogen (N) uptake efficiency in autumn are necessary, especially after pre crops with a high N release. In 2003 and 2004 a field trial was conducted in Northern Germany to investigate autumn N uptake and nitrate leaching in autumn sown winter wheat (Triticum aestivum L.) and winter oilseed rape (Brassica napus) grown intercropped with catch crops. Catch crops in pure stands were sown as control. In each system three catch crops common vetch (Vicia sativa), forage rape (Brassica napus) and oats (Avena sativa) were tested simultaneously. The experiment was run parallel after grass clover (high N status) and oats (low N status). N uptake, soil mineral nitrogen (N_{min}) and nitrate leaching of all stands were determined. Especially with winter wheat intercropping with catch crops increased N-uptake in autumn. In all stands forage rape and oats led to a higher N uptake than common vetch. In comparison to pure sown winter wheat, intercropping reduced N_{min} by more than 30 %. Nitrate leaching was highest after grass clover. Averaged over both pre crops intercropping of winter wheat and catch crops led to a reduction of nitrate leaching in a range of 38 to 60 %. Grown as intercrop to winter oilseed rape forage rape and oats decreased nitrate leaching compared to pure sown rape by 50 and 39 %, respectively. If cultivation of winter wheat after N intensive pre cop in winter mild climates is wanted, an intercropped production system with catch crops is a mean to reduce N leaching risks. Further investigations are necessary to clarify on yield performance of the main crops when growing together with catch crops.

Introduction

In organic farming winter wheat and winter oilseed rape is typically grown after good pre-crops such as grass clover as it pays well in terms of yield and quality. Especially under climatic conditions with wet mild winters much nitrate may be lost by leaching before spring, because winter cereals develop slowly and their N-uptake is smaller than the N amount mineralized from incorporated pre-crop residues. The benefit of catch crops in pure stand to reduce the soil content of mineral N and nitrate leaching over winter is documented by many studies (Meisinger et al. 1991, McLenaghen 1996, Francis et al. 1998, Justes et al. 1999, Aronsson 2000). Autumn sown catch crops grown as understorey to winter wheat could improve N-uptake of winter cereals and therefore lower the risk of unproductive N-leaching. After freezing off or incorporation between the main crop rows N release from catch crops residues could improve N availability for the cereal crop. Therefore catch crops were cultivated together with winter wheat and winter oilseed rape, respectively, in an intercropped growing system

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and compared to pure sown wheat and rape as well as to classic overwintering pure stand catch crops grown before a spring crop. The hypotheses of the investigation are that because of the temporal N retention by the accompanying catch crops over winter less nitrate losses occur and both environmental and nutritional effects of the overwintering main crops will be improved.

Materials and methods

Field experiments were carried out in Northern Germany (53° 40´ N; 10° 35´ E) at the organic managed experimental farm Lindhof (Kiel university) in 2003/04 and 2004/05 in a split plot design with three replicates. The site is characterised by Luvisols and Cambisols as soil types, a mean annual air temperature of 8,7°C and a mean annual precipitation of 774 mm. Winter wheat (*Triticum aestivum*) and winter oilseed rape (*Brassica napus*) were grown intercropped with catch crops with the aim to improve autumn N uptake and to avoid unproductive nitrate leaching. Pure sown wheat and oilseed rape as well as pure stands of catch crops were sown as control (Table 1). In each system three catch crops common vetch (*Vicia sativa*), forage rape (*Brassica napus*) and oats (*Avena sativa*) were established at the end of August, 2003 and 2004, respectively. The pure stands catch crops were sown at a row distance of 12 cm, while in the intercropped treatments a wide row spacing of 36 cm was chosen. Between the wider rows in half of the plots winter rape was sown at the same time, while in the remaining plots winter wheat was established five weeks later at the beginning of October. To analyse the influence of the soil N status the experiment was run simultaneously after two different preceding crops grass clover (high N status) and oats (low N status).

Total plant N uptake (shoot and roots), soil mineral nitrogen (N_{min}) in spring and autumn as well as nitrate leaching of all stands was measured. Leaching of nitrate was determined with ceramic suction cups. Leachate was sampled weekly between mid of November and mid of March during both winters and analyzed for NO_3 concentrations. The volume of leaching water was calculated by a general water balance model. Statistical analyses were carried out with the procedure Mixed of the SAS® Software (Vers. 9 SAS Institute 2001). Multiple comparisons of means were performed using the T-test with correction according to Bonferroni-Holm.

Tab. 1: Factors and factor levels of the field experiment

Factor	Factor level
1. Preceding crop	1.1 Three times mulched grass clover 1.2 Oats
2. Main crop	2.1 Winter wheat 2.2 Winter oilseed rape 2.3 Spring wheat
3. Catch crop	3.1 Without catch crop 3.2 Common vetch 3.3 Forage rape 3.4 Oats
4. Replications	3

Results

Catch crops in the intercropped system realised a comparable N-uptake to pure sown catch crops and were especially beneficial in combination with winter wheat, because of low biomass productivity of winter wheat (Tab. 1). The catch crops forage rape and oats showed a higher N uptake capacity than common vetch. Catch crops were able to reduce N_{min} in autumn by 32-45 % compared to the pure sown winter wheat. Averaged over the two main crops all catch crops showed higher soil N_{min} contents in autumn than in spring. Differences reached from 11.5 to 30.2 kg ha^{-1} and indicate nitrogen losses over winter. The differences were highest after the pure stands of winter wheat and oilseed rape, followed by the treatments common vetch. Pure sown winter wheat showed higher leaching losses than intercropped wheat. Averaged over both pre crops intercropping of catch crops and winter wheat led to a reduction of nitrate leaching in a range of 38 to 60 %. In each of the three systems forage rape and oats used as catch crops showed the highest reduction of nitrate leaching.

Tab. 2: Impact of main crop and catch crop on plant-N-uptake, soil mineral N in autumn and spring and on leached nitrate-N over winter
(averaged over 2 experimental years and 2 pre-crops)

Main crop	Catch crop	Plant-N-Uptake in Autumn- (kg N ha^{-1})	Autumn-Nmin (kg N ha^{-1})	Spring-Nmin (kg N ha^{-1})	Nitrate-N leached over winter (kg N ha^{-1})
Winter wheat	Without	28.1 c*	76.0 a	45.8 a	87.7 a
Winter wheat	Common vetch	66.5 b	51.8 b	34.7 ab	54.3 b
Winter wheat	Forage rape	92.4 ab	42.1 b	32.2 ab	45.8 bc
Winter wheat	Oats	88.9 ab	51.1 b	39.1 ab	35.0 c
Winter rape	Without	64.0 b	55.4 b	30.4 b	57.6 b
Winter rape	Common vetch	72.1 b	48.5 b	28.7 b	57.0 b
Winter rape	Forage rape	93.1 ab	38.8 b	25.8 b	28.6 c
Winter rape	Oats	112.0 a	37.2 b	23.2 b	35.0 c
Spring wheat	Without	79.2 b	46.1 b	31.4 ab	38.1 bc
Spring wheat	Common vetch	57.8 b	45.8 b	29.5 b	41.8 bc
Spring wheat	Forage rape	78.2 b	37.6 b	27.1 b	27.6 c
Spring wheat	Oats	75.1 b	35.2 b	23.7 b	28.7 c

*) same letters in one column are not significantly different P≤0.05

Tab. 3: Impact of pre crop on plant-N-uptake, soil mineral N in autumn and spring and on leached nitrate-N over winter
(averaged over 2 experimental years, 4 catch crops and 3 main crops)

pre crop	Plant-N-Uptake in Autumn- (kg N ha^{-1})	Autumn-Nmin (kg N ha^{-1})	Spring-Nmin (kg N ha^{-1})	Nitrate-N leached over winter (kg N ha^{-1})
Grass clover	89.1 a*	60.1 a	39.8 a	64.4 a
Oats	61.0 b	34.2 b	38.2 a	25.1 b

*) same letters in one column are not significantly different P≤0.05

Comparing the effects of the pre crop (Tab. 3.) plant-N-uptake and soil N_{min} in autumn was higher after grass clover confirming the hypothesed higher autumn N-release from incorporated crop residues. While after grass clover losses of soil N_{min} over winter occurred, net mineralization after oats led to higher spring compared to autumn N_{min}-values. On average over all treatments after grass clover much higher nitrate-N-leaching losses were determined compared to oats as pre crop.

Discussion

The in literature well described ability of catch crops to reduce nitrate leaching losses over winter is confirmed even when catch crops are sown late in northern latitudes with a time limited vegetation period. The before this study in literature less often discussed hypotheses that accompanying catch crops increase N-uptake and therefore decrease nitrate leaching losses in winter cereals could be verified. The investigation highlights again the high risk of nitrogen leaching losses growing winter wheat after good pre crops in winter mild climates. As due to economic reasons this is quite typical for organic wheat production, all measures have to be taken into account to guarantee an in all aspects environmental friendly production system. Intercropping winter cereals with autumn sown catch crops is a mean to reduce N leaching risks. Due to concurrence between catch crop and main crop with respect to other growing factors, further investigations are necessary to clarify on yield performance of the proposed growing system (Mauscherning 2008).

Conclusions

Growing catch crops is a mean to avoid unnecessary environmental risky leaching losses of the important growing factor nitrogen also under winter mild conditions in northern latitudes with a time limited vegetation period. If due to economic reasons in these climates cultivation of winter wheat after N intensive pre crops is wanted, an intercropped production system with catch crops as understorey is a mean to reduce N leaching risks. Further investigations are necessary to optimise yield performance and quality of the main crops when growing together with catch crops.

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Plant nutrition

Agronomic options for the management of phosphorus in Australian rain-fed organic broadacre farming systems

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Key words: phosphorus, manures, composts, P-efficiency, organic matter

Abstract

The paper is an overview of strategies for agronomic management of P in organic broad-acre farming systems within the Australian rain-fed cereal/livestock belt. It concludes that to raise and maintain adequate plant-available P in these systems the importation of organic manures or composts from off-farm will be required, although the immediate issue may be access to economically viable sources. Improving the P-use efficiency of the system by incorporating species into rotation or intercropping systems that are able to access P from less soluble sources has been a successful strategy elsewhere in the world and deserves further research effort in Australia. Agronomic management to maximise quantity and quality of pasture and crop plant residues undoubtedly builds labile soil organic matter and facilitates P cycling, but the strategy may be of limited benefit in low rainfall areas that do not have the capacity to produce large plant biomass inputs. Progress in selection and breeding for cereal genotypes that are more P-efficient and other plant genotypes that can access less labile P sources is gaining momentum but still remains a long term prospect.

Introduction

There has been relatively little reported research in Australia into the agronomic management and nutritional aspects of broadacre organic farming systems although there is far more information published for organic cropping systems in other parts of the world, such as Europe and Canada. Overall, the work has highlighted that, in common with other low-input systems, the maintenance of plant-available P is a major limitation. The problem is particularly extreme in stockless systems without access to manure and in mixed farming systems practiced on inherently infertile soils, as is the case for much of Australia (Penfold 2000).

In this paper, three broad strategies for agronomic management of P in Australian broadacre organic farming systems are considered. These strategies include (i) potential approaches for maximising the P use-efficiency of crops and pasture species in the system, (ii) practices for increasing soil P cycling to facilitate release and synchronous uptake of plant-available P, and (iii) import of allowable inputs that contain P.

Climate and soils of Australian rainfed broadacre agriculture

A key feature of Australian farming systems is the nature of the rainfall, in particular the low annual averages, high variability, and long dry or wet periods. Also, there is a wide range of soil types. Australian soils in the cereal/livestock belt are inherently low

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in soil organic matter (range 0.5 – 2%), as determined by the fixed factors of climate, depth, stoniness, mineralogy and texture. Australia, with some of the oldest, most weathered soils of the world, generally has soil P levels which are low by world standards. The total P content of Australian soils on average is 0.03%, compared with 0.04 - 0.10% for American soils and 0.05% for English soils.

Options for maximising P use-efficiency by crops/pastures

Utilisation of species or genotypes with high DM productivity or/grain yield per unit of P uptake

P use-efficiency by crops or pastures in simple terms can be defined as the amount of shoot biomass per unit of P present in the plant. It represents the integration of plant P uptake from soil and P translocation within the plant, processes that are both extremely complex.

The P efficiency ratio, expressed in terms of grain yield per unit of P in the plant shoot, attempts to describe the utilisation of P that a plant extracts from soil and fertiliser sources to produce grain. P efficiency ratios reported for field grown plants in dryland farming systems vary widely from 250 to 565 kg grain/kg P in shoots (Batten 1992). There is a growing consensus that sufficient genotypic variation of P efficiency within cereals exists to warrant breeding efforts. Indeed, a comprehensive Australian study that screened over 100 cereal genotypes demonstrated a wide variation in soluble P uptake efficiency (Osborne and Rengel 2002b) as well as in the capacity to use less soluble forms of P such as phytate and iron phosphate. Rye and triticale appeared more efficient than wheat at taking up and utilising P at low rates of P supply, and in being able to access less soluble forms of P.

There are reasons for seeking genotypes that achieve high yields of grain with low concentrations of P such as the negative association between loaf volume and high grain P and the positive correlation between low grain P and lower concentrations of the anti-nutritional factor phytic acid (Batten 1992). Nevertheless, high grain P may be an advantage for organic crops if seed is going to be kept for sowing on-farm, a factor which needs to be considered in overall management of P in the farming system. High seed P (up to 0.37% for wheat and 0.79% for annual Medicago spp.) has been associated positively in Western Australia with seedling vigour and significantly higher final dry matter production, both in the presence and absence of P fertiliser application, and also with higher wheat and lupin yields.

Increase the capacity for P cycling and release of available P

An approach consistent with the ethos of organic farming is to use agronomic strategies that increase soil organic matter, such as retention of crop residues and longer phases of pastures, and thus increase soil organic P. Without significant external inputs however, raising soil organic matter levels can be a very slow process especially in a semi-arid climate, as demonstrated from some farming systems research in South Australia where after eight years there was no significant increase in soil organic carbon under organic or biodynamic practices (Penfold and Miyan 1998), although paradoxically organic carbon did increase in the conventionally farmed treatment. Low plant-available P in farming systems may impact on N contribution from legumes in that if P is restricted then N fixation may also be reduced (Nguluu 1993) and residues will be reduced in P. It is therefore critical to a sustainable organic crop/pasture system in Australia to provide the legume phase with adequate P to generate the N to support the cereal phase of the rotation. There remains further scope for incorporating into the rotation crop species that are known to excrete P solubilising compounds including lupin, pigeonpea, chickpea, lucerne, white clover and cocksfoot (Li et al. 1997).

Import allowable and economically viable P inputs

Within the required standards for organic production in Australia there are mineral and organic options for P fertilisers. Reactive phosphate rock (RPR) and phosphate rock (PR) are allowable mineral P inputs to organic systems, but their value has been reported as limited (Ryan et al. 2004).

A more valuable P source is likely to be manures and composts. Recent changes in pig production systems from intensive shed to deep litter systems with pigs running on straw has increased the availability of pig manure for broad-acre application. Considerable expansion of the chicken meat industry, where the birds again live on straw or rice hulls, is further assisting in providing manures available for composting and use in organic production systems. On present estimates, there is enough manure generated from these systems in Australia to provide the phosphorus replacement requirements for over 1 million hectares of cropping land.

Transport costs associated with the movement of fertiliser products of low nutrient percentages (relative to chemical fertilisers) has traditionally been an impediment to their widespread use. However, recent increases in chemical fertiliser prices now show the nutrients contained in composts and manures to be relatively undervalued. With consideration for this discrepancy, calculations suggest chicken litter compost could be transported up to 300 kilometres and still equate with a similar amount of synthetic fertiliser delivered to the same distance. The efficiency of nutrient transport may be further enhanced by fortification of the compost with rock phosphate to produce phospho-compost - a process which is likely to also enhance the value of PR by increasing phosphorous availability following soil application (Pareek et al. 2004). Phospho-composting utilises the organic acids and humic substances produced by the bacteria and fungi in a compost pile to release P from PR, and a consequent chelating function performed on calcium, iron and aluminium (Zapata and Roy 2004).

Anaerobic Digestion – Energy from Compost

Within manures is embodied a considerable amount of energy in the form of C bonds which would normally become greenhouse gas. Using anaerobic digestion, methane is produced which can be used within the animal production unit for heating or fuel for transport or power generation. The residue from the anaerobic digestion can be used as a fertiliser, as it remains rich in N and P. One study in Germany applied fresh manures, composted manures, digested manures and N amended digested manures to crops in an 8 year rotation (Möller et al. 2006) and concluded there were no negative effects on nutrient availability following anaerobic digestion.

Pyrolysis has been proposed as an alternative to anaerobic digestion for energy and nutrient extraction from manures. The principle energy product generated by pyrolysis is oil and the sludge nutrients are recovered in the char. A study using sludge from a pilot plant in Western Australia confirmed the P was plant available but found the N was insoluble (Bridle and Pritchard 2004).

Conclusions

Without some radical changes in approaches to P management, sustainable broad-acre organic cropping in Australia is likely to remain constrained to areas with relatively high rainfall and soil P fertility. For those farms where soil P levels are low, the importation of P as manures or composts may be a feasible option to produce crops and pastures not constrained by P deficiency. Amending the imported products with additional rock phosphate could further enhance their viability. As energy and greenhouse gas pollutants becoming increasingly important issues, the capturing of these products via digestion or pyrolysis may ultimately become critical. In the meantime, work must continue towards increasing the P use efficiency of plants and enhancing soil biological health by using perennials and rotations to maximise P cycling.

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Comparison of effect of zinc-enriched pod of Phaseolus vulgaris and inner rice husk composts with zinc sulphate and zinc 14% chelate on zinc availability in maize plant in a calcareous soil

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Key words: Zinc-enriched compost, zinc sulphate, zinc chelate, maize, calcareous soil

Abstract

Mixtures of Zn salts and organic matter have been used successfully in controlling zinc deficiency in various crops. The aim of the present study was to optimize the effectiveness, on zinc availability in maize, of natural organic substances by enriching them with zinc sulfate. For this purpose pod of Phaseolus vulgaris and inner rice husk, as abundant organic wastes in the north of Iran, were incubated with increasing quantities of zinc sulphate. The effect of these zinc-enriched composts, zinc sulphate, and zinc 14% chelate on zinc availability in maize in a calcareous soil was studied in a greenhouse experiment. DTPA-extractable zinc of the soil, total zinc concentration, and chlorophyll of plant leaves were measured. Soil applications of all treatments, especially zinc-enriched composts, increased DTPA-extractable zinc more than control treatment, but this increase is not significant for zinc chelate. The plant analysis indicated that zinc-enriched composts of both organic matters significantly increased total zinc concentration in plant leaves more than control treatment, and their effects increased by increasing the level of enrichment until toxic level, even over that of zinc chelate. Non-enriched of both organic matters and zinc chelate had the most effect on leaf chlorophyll and significantly increased the amount of chlorophyll more than control treatment.

Introduction

Zinc deficiency is the most widespread micronutrient disorder among different crops (Westfall et al., 1971).It is more common in calcareous soils. Several organic and inorganic zinc compounds can be used to correct zinc deficiency, but crop response to zinc fertilization varies with the zinc fertilizer sources (Boawn, 1973). Several studies reported that, under greenhouse conditions, the application of nonchelated zinc fertilizers to calcareous soils is less effective than chelated forms of zinc (Hergert, et al., 1984).In comparison to inorganic zinc fertilizers, commercially available zinc chelates are 3 to 5 times as effective, but because of very high cost they are not always economically employable (James, 1992; Hergert, et al., 1984). The aim of this study was to produce two zinc-enriched composts from pod of Phaseolus vulgaris (PV) and inner rice husk (RH) by enriching them with zinc sulphate, then comparing the effect with zinc 14% chelate (Zn-EDTA) on zinc availability in maize (Zea mays L.) in calcareous soil in a greenhouse experiment. These organic matters seem to be especially favourable, because they are abundant in the north of Iran. The pod of

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Phaseolus vulgaris contain many active proteins, and rice husk has a large amount of lignin and cellulose and becomes particularly enriched with carboxyl and hydroxyl groups during decomposition (Bergmann, 1983), which might be able to form organic zinc complexes via chelatization.

Materials and methods

Pod of Phaseolus vulgaris (1000g) and inner rice husk (2000g) were incubated with increasing amounts (0, 1.36, 2.72 and 4.08 % weight) of net zinc as zinc sulphate source (or 0, 4, 8, and 12 % weight from zinc sulphate 34%) in three replications. The incubation was carried out during 80 days for Phaseolus vulgaris and 160 days for rice husk in a greenhouse at constant temperature (30ºC) and enough moisture (moisture > 60%). After the end of incubation, composts were dried (at 65ºC) and weighed. Organic carbon (Walky-black), Total N (Kjeldahl), and total zinc (dry ashing and HCL 2N) were measured (Table 1 and Table 2).

Tab. 1: Chemical analysis of pod of phaseolus vulgaris and inner rice husk

	O.C (%)	T.N (%)	C/N	Total Zinc(ppm)
Pod of Phaseolus vulgaris	69	1.151	59.94	40
Inner rice husk	77.14	1.163	64.32	30

Tab. 2: Chemical properties of produced composts

Composts	Weight loss (%)	O.C (%)	T.N (%)	C/N	Total zinc (%)
Pod of Phaseolus vulgaris	81.874	60.187	2.3	21.162	0.2136
PV+1.36%Zn	73.356	64.74	2.127	30.47	2.8359
PV+2.72%Zn	55.713	65.52	1.655	39.693	3.3565
PV+4.08%Zn	48.54	64.717	1.411	46.382	4.306
Inner rice husk	43.45	62	1.280	48.42	0.0985
RH+1.36% Zn	36	66.8	1.256	54.66	0.7493
RH+2.72% Zn	34.18	68.04	1.175	57.873	2.2197
RH+4.08% Zn	32.15	72.76	1.142	63.747	3.1762

This study was carried out on maize (as a susceptible plant to zinc deficiency) growing in a calcareous soil, in a greenhouse experiment in a completely randomized design with three replications. Physical and chemical properties of calcareous soil are presented in Table (3.). The amount of application of pod of Phaseolus vulgaris composts was 5g/kg soil (0.5%weight of soil), the amount of application of rice husk composts was 10g/kg soil (1% weight of soil), and the amount of application of zinc 14% chelate and $ZnSO_4$ treatment was 10 mg/kg soil of net Zn.

Tab. 3: Physical and chemical properties of the soil.

Deph cm	EC (ds/m)	pH (1:2.5)	T.N.V %	O.C %	P	K	Fe ppm	Mn	Zn	Cu	Texture
0-30	1	7.64	40	0.94	8	240	6.2	0.8	0.63	1.5	loam

Before harvesting, the leaf chlorophyll a and b and total chlorophyll concentration were estimated with a SPAD-502 meter (Minolta Co., Osaka, Japan) in fresh leaves. After 80 days, top organs of the plants were harvested and weighed. Leaves were washed with tap water and three times with distilled water, dried at 65ºC, and weighed. Total zinc and iron and manganese of leaves were measured by dry ashing and HCL 2N method and atomic adsorption spectrophotometry (Varian Spectr AA 220). In the experimental soil, DTPA-extractable zinc was determined by the method of Lindsay and Norvell (1978). These results are presented in Table 4.

Tab. 4: Effect of treatments on the averages of chlorophyll (Ch) a, chlorophyll b, chlorophyll a+b, and total zinc, iron, and manganese values of maize.

Treatment	DTPA Zn $mg.kg^{-1}$	Ch. a $mg.cm^{-2}$	Ch. b $mg.cm^{-2}$	Ch. a+b **$mg.cm^{-2}$**	T- Zn $mg.kg^{-1}$	T-Fe $mg.kg^{-1}$	T-Mn $mg.kg^{-1}$
F_0 (control)	0.57	0.021	0.007	0.029	35.19	28.43	76.2
F_1 ($ZnSO_4.H_2O$)	1.78**	0.027	0.008	0.036	77.22**	50.1	79.7**
PV[1](Phaseolus vulgaris)	5.71**	0.029 **	0.009	0.039**	90.6**	42.1**	77.1**
PV+1.36%Zn	12.67**	0.026	0.008	0.034	314.5**	52.4**	89.9**
PV+2.728%Zn	13.98**	0.026	0.008	0.034	392.3*	50.33 **	82.67
PV+4.08%Zn	14.48**	0.024	0.007	0.0317	532.2**	62.8**	94.3**
RH[2] (inner Rice husk)	5.89**	0.028	0.009	0.037**	99.6**	14.9**	73**
RH+1.36%Zn	12.87**	0.027	0.008	0.036	300.4**	42.8**	91.16 **
RH+2.72%Zn	13.64**	0.024	0.007	0.031	438.6**	38.5**	91.7**
RH+4.08%Zn	14.48**	0.022	0.007	0.028	550.8**	28.4**	105.4 **
Zn 14%chelate (Zn-EDTA)	0.86	0.030**	0.009 **	0.040**	141.3**	29.7**	79.4**

Results and Discussion

Results indicated (Table4) that soil application of all treatments, especially zinc-enriched composts, increased DTPA-extractable zinc more than control treatments, but this increase is not significant (α=0.01) for zinc chelate. In zinc-enriched composts of both organic matters with increasing percentage of enrichment, DTPA-extractable zinc of the soil increases. The plant analysis showed that zinc-enriched composts of both organic matters, significantly (α=0.01) increased total zinc concentration in plant leaves more than control treatments, and their effects increased by increasing levels of enrichment until toxic level, even over that of zinc chelate, just like DTPA-extractable zinc of the soil. Non-enriched composts of pod of *Phaseolus vulgaris* and rice husk and zinc chelate had the most effect on leaf chlorophyll and significantly (α=0.01) increased the amount of chlorophyll a, b, and a+b more than control treatment. However, in zinc-enriched composts of both organic matters, with increasing percentage of enrichment and increases of zinc concentration in the soil, the amount of chlorophyll decreases. Iron chlorosis symptoms appeared in these treatments. Wallace et al. (1976) reported that high amount of zinc resulted in Fe deficiency on soybean. Safaya (1976) reported a positive effect of applying zinc on Mn in plants. Mn and Fe had indicated antagonistic effect with each other too**.** Hewitte (1948) reported that manganese and heavy metals with similar chemical properties like iron might react with porphyrin compounds, thereby inactivating them for subsequent conversion to chlorophyll.

Conclusion

As a concluding remarks, the presented data showed that application of composts of pod of Phaseolus vulgaris and inner rice husk had same effect as zinc 14% chelate even, over than it. Zn-enriched composts treatments showed zinc toxicity. We suggest to use these products with Fe–fertilizers. Caused chlorose by rice husk compost was by rice husk compost stronger than Phaseolus compost. Contrary to zinc 14 % chelate, the compost of Phaseolus vulgaris or rice husk is not of high costs and farmers may produce it themselves.

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Nitrogen Utilization in Integrated Crop and Animal Production

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Key words: nitrogen utilization, nutrient circulation, integrated production

Abstract

The principles of organic production are based on integration between crop and animal production and self-regulated nutrient intensity. A comparison between specialized dairy and crop farm models and an integrated dairy and crop farm model showed 24 % higher total production per area and higher nitrogen utilization in the integrated system. The main factors were more efficient nutrient circulation, better utilization of legume crops and low intensity of nitrogen on non-legume crops.

Introduction

The main factors influencing nutrient utilization in agriculture are the production line (crop vs. animal production) and the degree of intensity and specialization of production. Organic production is based on integration between crop and animal production and self-regulated nutrient intensity. However, many organic farms are specialized in crop production based only on green manure and farm yard manure (FYM) from neighbouring farms. On the other hand, animal farms widely use purchased fodder. All of this may effect the utilization of nutrients, yet hardly any comparisons or analytical surveys between specialized and integrated (organic) farms can be found in literature.

The aims of this study were:
a) To model specialized organic crop and animal farms and an integrated farm
b) To identify the differences in nutrient balances and utilization between the models
c) To optimize nutrient utilization by means of integrating crop and animal production

Material and methods

A more detailed analysis was made of nitrogen (N) utilization on 9 organic farms in eastern Finland. The farmers were personally interviewed in 2004 and all the main nutrient flows were identified for the years 2002-2004. The assumption of a steady-state with balanced systems and reserve nutrients in the soil was applied. Biological N fixation (BNF) was assumed to account for 70 – 90 % of the total nitrogen content in the legume biomass (Kristensen et al. 1995, STANK 1998, Väisänen 2000). Red clover, white clover and alsike clover were grown in perennial mixture leys. Pea and annual vetch were annual legumes. (Seuri 2005).

Equal amounts of milk, beef and bread cereal were produced either on a specialized dairy farm (D) model and a specialized crop farm (C) model jointly or on an integrated dairy and crop farm (I) model. The share of fodder production was 80 % and bread cereal 20 % of the total yield, based on the average Finnish diet and use of arable land. BNF and atmospheric deposition (5 kg/ha annually) were the only external inputs of nitrogen (=primary nitrogen) in both systems. On farm C, all the harvested yield was

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sold (either to farm D as fodder or outside the system as bread cereal) and no FYM was used. On farm D, all the harvested yield was used as fodder. In addition, about 20 % of the fodder was purchased from farm C. All of the FYM was used only on farm D. On farm I, no fodder was purchased, but 20 % of total yield was sold as bread cereal.

Results

The major characteristics of the farm models are presented in Tables 1 and 2; more detailed N utilization is presented in Table 3.

Tab.1: Characteristics of three farm models: Specialized Dairy Farm (D), Specialized Crop Farm (C) and Integrated Dairy and Crop Farm (I). Both of the dairy farms (D & I) keep equal numbers of calves for replacement, all others are sold immediately after the suckling period. Replacement of the cows takes place after three milking periods.

	D	C	I
Crop rotation / (crops %)			
ley / green fallow	3 yrs. (60%)	2 yrs. (40%)	2 yrs. (40%)
cereals	2 yrs. (40%)	2 yrs. (40%)	2 yrs. (40%)
rape seed	-	1 yr. (20%)	-
cereal+peas	-	-	1 yr. (20%)
Legumes % / non-legumes %	60 / 40	40 / 60	60 / 40
Yield level (FU/ha & N kg/ha)			
ley /(green fallow)	3200 & 85	(green fallow)	3200 & 85
cereals	2200 & 42	2200 & 42	2000 & 38
rape seed	-	1800 & 42	-
cereal+peas	-	-	2000 & 52
Harvested N yield (kg/ha)	68	25	60
Animal density (AU/ha	0.71	-	0.43
Milk yield (kg/cow)	7350	-	7000

Tab. 2: Legume yields and BNF on farm models. C*, no legume yield is harvested, but ploughed in as green manure; only the first year ley exists (twice in 5-year-rotation) on farm C.

Crop	Farms D & C*	Farm I	Farms D, C & I
	Yield (FU/ha)	Yield (FU/ha)	BNF (N kg/ha)
First-year ley	3600	3400	120
Second-year ley	3200	3000	80
Third-year ley	2800	-	40
Cereal + peas	-	2000	40

The total average BNF is equal (48 kg/ha) in all the farm models. However, there is quite great variation between N intensity on non-legumes (=manure or green manure for non-legumes). The N intensity on non-legumes is highest on farm D (100 kg/ha), due to high amount of manure on a limited non-legume area (40%). Also on farm C the N intensity is higher (80 kg/ha) on non-legumes than on farm I (65 kg/ha). (Tab. 3).

Due to the lower N intensity on non-legumes, 10 % lower crop yield is assumed on farm I than on D and C (Tab. 1.).

Despite the lower yield level because of lower N intensity on non-legumes, the average total production is higher in integrated production (I) than in specialized production (D+C). More arable land, 24 %, is needed on the specialized farms than on the integrated farm to produce an equal “food basket” (milk, beef and (bread)cereal) (Tab. 3.). This is due to the green fallow on the specialized crop farm.

Tab. 3: N flows and balances in three model systems. Comparison by equal total production, I vs. D+C (sum of 0.57 ha D and 0.67 ha C equals 1 ha I); and by equal area (1 ha).

*Note: System boundaries are slightly different between EP and EA (**bolded** figures); e.g. purchased fodder in EP is not an input or output, but within system boundaries as it is purchased from farm C; in EA it is external input (farm D) and output (farm C).*

				Equal production (EP)			Equal area (EA)	
			I	D+C	D	C	D	C
	symbol	unit	(1 ha)	(1.24 ha)	(0.57 ha)	(0.67 ha)	(1 ha)	(1 ha)
Harvested N yield [1]	Y	(kg N)	60	56	39	17	68	25
N intensity on non-legumes [2]		(kg N/ha)	65	89	100	80	100	80
Deposition	p_1	(kg N)	5	6	3	3	5	5
BNF	p_2	(kg N)	48	60	28	32	48	48
Total fodder	F	(kg N)	51	47	47		82	
Fodder harvested	F_h	(kg N)	51	-	39		68	
Fodder purchased	F_p	(kg N)	-	-	**8**		**14**	
FYM (= F-A-L)	M	(kg N)	26	23	23		40	
FYM (fodder harvested)	m	(kg N)	26	-	19		33	
FYM (fodder purchased)	p_3	(kg N)	-	-	**4**		**7**	
Losses outside field [3]	L	(kg N)	13	12	12		21	
Animal products sold	A	(kg N)	12	12	12		21	
Crop products sold	C	(kg N)	9	**9**		**9 (+8)**		**25**
Primary N (= p_1+p_2+p_3)	P	(kg N)	53	**66**	**31**	35	**60**	53
Secondary N (=M-p_3)	S	(kg N)	26	**23**	**23**		**33**	
Circulation factor (P+S)/P		(-)	1.49	**1.35**	**1.75**	1	**1.55**	1
Farm gate balance p_1+p_2+Fp-C-A		(kg N)	32	**45**			**46**	28
output/input (C+A)/(p_1+p_2+Fp)		(-)	0.39	**0.32**			**0.32**	0.47
Field balance p_1+p_2+M-Y		(kg N)	19	**33**			**25**	28
output/input Y/(p_1+p_2+M)		(-)	0.76	**0.63**			**0.73**	0.47
PPB [4]= Y/P		(-)	1.13	**0.85**	**1.25**	0.47	**1.14**	0.47

1 See table 1.
2 FYM or green manure N for non-legumes
3 40 kg N/cow (incl. young cattle for replacement) (Grönroos et.al. 1998)
4 Primary production balance (Seuri 2005)

The nutrient balances describe the nutrient utilization, whereas comparison by area does not show any clear difference between the models. Comparison by equal total production indicates better utilization on the integrated farm than on the specialized farms jointly by all the indicator balances used (farm gate balance, field balance, PPB). The difference between primary N is 24 % (53 kg vs. 66 kg) for equal total production.

The major difference between these two production strategies is nutrient circulation. In the integrated system (I) the circulation factor of N is as high as 1.49. In the specialized system (D+C) it is clearly lower, 1.35. Another major difference is the poor field balance (0.47) in the specialized crop production compared to the field balance in the integrated system (0.76). This indicates the importance of utilization of legume yield. On farm C, no legume yield is utilized as a final output of the system, but only as a source of N for a non-legume cash crop.

Conclusions

N intensity is highly dependent on the proportion of legume crops in the crop rotation. However, with increasing proportion of legumes in the crop rotation, the risk of serious pathogen problems increases. Generally, the maximum proportion of legumes in crop rotation is around 60 %. Model D is based on this hypothetical maximum legume area. In addition, the amount of FYM is increased by 20 % using purchased fodder. Farm D has a slightly higher circulation factor and PPB than farm I, and the total yield is also slightly higher. Since the final products of these two farms are not equal, the comparison is misleading.

Model C is based on a minimum legume area, since legume crops are not cash crops at all. Hypothetically, a slightly lower N intensity on non-legumes could be possible. However, the risk of total crop failure and poor quality of yield in unfavourable weather conditions increases drastically. The poor PPB (0.47) reflects the weakness of the system: no nutrient circulation at all and no direct utilization of legume crops.

Model I is run with the lowest possible N intensity on non-legumes. However, the risk of total crop failure and poor yield quality can be controlled with help of (ruminant)cattle. The circulation factor is lower than in model D because of the 20 % cash crop area. However, legume crops are managed more efficiently resulting in the highest field balance (0.76). In order to produce the given "food basket", this model is superior to the specialized alternative (D+C). According to the present data, this model has close to optimum N utilization. However, other nutrients must be replaced by completing nutrient recycling or from external sources.

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New Approaches to Phosphorus Regulation and Management

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Key words: Phosphorus, certification, research, farming system

Abstract

Phosphorus (P) conservation and the environmental, ecological and economic issues related to over-use and under-use of P on organic farms are addressed. Re-examination of Certification Standards is recommended to ensure the conservation and efficient use of P through adaptation of organic management to local conditions, ecology, culture and scale. Changes that will conserve P and minimise environmental risk are identified, along with the necessary research to make this possible.

Introduction

P export from organic farms is not an issue where soil is fertile, P export is low, and crop and livestock production are balanced by high internal recycling of nutrients, as in mixed farms of the Swiss Midlands (Maeder *et al.* 2002) - few farms can even aspire to this ideal. For others, P is a non-renewable input which is mostly derived directly, or indirectly, from declining stocks of rock phosphate (RP). Paradoxically, available soil-P is declining on some farms/regions causing economic and ecological concern, whilst increasing in others to the point of ecological concern. Here we overview the literature on P in organic farms and make a case-study of Australia to (i) explore whether the cornerstone values of organic production are being maintained, (ii) examine the case for changes in the Certification Standards, and (iii) identify research priorities.

The stocks and flows of P

Soil P dynamics are outlined by Smeck (1985) **-** the '*soil solution'* contains small amounts of dissolved organic and inorganic P. A greater proportion of the total P is chemically *sorbed* in soil or held in readily mineralisable organic forms. Sorbed P replaces plant uptake from the soil solution. In naturally fertile or over-fertilized soils the stock of sorbed P is large: in parts of Europe and North America good crops have been grown without P-fertiliser for decades by depleting sorbed P. Most soil P is in *sparingly soluble* minerals or inaccessible organic matter. Newly added dissolved P is sorbed within hours/days of application or being mineralized, and is eventually 'fixed' into slowly available forms – in Australian studies only 10-20% of applied P is used by plants in the year of application (Bolland and Gilkes 1998, Bünemann *et al.* 2005). Biological changes under organic management may increase access to less available forms of P (Jakobsen *et al*. 2005), plants may be selected for improved access to less-available P (Harvey 2008), and organically-grown plants may access more subsoil P than conventional crops (Cornish 2008). These processes only delay the requirement for P to be replaced by fertiliser or manure (Cornish 2008). If not, the plant-available fraction of P will be exhausted. All ecosystems need to replace the P removed.

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Most P absorbed by agricultural plants passes to humans, directly or via animal products. Animal waste is mostly returned to soil, but human waste has in the past mostly returned to surface water in sewage - a major stock of P denied to organic farmers. This policy removes humans from the ecosystem, depletes P from terrestrial ecosystems and contributes to nutrient enrichment of surface waters. All farmers 'trade' P by importing fertiliser, manure, compost and grain, and selling products. As a result of the global and regional P-trade, parts of Western Europe and North America have greatly elevated P concentrations in soil, including any organic farms with a positive farm P balance (Stockdale and Watson, 2002; Oberson and Frossard 2005). Elsewhere, concern is generally for declining soil P and productivity (Cornish, 2008). If no P is applied, the soil stock of P is depleted, which may be *desirable* if it reduces environmental risk, or *undesirable* if P deficiency reduces the protective cover of vegetation over erosion-prone soils and when it forces farmers into low profitability or food insecurity.

Environmental threat from excess nutrient use

Intensive agriculture in Europe is regulated to reduce the environmental risk from N or P inputs significantly exceeding outputs. It may take years for a positive P balance to increase risk over a farm, but localised areas can be at risk earlier. Risks emerge quickly in soil with low P sorption capacity. The issue is complex when manure is used for fertiliser. It is impossible to regulate the use of manure to manage both N and P together. Where manure is the main source of N for crops, more P is applied than necessary (Wells *et al*. 2002), increasing environmental risks. Separating animal and crop enterprises amplifies the problem, yet stockless grain farms and intensive animal enterprises may both be certified. Both face significant issues: ecologically responsible disposal of animal waste; or for farmers who depend on imported manure for N, reduced need for manure achieved ultimately by including more legumes in rotations.

Environmental threat from insufficient phosphorus fertiliser use

Soil P may be low, as with subsistence farmers in parts of Africa (Oberson, unpublished) and India (Cornish, unpublished), and in developed economies such as Australia (National Land and Water Audit, 2001). P export without replacement further lowers concentrations of available P, reduces N-fixation by legumes, and cuts plant productivity. P is transferred from grazed to cropped areas and from there to humans either directly in grain or in meat from animals fed on the grain. In poor rural communities nutrient transfer to near the homestead impoverishes grazed land and increases grazing pressure and land degradation, whether organic or not.

Fertilizer use, phosphorus deficiency, and economic viability

Manure is not always available to organic farmers. In lesser-developed countries manure is in short supply if it is used for fuel, and although individual land holdings may be small, animals range over 'common' areas so manure collection is not feasible (Bationo *et al*. 2007). Manure collection is also not possible in some developed regions with low-moderate rainfall as in Australia where crops are produced on large mixed farms. In Europe and North America stockless farms have limited access to manure although most of them have enjoyed sufficiently high fertility to raise crops organically without P-fertiliser. However, P concentrations are falling, questioning the sustainability of this practice. Conventional soil testing may not provide answers. Failure to use fertiliser in each of these situations has serious economic consequences. The major fertilisers used in organic farming are based on reactive phosphate rock (RPR) which requires acid soil and sufficient rainfall to be effective.

This excludes much of the world where available soil P is low and fertiliser is needed, including southern Australia where RPR is ineffective in organic crops (Dann *et al*. 1996). This, combined with poor supplies of manure or compost, makes soil P management very difficult for a large grain-producing area. The farmers have tried many P fertilizers, yet productivity is low (Cornish 2008). Their over-optimistic use of fertiliser is uneconomic, inefficient and not in accord with basic principles of organic farming. Yet animal and cropping enterprises are integrated and much of the grain is retained on-farm, thus recycling nutrients in strict conformity with organic principles. **The Standards** do not accommodate the economic imperative to lift productivity from impoverished soil in which allowable forms of P are ineffective or unavailable. This is not a healthy ecosystem, and nor is it sustainable, even if good organic practice is otherwise observed. Soluble P added to soil with *high P sorption capacity* and *low solution P* is rapidly incorporated into bio-geochemical cycling. The soluble P feeds the soil, which in turn feeds the plant. Adding soluble P when necessary to maintain soil health seems, to us, to adhere to the organic maxim: “feed the soil, not the plant”.

It is important for organic farming to maintain the principles of minimising imports by maximising opportunities for recycling; maximising efficiency of resource use; and supporting plants through the soil ecosystem. It is also important that the soil ecosystem itself be ‘fed’. Our present knowledge and fertilizer options leave some important situations, exemplified in the foregoing overview and Australian studies, where soluble P remains the only option for feeding P to the soil ecosystem in a way that it can support economic levels of plant production.

Nutrient deficiency reduces water-use efficiency

In water-limited environments, water is the most precious resource after land, and yet nutrient deficiency often sets an upper limit to yield. Farmers have *some* control over nutrients but *little* control over water. With low nutrient inputs, stable production is achieved, but at the cost of a low level of productivity. Production in natural ecosystems in such environments varies inter-annually in response to varying rainfall. Stable but low level yields are not a sign of sustainability.

Organic Certification Standards

Farming systems evolve in a more complex socio-economic environment than when Standards for organic production were first conceived. For example, it could not have been anticipated that changing ‘culture’ and scales of production would lead to the stockless or intensive animal farms now accommodated within the Standards, without ensuring that subsequent problems of nutrient enrichment or depletion are managed. Organic principles embrace the idea of “adaptation of organic management to local conditions, ecology, culture and scale”, but there are many examples of failure to adapt or develop systems that (i) adequately conserve or recycle P, (ii) reflect the unavailability of organic-P sources despite sound organic practice, (iii) reflect gross differences in soils between regions and (iv) differences in the capacity of soils to retain P against environmental losses. The application of Organic Standards has focused on details, whilst in some ways blurring the fundamental aims.

We recommend overhauling the Standards to reassert the core values and objectives of organic farming. Greater sophistication in their interpretation and application is needed, informed by science, to match the heterogeneity in farming systems, regions, soils and cultures. *Accumulation and decline in P must both be addressed, including* *an allowance for soluble P where it is the only option for feeding P to the soil ecosystem.* Here, the same flexibility is needed that in Europe allows (i) soluble potassium as K_2SO_4 to be used and (ii) accommodates both stockless farms and intensive livestock farms, against all ecological principles. Greater attention is needed in the Standards to nutrient recycling, plus monitoring and evaluation of trends in soil P and the balance of P at the farm gate.

Research and extension

Priorities are to quantify P cycling processes and develop suitable soil tests for organic farms; to improve plant access to reserves of soil P where they are high; to develop strategies for farmers to manage the transition from P sufficiency to deficiency; and to improve the availability of RP. Cultural change should allow the unsustainable blanket ban on human waste to be reconsidered and foster research to make it safe. Other ways to recycle nutrients need to be identified and promoted along with opportunities to reduce P inputs where they are needlessly high. Farmers should also be alerted to the potential costs of over depleting soil P. Fertility management products, and techniques involving paid services (e.g. the 'Albrecht' system) need proper evaluation.

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Economic aspects of the application of different organic materials as N-sources in organic production of lettuce

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Key words: lettuce, fertilization, yield, profit

Abstract

In a field experiment on a farm registered for organic production, we studied the effect of the application of different organic materials (OM): farmyard manure (FYM), guano (G), soybean seed (S), forage pea seed (P) on lettuce yield. Besides yield, we also analyzed the economic profitability of the application of different OM. Fresh lettuce yield was significantly higher with OM treatments than with the treatments without fertilization. The highest yield was obtained with the FYM treatment (43.7 t ha^{-1}), and the lowest with the application of P (42.0 t ha^{-1}). The highest additional profit was obtained with the FYM treatment (1123 EUR ha^{-1}) and the lowest with the application of P (475 EUR ha^{-1}).

Introduction

Organic production does not allow the application of mineral fertilizers obtained industrially so the lack of mineral forms of nitrogen (N) early in the spring is often a factor which limits the yield of early crops, even on naturally fertile soils. The application of organic fertilizers with higher contents of N (>1.5%), i.e. a narrower C/N ratio (<20), and their mineralization in the soil can release significant amounts of N in a mineralized, available form and so satisfy the needs of crops for N (Amlinger et al., 2003; Bavec et al., 2006). The aim of this paper is to study the effect of the application of different OM (organic N fertilizers) on lettuce yield and profitability.

Materials and methods

In a field experiment set up on a farm certified for organic production, during the year 2007 we studied the effect of the application of different OM on one set of lettuce (*Lactuca sativa sub.sp. sekalina*) yield. Besides the yield, we also analyzed economic profitability of the application of OM. The experiment was set up applying random block system with four replications. The treatments were: rotten farmyard manure (FYM), guano (G), ground soybean (*Glycine hispida*) seed (S), ground forage pea *(Pisum sativum)* seed (P). OM fertilization doses were calculated with the following formula:

$$Nf = (Ntg-Ni-Npot) / k \quad (1)$$

When values for Ntg, Ni and Npot are entered into Equation 1, we get:

$$Nf = 40 \text{ kg N ha}^{-1} / k \quad (2)$$

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Nf – amount of N applied through different OM (kg N ha^{-1}); **Ntg** – amount of N required for the projected lettuce yield (120 kg N ha^{-1}); **Ni** – mineral N content in the soil at the time of sowing (32 kg N ha^{-1}); **Npot** – amount of mineral N which will be released by the mineralization of organic matter in the soil during lettuce vegetation (48 kg N ha^{-1}); **k** – coefficient of the availability of total N applied through different OM (potentially mineralizable N). Npot and k values were calculated with a previously performed incubation experiment (unpublished data) and are given in Tab. 1.

Tab. 1: Basic data on OM and applied amounts of N in experimental plot

Treatments[1]	N total (% DM[2])	P total (% DM)	K total (% DM)	C/N ratio	K[3]	OM applied (kg ha^{-1})	Nf [4] (kg ha^{-1})
FYM	2	1.06	2.14	10.41	0.268	7421	148
G	15.32	0.14	0.07	2.89	0.670	391	60
S	6.65	1.08	1.18	7.50	0.377	1593	106
P	4.08	0.83	0.68	10.17	0.334	2912	119

[1] FYM, farmyard manure; G, guano; S, soybean seed; P, forage pea seed; [2] DM, dry matter; [3] k, coefficient of the availability of total N applied (potentially mineralizable N); [4] Total amount of N applied through different OM

Organic materials were applied immediately before sowing. The area of the experiment plot was 5.4 m^2, between-row spacing was 0.3 m and within-row spacing 0.25 m. Lettuce was sown on 18 March and harvested on 12 May. After sowing lettuce was covered with agril foil which was removed after four weeks. Soil humidity during vegetation was maintained at the level of 60-70% of field capacity, with “Tifon” irrigation system. Basic characteristics of the chernozem on which the experiment was set up: pH 7.52; 0.17% $CaCO_3$; 1.92% C; 11 mg $100g^{-1}$ Al-P_2O_5 and 26.8 mg $100g^{-1}$ Al-K_2O.

Results

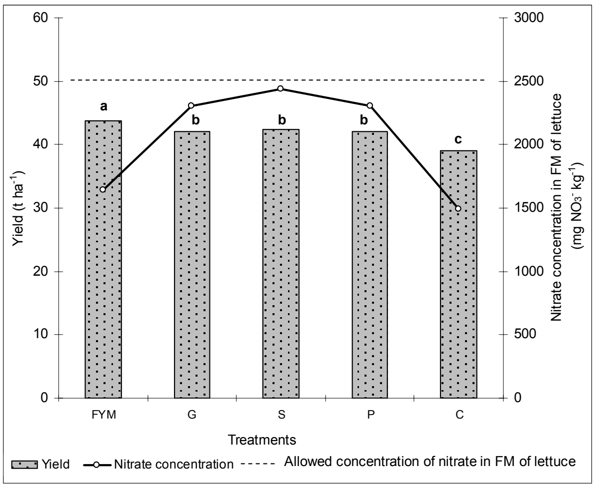
Economic profitability of the application of FYM and G was calculated using their market prices (Tab. 2). For the calculation of economic profitability of the application of S and P we used the data on production costs (The Association of Cooperative Farms of Serbia) for the projected yield of 2.2 t ha^{-1} (S) and 3.0 t ha^{-1} (P).

Tab. 2: Costs of the production of S and P and market prices of FYM and G in 2007

Costs	FYM	G	S	P
Total costs of production/purchase[1]	16	250	265	265
Costs of OM preparation and incorporation (EUR ha^{-1})	50	50	70	70

FYM, farmyard manure; G, guano; S, soybean seed; P, forage pea seed; [1] For FYM and G EUR t^{-1}; for S and P EUR ha^{-1}

Fresh lettuce yield was significantly higher with OM treatments than with treatments without fertilization (Figure 1). With FYM lettuce yield was significantly higher both than the control and than other fertilization treatments. Among G, P and S treatments there were no significant differences, because the same amount of potentially mineralizable N was applied.



FYM, farmyard manure; G, guano; S, soybean seed; P, forage pea seed; C, unfertilized plot; FM, fresh matter; Yield followed by different letters was significantly different at P<0.05

Figure 1: Fresh lettuce yield and profit made compared to the control

At harvest concentrations of NO_3^- in the fresh matter of lettuce was within the limits of maximum allowed concentrations (Commission Regulation (EC) No 466/2001). Tab. 3 shows additional profit calculated on the basis of market prices of lettuce (0.38 EUR per kg), reduced by harvest, packing and sale costs (0.1 EUR per kg of lettuce) and by the cost of the application of OM. The calculation does not include the costs of the production of lettuce because they were the same for all treatments. The profit therefore is the additional profit made through the application of OM.

Tab. 3: Economic indicators of the application of different OM

Treatments[1]	Differences in yield compared to control (kg ha^{-1})	Price of 1 kg N from different OM (EUR kg^{-1})[2]	N total applied (kg ha^{-1})	OM application costs (EUR ha^{-1})[3]	Additional net profit on fertilized plots (EUR ha^{-1})
FYM	4608	0.8	148	168	1123
G	2954	1.62	60	147	680
S	3204	1.9	106	271	626
P	2899	2.25	119	337	475

[1] FYM, farmyard manure; G, guano; S, soybean seed; P, forage pea seed; [2] Calculated on the basis of the production costs (S, P) and market prices (FYM, G); [3] Calculated on the basis of the price of N unit and costs of preparation and OM soil incorporation

FYM had the lowest price of N unit, which is 2-3 times lower than the other OM (Tab. 3). The costs of the application of S and P were approximately two times higher than the prices of FYM and G. As a result of the highest price and lowest yield, the lowest additional profit was made with P treatment. The highest profit was made with FYM treatment.

Discussion

Significantly higher lettuce yield with FYM treatment can be explained by the fact that the application of FYM has a positive effect on physical and chemical characteristics of the soil (Cuvardic et al. 2006), and with the fact that its application introduced significantly higher amounts of P and K into the soil than was the case with other treatments (Tab. 1). Nitrogen use efficiency in the field corresponded to C/N ratio (r^2 = 0.95) and coefficient k determined by incubation experiment (r^2 = 0.80). Nitrogen use efficiency was in the range from 12.16% (FYM) to 28.33% (G). With all applied treatments except FYM the application costs were proportional to the price of N unit. High costs of FYM application when compared to the price of N unit are a result of relatively low content of total N and a low availability coefficient (k). When we compare S, P and G treatments, among which no significant differences in yield were recorded, G proves to be the most economical OM, which had lowest application costs and highest additional profit.

Conclusions

The application of studied OM resulted in a significant increase in lettuce yield, ranging from 2.9 (G) to 4.6 t ha^{-1} (FYM), compared to the control and additional profit ranging from 475 (P) to 1123 EUR ha^{-1} (FYM). If mineralization potential and the content of mineral N in the soil during sowing are taken into account when fertilization norms are being determined, profit can be made even when expensive fertilizers such as S and P are used. The highest profit was made with FYM treatment and lowest with P treatment which had the highest price of N unit.

Acknowledgments

This work was funded by the Ministry of Science and Environment of the Republic of Serbia, project number TR 6906B. We are grateful to Andria Vozar, the farmer who helped us in our research.

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Element composition and quality of lettuce (*Lactuca sativa* var. Biweri), grown with sheep-manure composts

Radics, L.[1], Pusztai, P.[1], Biró, B.[2], Biró, Zs.[1], Németh, T.[2] & Monori, I.[3]

Key words: compost, manure, phosphorus, nitrogen, lettuce

Abstract

Two representative Hungarian soil-types (slightly humus sandy and loamy saline) were used to study the effect of various compost-products, made from sheep-yard manure and phosphorous amendments on the biomass-production of lettuce (Lactuca sativa var. Biweri) in a pot-experiment. Two types of phosphorous amendments, such as raw-phosphate with high- or a phosphorous rock with low solubility were used as amendments during the twelve-week composting process. Pots of five-hundred g weight were used and considering the ecophysiological demand of the lettuce, low (30 t/ha) optimum (60 t/ha) and provocative (120 t/ha) levels of manure compost were applied to the soils. Yield of lettuce and mineral content analysis were done by ICP and soil-analysis by TVG. Statistical differences were shown (LSD5%) following ANOVA. An increasing yield of lettuce was recorded simultaneously by the compost doses up to the provocative level at both soil-types. Effect of composts was found to be the best at the low-fertility sandy soil with slight humus content. Among the compost-types, the low-releasing-phosphorous-rock was the most appropriate also on the sandy soil. Summarizing the results, sheep-manure-composts could be the prospective amendments for the low-fertility soils.

Introduction

It is common to improve the soil fertility with different types of artificial and natural fertilisers in the farming practice (Biró et *al*. 2005). Composting has become an everyday routine in manure treatments nowadays to keep the original nutrient value, improve the physical characteristic and to speed up the biological degradation, while reducing the nitrate-nitrogen losses (Füleky, 1999).

It is expected that composts enriched with different amendments can provide advantages (ie. higher yields) or disadvantages because of some plant chemical ingredients (e.g. higher nitrate content) depending of the actual type of the compost, dosage and not least of the soil type. Our experiment was targeted on getting information on these parameters. Typical Hungarian soil types were selected and used for the test with different dosage of sheep manure based compost mixed and amended with different substances. All the rules of organic farming regulation were strictly kept when the amendments, manure and management were selected (Radics, 2001).

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Materials and methods

Two representative, but in their main characteristic different Hungarian soil-types (low humus sandy soil and loamy saline one) were used to study the effect of various compost-products. Sheep manure was composted for 3 month. This compost was completed with phosphorous amendments to measure the effect of different compost mixtures on the biomass-production of the lettuce in a pot-experiment.

Originally the research involved nine compost types. We've also examined the effect of some compost types, which were ameliorated with selected phosphates. Phosphorus is one of the most crucial nutrients in the soil because of its low availability. During the composting process we used a highly soluble raw-phosphate (K4) and a high phosphorous content rock (K7) of low solubility (Zapata, 2004). The added phosphate provided more continuous nutrient supply. The particular amount, the mixture content and the technology itself are under procedures for obtaining patent protection, so that it is not public yet. Two controls were used: sheep manure compost with zero P amendment (K1) and pure soil without any compost as null control (K0). After completing the compost mixtures, soil and compost samples were dried, ground and filled into the pots. To find the optimal amount of compost three different doses were tested according to the needs of lettuce as it was cited in literature. Low level was 30 t/ha equivalent, optimum level was 60 t/ha equivalent and provocative level was 120 t/ha equivalent dosage. The total weight of soil and compost sample mixture was 500g in pots and was placed in a light room (Penning, 1989).Fresh weight of shoots, length and width of leaves of lettuce were measured after 10 weeks and dried to a constant weight on 65 °C before the plant nutrient content was analysed (ICP). Soil samples were scrutinized with standardised general and full analyses (TVG**). Data were analysed by one-way ANOVA with t-test.

Results

The total nitrogen content of lettuce leaves is shown on Figure 1.

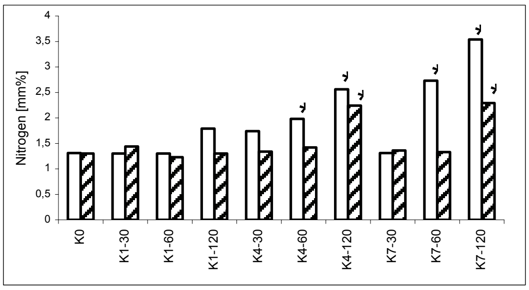

Figure 1: Total nitrogen content in the leaves of lettuce on slightly humus sandy and (solid white) loamy saline soils (stripped) depending on different compost doses. Significant differences from zero phosphorus amendment (K1-x) are labelled with *.

. Standardized General Full Chemical Plant Analysis

** Standardized General Full Chemical Soil Analysis

Mineral content analyses of lettuce showed that the total nitrogen content of lettuce was practically equal on both examined soil types. Compared to the control treatment (pure sheep manure, K1) the highest dose showed significant difference in most cases.

But, on sandy soil plots, the treatment with medium dose compost with raw-phosphate amendments also gave significantly higher nitrogen content of lettuce.

Each treatment had significantly higher phosphorus content in lettuce leaves compared to the control treatment (no added phosphorus, K0) on sandy soil plots except the smallest dosage of phosphorous rock. The smallest dosage could only be significantly higher in raw phosphate amended mixture on saline soil plots. Phosphorous rock was more effective to provide nutrients for lettuce than raw phosphate.

Phosphorus content in the leaves of lettuce is shown on Figure 2.

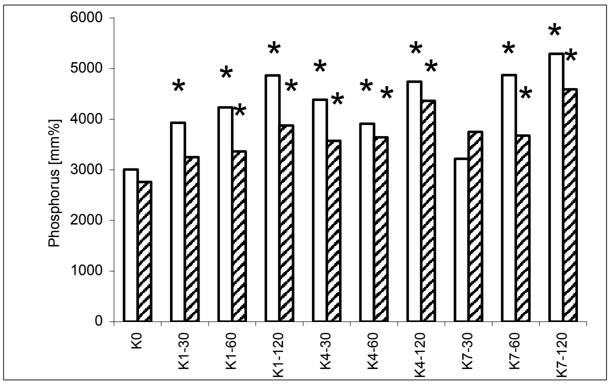

Figure 2: Phosphorus content in the leaves of lettuce on slightly humus sandy and (solid white) loamy saline soils (stripped) depending on different compost doses. Significant differences from zero phosphorus amendment (K1-x) are labelled with *.

The phosphorus content is significantly higher in lettuce leaves compared with the control treatment (K0) in almost all doses on sandy soil tests. The only exception was the smallest dose of phosphorous rock compost treatment.

Low-dose treatments could only have significant effects on plant phosphorus content if the treatment was raw-phosphate enriched compost in loamy saline soil test.

Comparing compost mixture varieties, phosphorous rock treatment effectively increased phosphorous content of lettuce. Presumably phosphorous with slow solubility is ideal because it provides steadier availability during the growing season. Increment of phosphorous content was less on loamy saline than on sandy soil, but differences were still well detectable.

Discussion

Mineral content of lettuce strongly increased under high doses of compost on sandy soil. The total nitrogen content was 2-3 times higher in the lettuce leaves in these cases. This phenomenon indicates that there is a potential risk of the nitrate-accumulation especially on sandy soil as it could be found in the literature (Biró et al. 2005, Fodor et al. 2006).

Changes of phosphorous content were similar to the ones of the nitrogen content. It was verified that phosphorous amended compost could provide more soluble phosphorous to the soil and to the crops compared with not treated compost.In the case of loamy saline soil, significant nitrogen-growth was also observable in the soil at the end of the growing season, but in the lettuce leaves only. The highest dose of both compost forms caused a significant difference. Accordingly, the risk of nitrate and nitrite uptake is lower compared to sandy soils.

Summarising economical, environmental and food-quality aspects low and medium doses of compost seems to be expedient. When you determine doses at establishment of a new crop production system, basic physical, chemical and biological characteristics of the soil and quality of the applied compost should be considered too, as other authors referred it also (Radics, 2001; Seléndy, 1999; Füleky, 1999, Várallyay, 2002).

Conclusions

Summarizing the results, the sheep-manure-composts could be a promising amendments for the low-fertility soils and it is recommended to use as compost for lettuce. At the higher doses, however, beyond the optimal level for organic agricultural conditions, there could be a potential risk of nitrate-accumulation, which needs to be considered at the frequent application. However, it is expected that the results are the same under field conditions, it is necessary to extend the experiment to outdoor trials to get information about the true effect in the circumstances of a farm production.

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Potentials of beneficial micro-organisms

Plant-probiotic microorganisms for a sustainable buffer of input reduction in organic and low-input tomato production systems

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Key words: Organic tomato; Input reduction; Plant-probiotic microorganisms; Sustainable production; Farmer participation.

Abstract

A consortium of plant-probiotic microorganisms is under investigation in open field conditions, at the ICEA-certified Organic Farm "La Carioncella", for its ability to ensure durable soil fertility while buffering nutritional inputs reduction. The primary objective of our QLIF-WP333 three-years-long project is to produce scientific data to help farmers in managing soil probiotics, as a way to reduce inputs, production costs, while keeping quality and sustainability of organic and low-input tomato production systems.

Introduction

The root surface and the close rhizosphere are habitats where microbial activity is maximum, due to several modification of soil environment: release of bioactive compounds from the roots, soil aggregate formation, roots respiration, *etc*. Population density and diversity of microorganisms that are in close relation with plant roots were recently evidenced to be finely regulated by each plant genotype (Picard *et al*., 2008). This finding is especially important for organic and low-input agriculture. In fact, rhizospheric plant-growth-promoting prokaryotes and eukaryotes (now called PPM, for Plant-Probiotic Microorganisms) do positively and directly affect plant production through several mechanisms, such as biological nitrogen fixation, solubilization of organic nitrogen, phosphorous, iron and oligoelements, enhanced water supply, synthesis of plant hormones and plant hormone regulators (Picard and Bosco, 2008). PPM can also indirectly promote plant growth by antagonizing the action of phytopathogens, pests and weeds (Lugtenberg *et al*., 2002). As the diversity of terrestrial plants is dependent from the diversity of their co-evolved soil probiotics (van der Heijden *et al*., 1998), sustainable innovations in organic and low-input agriculture will need to take into account the biological need of plants to co-operating with PPM. Our present research aims to achieve a better understanding on how plant-probiotic micro-flora management could buffer future reduction of external inputs, while keeping tomato fruit quality and system sustainability.

Materials and methods

Plant materials consisted of tomato (*Solanum lycopersicum* L.) 'Riogrande', an industrial processing cultivar, chosen by the organic farmer because it already produced good yield, quality in his own farm during the past ten years. Microbial inputs

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(M) consisted in an experimental consortium of PPM (Bosco et al., 2007), containing the arbuscular mycorrhizal fungi (AMF) *Glomus mosseae* GP11, *G. viscosum* GC41, *G. intraradices* GB67, as well as plant-growth-promoting-rhizobacteria (PGPR) like *Pseudomonas* sp. PN01, *P. fluorescens* PA28, *Bacillus subtilis* BA41, *Streptomyces* sp. SB14, three Italian strains of free-living nitrogen-fixing bacteria (BUSCoB Culture Collection), and the antagonistic saprophytic fungus *Trichoderma viride* TH03. Compost inputs consisted in a commercial green compost (1.8% total N, 30% total C) produced by Nuova Geovis S.p.A. near Bologna.

Trials were performed with the active participation of the farmer at the Carioncella organic farm, in northern Italy, which holds the AIAB-ICEA certificate since 1993. In 2007, tomato seedlings were re-planted into the same four replication blocks established in 2006. Each block was randomly divided into main-plots and sub-plots as summarized in Table 1.

Tab. 1: Experimental combinations of compost (C) and microbial (M) inputs

	Year	Main-plots					
		1		2		3	
Sub-plots	2006	C0M0(-)		C1M0(-)		C2M0(-)	
	2007	C0 (+)	C0 (-)	C1 (+)	C1 (-)	C2 (+)	C2 (-)
	2006	C0M1(-)		C1M1(-)		C2M1(-)	
	2007	C0 (+)	C0 (-)	C1 (+)	C1 (-)	C2 (+)	C2 (-)
	2006	C0M2(-)		C1M2(-)		C2M2(-)	
	2007	C0 (+)	C0 (-)	C1 (+)	C1 (-)	C2 (+)	C2 (-)

C: compost inputs equivalent to zero (C0), 100 kg per ha (C1), 200 kg per ha (C2).
M: microbial inputs equivalent to zero (M0), 40 kg per ha (M1), 80 kg per ha (M2).
(+): nursery-inoculated tomato seedlings; (-) non inoculated seedlings.

<u>Evaluations</u>

In 2007 growing season, tomato fruits representing 18 different treatments (Table 1) were harvested from all the subplots and analyzed. Total and marketable fresh weight (Kg) per subplot were recorded. Fruit average weight (g) and size (longitudinal and transversal diameters) (mm) were determined. All yield data were subjected to one-way analysis of variance (ANOVA) to compare the different treatments. In order to show whether the 2006 treatments had any continued effect on 2007 yield, all data of 2006 subplots (Bosco *et al*., 2007) were compared with those of 2007 non inoculated subplots. A representative sample of marketable fruits (2 Kg) per subplot of the last harvest was analysed for quality parameters such as soluble solids (°Brix), titratable acidity (mEq 100 g^{-1}), firmness (Kg cm^{2-1}), and pH. Soluble solid concentration of the clarified tomato juice was determined using a hand-held Atago PR1 refractometer which provides values as Brix degrees (Brix range 0-32% at 20 °C). Acidity was determined by titration with sodium hydroxide 0,1 mol l^{-1} and values were expressed in mEq of citric acid per 100 g. The pH was determined using a Metrohm Model 654 pH-meter. Firmness was measured by using a pressure tester (Forge Gauge, Lutron FG-5000-A) fitted with a cylindrical plunger of 6 mm in diameter. ANOVA was used to compare quality parameters between treatments. Mycorrhizal colonisation of tomato roots was monitored by a microscopic method (McGonigle *et al*., 1990;) on roots sampled at two dates (8^{th} and 10^{th} weeks after planting), and analysed with ANOVA.

Results

Significant differences (*p<0.05)* according to the Duncan's multiple range test were detected between tomato fruit yields of 2007 non-inoculated subplots and 2006 inoculated ones. The medium amendment of compost in the 2007 growing season more positively influenced yield than the high compost amendment of 2006 season. The quality of marketable fruits was not significantly different between 2007 treatments. Mycorrhizal index was significantly different (*p<0.05)* between 2006 M inputs in the roots corresponding to the first 2007 sampling. In particular, the low PPM input (M1) positively influenced the mycorrhizal index in comparison to the control (Fig. 1). In the same way, compost inputs enhanced mycorrhizal colonisation (non significant). The mycorrhizal colonisation was significantly higher in the second sampling, but the differences between treatments lost their significance (Fig. 1). It is interesting to note that the mycorrhizal index of plants non-inoculated in 2007 wasn't significant different from the index of those sampled in 2006 PPM-inoculated subplots.

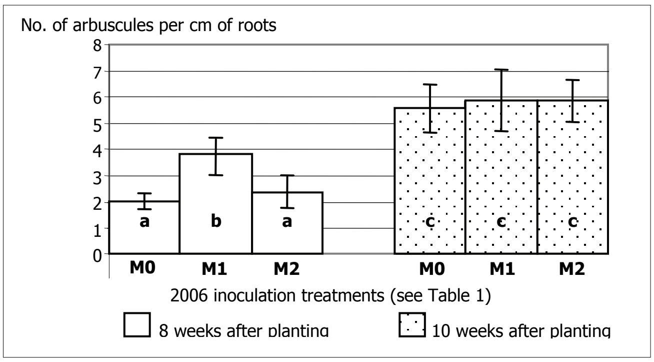

Figure 1: 2007 root mycorrhizal colonisation due to 2006 microbial (M) inputs: the columns sharing the same letter(s) do not differ significantly.

Discussion

Plant-probiotic microorganisms are emerging as a sustainable production factor for future agriculture. However, few experimental works have been done to assess their actual impact on organic and low-input tomato fruit yield and quality. By comparing results from our 2006 (Bosco et al., 2007) and 2007 field plots, we could evidence that plants non treated in 2007 did produce significant higher yields than plants grown in 2006 treated plots, even if tomato was re-planted after tomato (experimental low-input conditions) in an organic managed farm. In 2006-treated plots, the 2007 reduction of compost input (C1) did not reduce yields, nor fruit quality, suggesting a long-lasting, buffering effect by the first-year PPM treatment. This is in agreement with (and could be explained by) the observed stability of mycorrhizal index between roots sampled in 2007 and 2006 growing seasons. However, a third experimental growing season is desirable and already started to verify this explanation.

Concusions

As the moderate PPM input (M1) in 2006 had its positive impact on the second growing season, and could buffer the 2007 reduction of compost inputs (C1), without reducing tomato fruit yield and quality, we are now concerned with the actual cause of such an effect. Further research into microbial parameters, such as community diversity and structure evaluation, should help to understand the interactions of natural soil microflora, external inputs of plant-probiotic microorganisms, reduced inputs of fertilizers, and tomato fruit yield, quality, production costs, system sustainability.

Acknowledgments

We thank Nuova Geovis SpA for donation of green compost, Pedro Guzman, Linda Zamariola, and the Sabbioni family for their help during the establishment and running of field experiments. Authors from Bologna and Quart gratefully acknowledge funding from the European Community financial participation under the Sixth Framework Programme for Research, Technological Development and Demonstration Activities for the Integrated Project QUALITYLOWINPUTFOOD, FP6-FOOD-CT-2003- 506358.

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Tools for innovative organic breeding arise from rhizosphere microbial ecology

Bosco, M.[1] & Picard, C.[1]

Key words: Plant genotype; below-ground potential; Organic breeding; Plant-probiotic micro-organisms.

Abstract

Research on soil microbial ecology is beginning to elucidate how and how much beneficial soil micro-organisms (i.e. plant-probiotics) contribute to plant integrity and plant environmental fitness. The differences so far highlighted among crop varieties show highly positive interactions with plant-probiotic microflora (PPM), and upgrade the role of soil PPM at the level of other essential factors for sustainable plant breeding. Current research efforts, aimed to rapidly achieve crop varieties fitting for low-input and organic production systems, finally take into account the capacity of each individual variety to efficiently exploit indigenous PPM.

Introduction

In natural environments, the nutrients uptake of plants, as well as their health, is greatly regulated by the presence and activity of beneficial micro-organisms, *i.e*. those known to enhance plant growth by fixing atmospheric nitrogen, solubilizing phosphorus, nitrogen, iron and other nutrients, by producing bioactive compounds that stimulate root proliferation and by suppressing root diseases. These beneficial micro-organisms are now called "plant probiotics" (Picard and Bosco, 2007), and include mycorrhizal fungi, antagonistic fungi and the large group of Plant Growth Promoting Rhizobacteria (PGPR). The term "probiotic" has been borrowed from another ecosystem, the gastrointestinal tract, where probiotic bacteria and yeasts can exert health-promoting properties, such as solubilizing nutrients, producing vitamins *in situ*, reducing the symptoms of diarrhea and of inflammatory bowel diseases. The common idea for plant- and gastrointestinal- probiotics is that in both cases a beneficial micro-flora minimizes a range of biotic and abiotic stresses.

Despite the fundamental role of plant-probiotic micro-flora (PPM), its interactions with plant-root systems have been largely ignored in agro-ecosystems. In fact, modern agricultural soils are almost universally maintained at high fertility, and the selection of most of the current crop varieties has been made under these conditions. Furthermore, resistance toward soil-borne pathogens has been in general ignored. Possibly as a consequence, modern breeding programs may have yielded cultivars highly dependent on fertilizer and pesticide supply, and that have diminished capacity to form synergistic microbial associations. For example, modern strawberry cultivars, selected under utilization of methyl bromide soil fumigation, resulted to be non-adapted to the sublethal effects of organisms in non-fumigated soils (Fort *et al.*, 1996). Similarly, Hetrick *et al.* (1995) found that older cultivated wheats, developed prior to 1950 and thus before the widespread use of inorganic fertilizers in breeding programs, were more reliant on mycorrhizal symbiosis than modern wheat varieties. This is in

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agreement with Engelhard *et al*. (2000), who found that wild rice species and older rice varieties were preferred over modern rice cultivars by endophytes of roots such as *Azoarcus* spp. Confirming the hypothesis of the loss of beneficial root microbial associations during modern breeding programs in highly fertilized systems are the rare cases of varieties selected in low fertilized soils, such as the current Brazilian cereal and sugar cane genotypes. In fact, these cultivars can especially benefit from associative N_2 fixation (Baldani *et al.,* 2002), allowing the reduction or complete elimination of N fertilization for these crops.

All these findings highlight the fact that it may be difficult to select cultivars for lower-input agriculture from the elite cultivars currently used in conventional agriculture. In order to increase or maintain the rate of production despite less input of H_2O, N, P, Fe or pesticides, it seems thus primordial to breed new crop varieties able to obtain their nutrient supply and their root protection mainly from an efficient association with PPM.

Materials and methods

Host variation in responsiveness to beneficial micro-organisms generally has been expressed as microbial root-colonization density and diversity, as well as effective plant growth stimulation and protection (Tanksley and McCouch, 1997). Concerning atmospheric nitrogen fixation, root nitrogenase activity and quantification of plant N derived from the atmosphere have also be taken in consideration, both for rhizobial-legume symbiosis and plant associations with free-living microorganisms. Specifically for legumes, number of nodules was also a quantitative trait measured to assess host reaction (Herridge and Rose, 2000). Finally, the mycorrhizal responsiveness was defined in terms of Pi uptake and mycorrhizal dependency (MD) (Tawaraya, 2003).

Results and Discussion

Independent of the beneficial association studied, it has been established that host genotype has a substantial impact in determining the extent of microbial colonization. For example, it has been shown that there is significant genotypic variation in the responsiveness of legume cultivars to *Rhizobium*. In fact, a range of bean, soybeans as well as of Lucerne (Hungria and Phillips, 1993) genotypes differed in relative nodulation. Furthermore, high variability in nitrogen fixation was observed among crop legume genotypes, varying from 0 to 97% of crop nitrogen derived from nitrogen fixation (Herridge and Rose, 2000).

Concerning the mycorrhizal association, the majority of information on variability in MD was obtained in studies with the cereals *Zea mays* (maize), *Hordeum vulgare* (barley) and *Triticum aestivum* (bread wheat) (summarized by Smith and Read, 1997). For example, diversity in MD level was observed among wheat genotypes by Hetrick and colleagues (Hetrick *et al*., 1995). Interestingly, it was reported that diversity in capacity of wheat to sustain AM colonization was associated with yield responses, varying from zero to positive or negative values (Xavier and Germida, 1998). Furthermore, MD is often negatively correlated with root morphological traits, such as root length, root dry weight, root hair length and density of root hairs, traits known to improve the ability of the non-mycorrhizal plant to acquire Pi directly from the soil (reviewed in Tawaraya, 2003).

Finally, differential capacity to support associative PGPR has been clearly established among cereal species as well as among genotypes within cereal species. Maximal nitrogenase activity was reported to be dependent upon maize genotype (Ela *et al*., 1982). By comparing 69 rice lines from diverse backgrounds, Shrestha and Ladha (1996) demonstrated that nitrogen fixation differed significantly amongst the various lines, ranging from 1.3 to 20%. Those with high nitrogen fixation were mostly traditional varieties. More recently, Azevedo *et al*. (2005) observed that the genetic structure in populations of root-associated diazotroph colonizing rice, maize or sorghum was indeed plant-species dependent. Furthermore, Picard *et al*. (2008) gave recently clear evidence that maize genotype influences the size of PGPR communities involved in nitrogen fixation and plant protection, as well as the diversity of the AMF colonizing population.

Interestingly, all these variations among cultivars in interactions with PPM seem to have resulted from evolution over generations (Engelhard *et al*., 2000). More importantly, it was evidenced that root colonization by PPM could be an inherited trait (Smith *et al*., 1999), probably related to heterosis (Picard *et al*., 2008). Moreover, at least for the rhizobium-legume symbiosis, the specificity of the beneficial association also resembles a gene-for-gene system. In fact, the strain- and host-genotype-specific interactions are characterized by unique patterns of signal release and response (Pueppke *et al*., 1998).

Knowledge of the available genetic variability should be utilized for implementing a selection procedure adapted for low input environments. This selection can be carried out with conventional breeding procedures, i.e. by the direct detection of effective root association with beneficial micro-organisms, or can be integrated with the use of molecular marker tool. In that light, more and more studies were conducted to identify quantitative trait loci (QTLs) underlying the plants ability to establish a favourable rhizosphere microbial community. For example, by analyzing 197 recombinant inbred lines (RIL) in a mapping population of maize, Kaeppler *et al*. (2000) demonstrated that host variation on AM colonization was associated with two QTL. In the same manner, three quantitative trait loci in tomato associated with suppression of root infection by *Pythium torulosum* in response to introduction of the rhizobacterium *Bacillus cereus* strain UW85 explained 38% of the phenotypic variation observed (Smith *et al*., 1999).

Conclusions

From recent findings we understand that future efforts for breeding sustainable varieties must consider the below-ground genotype potential of each crop, often misunderstood. In particular, the scientific community of soil microbial ecologists supports very strongly the idea that a lot of new knowledge will be produced in the near future. Innovations in sustainable crop varieties will undoubtedly pass through the exploitation of plant-probiotic micro-organisms, by developing and testing, at laboratory, field, and biostatistic levels, a brand new breeding strategy targeted to crop varieties that rely the most part of their productivity, environmental fitness on PPM.

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How effective are 'Effective Microorganisms'? Results from an organic farming field experiment

Mayer, J.[1], Scheid, S.[1] & Oberholzer, H-R.[1]

Key words: Effective microorganisms, biofertilizer, soil fertility, soil biology

Abstract

The effectiveness of 'Effective Microorganisms' (EM) was investigated in a four years field experiment (2003-2006) at Zurich, Switzerland. The experiment was designed to enable clear differentiation between effects of the microorganisms in the EM treatments (Bokashi and EMA) and its substrate (sterilized treatments). Crop yields and soil microbiological parameters as soil respiration and microbial biomass were determined. The EM treatments showed no effect on yield and soil microorganisms which were caused by the EM microorganisms. Observed effects could be related to the effect of the carrier substrate of the EM products. The sampling time showed stronger effects on soil microbial biomass and soil respiration compared to the effect of the treatments. Hence 'Effective Microorganisms' are not able to improve yields and soil quality in mid term (4 years) in arable farming under temperate climatic conditions as in Central Europe.

Introduction

Biofertilizers are defined as substances containing living microorganisms which promote growth by increasing the supply of primary nutrients to the host plant (Vessey, 2003). In addition microorganisms that promote plant growth by control of deleterious organisms are defined as biopesticides (Banerjee et al., 2005). Both strategies are of particular importance in organic farming systems. Hence several products are on the market and listed in the regulations of governmental or farmer association's regulations on organic farming. For instance, in Switzerland about 60 preparations containing microorganisms are admitted for application in organic farming (FIBL-Hilfsstoffliste 2007; www.fibl.org).

However, there is poor evidence on the effectiveness of many preparations such as the Japanese 'Effective Microorganisms' (EM), which is widespread all over the world in organic and sustainable agricultural systems. It consists of 80 species of 'beneficial coexisting microorganisms' and contains lactic acid bacteria, phototrophic bacteria, *Actinomyces* and yeasts (Higa, 2001). It is recommended for crop production, to improve soil fertility, manure quality, crop yields, plant quality and health. But in the peer-reviewed scientific literature only a few references on the effects of EM with contradictory results can be found (Javaid, 2006; Khaliq et al., 2006;). No results are available for temperate climates and field conditions.

Our aim was to evaluate the effects of different preparations of 'Effective Microorganisms' (EM) on crop yields and on microbial parameters characterised by mass and activity of the microbial community during four years of field application under organic management.

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Materials and methods

A field experiment (randomised block design, 4 replicates) was established at Agroscope Reckenholz-Tänikon Research Station ART in Zurich, Switzerland, from 2003 to 2006 on an organically managed field (medium eutric Regosol, mean temperature 8.5°C, mean rainfall 1042 mm). Treatments of the EM preparations EMA as spraying agent and Bokashi as organic fertilizer were applied (Table 1). Treatments without EM and parallel treatments with autoclaved EM preparations, to separate the effect of the microorganisms from its substrate, served as controls (Table 1). Bokashi and the first EMA spraying were applied at sowing. The further EMA sprayings were spread during the vegetation period until flowering and after the cutting of lucerne.

Tab. 1: Treatments of the EM field experiment

No	Treatment[1]	EMA spraying[2]	EM-Bokashi[4]	Manure[4]
1	control	3 x H_2O	-	-
2	sp	3 x[3]	-	-
3	sp au	3 x au[3]	-	-
4	sp+bok	3 x	2.9 t ha^{-1}	-
5	sp+bok au	3 x au	2.9 t ha^{-1} au	-
6	sp+bok+m	3 x	2.9 t ha^{-1}	10 t ha^{-1}
7	sp+bok+m au	3 x au	2.9 t ha^{-1} au	10 t ha^{-1}

[1] bok = Bokashi; sp = spraying; m = manure; au = autoclaved
[2] 110 litre EMA ha^{-1} per application
[3] in 2003 additional pickling of potato seed stock with EMA
[4] fresh matter basis

Potatoes were cropped in 2003 followed by winter barley in 2004, lucerne in 2005 and winter wheat in 2006. Crop yields, soil microbial biomass C by chloroform fumigation extraction (CFE) and soil basal respiration were determined. Soil samples (0 – 20cm) were taken in March 2005, in October 2005 immediately before (autumn 05 I) and after sowing of winter wheat (autumn 05 II) and in March 2006.

Results

Crop yields

Potatoes showed no significant differences in yield in 2003. From 2004 to 2006 yields of the EMA spraying treatments 2 and 3 (sp, sp au; table 2) showed no differences to the untreated control. However yields differed considerably in treatments with additional Bokashi application. Winter barley yields in 2004 were increased compared to the control between 23% in treatment 6 (sp+bok+m) to 36% in treatment 4 (sp+bok), but the comparatively high differences were not significant. Differences of winter wheat yield to the control in 2006 ranged between 13% in treatment 6 (sp+bok+m) and 23% in treatment 7 (sp+bok+m au). But significant differences were only found between the control, treatment 3 (sp au) and treatment 7 (sp+bok+ m au) (Table 2). The additional application of manure to spraying combined with Bokashi application did not cause any distinct yield effects. The lucerne yields in 2005 showed a similar pattern but differences between the treatments were small. The statistical evaluation, comparing the factor living EM with sterilised EM (treatment 2, 4, 6 vs. 3, 5, 7) resulted in no significant difference.

Soil respiration and microbial biomass

Soil respiration (SR) did not differentiate between the untreated control and the EMA spraying treatments 2 - 3 (fig. 1A) on each sampling date. But SR increased in the treatments with additional Bokashi application (Treatment 1, 2, 3 vs. 4, 5, 6, 7). These differences were not consistent throughout the treatments with Bokashi application and during sampling dates. In autumn 05 II treatments 4, 5 and 7 differed significantly from 1 - 3, but not treatment 6. In spring 06 treatment 4, 6, and 7 differed significantly from 1 - 3, but not treatment 5. In analogy to crop yields the comparison of living EM with sterilised EM (treatment 2, 4, 6 vs. 3, 5, 7) resulted in no significant difference.

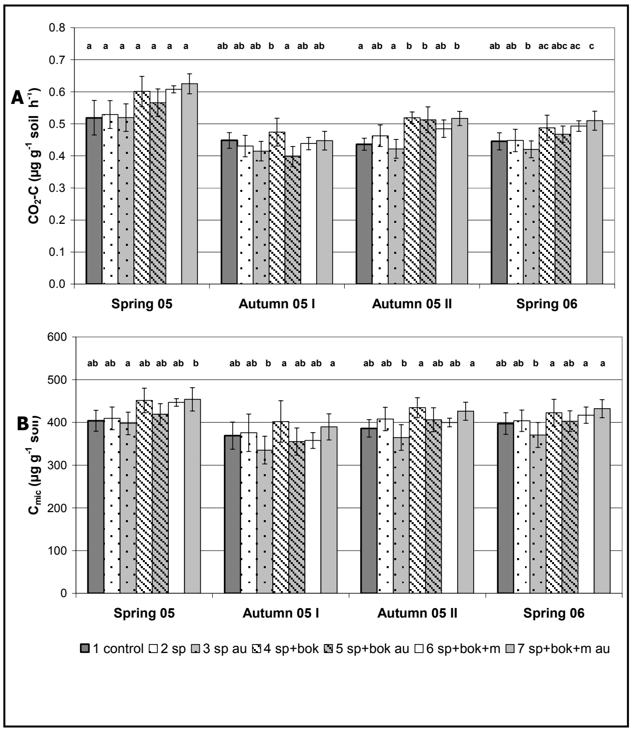
Tab. 2: Yields of main crops from 2003 – 2006. Differing letters in columns show significant differences of means (Tukey, p<0.05), [1]Summ of 4 cuts.

No	Treatment	Potatoes 2003	Winter barley 2004	Lucerne 2005[1]	Winter wheat 2006
		(t FM ha^{-1})	(t FM ha^{-1})	(t DM ha^{-1})	(t FM ha^{-1})
1	control	27.4 [a]	2.95 [a]	14.0 [a]	2.97 [a]
2	sp	33.3 [a]	3.30 [a]	14.6 [a]	3.16 [ab]
3	sp au	30.6 [a]	2.88 [a]	13.8 [a]	2.95 [a]
4	sp+bok	27.0 [a]	4.00 [a]	14.5 [a]	3.53 [ab]
5	sp+bok au	26.9 [a]	3.80 [a]	14.4 [a]	3.48 [ab]
6	sp+bok+m	30.3 [a]	3.63 [a]	15.1 [a]	3.36 [ab]
7	sp+bok+m au	29.0 [a]	3.75 [a]	14.7 [a]	3.64 [b]

The results of soil microbial biomass C were similar to soil respiration. No significant differences were found between the untreated control and treatment 2 and 3. Significant differences were only found between treatment 1 – 3 and 4 – 7 (Fig 1B). The differences were not consistent throughout the treatments with Bokashi application and during sampling dates. Treatments with living EM were not significantly different from the sterilised treatments (treatment 2, 4, 6 vs. 3, 5, 7). Distinct effects of sampling date were observed. Soil respiration and microbial C differed significantly at spring 05, autumn 05 I and autumn 05 II, but not between autumn 05 II and spring 06 (SR p< 0.000; CFE-C p<0.000).

Discussion and conclusions

Significant differences of EM treatments to the untreated control were only found between treatments with Bokashi application. EMA spraying alone had no effects on either crop yields or soil microbial parameters. Differences can be explained by the considerable amounts of nutrients of 401 kg N, 16 kg P, 33 kg K and 7 kg Mg ha^{-1} a^{-1} which were applied with Bokashi. However, the effects of additional manure application were small. No differences were found between EM treatments and the sterilized EM control treatments. Hence the observed effects could solely be related to the carrier substrate of Bokashi. The microorganisms in the EM preparations caused no effects. Overall the effects on soil microbial parameters were small and the sampling date showed greater differences as the treatments and fertilization effects. Our results are in good agreement with the findings of Priyadi et al. (2005) who found no effects of EM application on corn yields in Indonesia. Khaliq et al. (2006) found no EM effects by applying EM alone on seed cotton, but concluded an improved fertilizer effect combining NPK and organic matter applications with EM. However, these studies did not use sterilised treatments and thus the inter-pretation whether substrate or micro-bial effects are responsible for the observations is difficult.



We conclude from our results that the 4 years application of 'Effective Microorganisms' in the temperate climate of Central Europe under organic farming management caused no significant effects on crop yields and soil microbial parameters. Observed effects could solely be related to the nutrient inputs of the carrier substrate Bokashi, while the microorganisms had no effects. Effects of sampling time exceeded effects of treatments.

Figue 1: Soil respiration (A) and microbial biomass C (B) of soils at differing sampling dates. Autumn 05 I = before EM application, Autumn 05 II = after EM application; (Tukey, p<0.05)

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Influence of organic farming on arbuscular mycorrhizal fungal populations in a Mediterranean agro-ecosystem.

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Key words: arbuscular mycorrhizal fungi, glomalin-related soil protein, spore population, biodiversity, organic farming.

Abstract

Arbuscular mycorrhizal fungi (AMF) are key components of the soil microbiota, fundamental for soil fertility, plant nutrition and functioning of agroecosystems. Data on the interactions between organic practices and AMF populations are limited and inconsistent. Here we compared AM fungal communities and glomalin-related soil protein (GRSP) content occurring in a recently converted organically farmed soil with those occurring in a conventionally managed soil. The results show that the two farming systems did not significantly differ in AM fungal spore populations and glomalin-related soil protein. We hypothesize that in our experimental system, which was converted from conventional to organic farming only recently (5 years), there may not have been enough time to allow the establishment of differentiated AM fungal populations.

Introduction

Soil microbial communities are considered a vital factor for the functioning of agroecosystems and success in organic farming (Gosling et al., 2006). Glomeromycotan fungi form arbuscular mycorrhizal (AM) symbioses with most crop plants and are fundamental for soil fertility and plant nutrition and health. Since different species and isolates of AM fungi (AMF) show differences in plant growth responses and quality, any change in their populations may result in changes of agro-ecosystem productivity (van der Heijden et al., 1998). AMF are strongly affected by anthropogenic activities (Giovannetti and Gianinazzi-Pearson, 1994), and intensive agricultural practices, such as crop rotation fertilization pest control and tillage impact AMF, reducing population biodiversity (Helgason et al., 1998; Daniell et al., 2001). Organic agriculture has been shown to increase AMF root colonization and propagule numbers (Galvez et al. 2001; Oehl et al. 2003), although low input practices used in such management system do not always allow the level of biodiversity to increase, even after a long time (Franke-Snyder et al., 2001). Hence, understanding the structure and the dynamics of AMF populations as affected by diverse agricultural practices represents an important prerequisite for the success of organic farming. This

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work was intended to describe the AM fungal communities occurring in field trials comparing conventional and stockless organic farming.

Materials and methods

The experimental plots are located in the CIRAA (Interdepartmental Centre for Agri-environmental Research “E. Avanzi”, University of Pisa) experimental centre near Pisa (Italy), and are a part of the long-term experimental system MASCOT (Mediterranean Arable Systems COmparison Trial). MASCOT was established in Autumn 2001 as a long-term comparison between organic and conventional management system for a typical rotation of coastal Tuscany, characterized by the absence of livestock, and including sugar beet, common wheat, sunflower, pigeon bean, and durum wheat. In spring 2006 sugar beet was replaced by maize.

In the conventional management, crops were minerally fertilized with 602 kg ha^{-1} N , 487 kg ha^{-1} P_2O_5, 346 kg ha^{-1} K_2O distributed over the five years of rotation. In organic management all crops were supplied with 30 kg ha^{-1} N, 30 kg ha^{-1} P_2O_5, 0 kg ha^{-1} K_2O each year. Additionally, in the organic system, red clover was interseeded in common and durum wheat and used as a green manure for subsequent crops.

The five crops in the rotation were allocated to five fields and managed organically or conventionally (each group of five fields represents a system within a block; each crop is present every year). Systems were replicated three times according to a randomized complete block design. Additional information on the agricultural practices used in the organic and conventional systems can be found in Bàrberi and Mazzoncini (2006).

Soil samples consisted of seven random cores collected from each of three plots under organic and conventional management after the harvesting of maize. Samples were collected in the second half of June 2006 in the plots. AM fungal spores were extracted from 50 g soil samples by wet-sieving and decanting, down to a mesh size of 50 µm. Spores and sporocarps were examined under a dissecting microscope and the numbers and types of AM fungal spores were recorded. Only intact, healthy spores were counted. Spore identification was performed under the light microscope, after mounting the spores in polyvinyl alcohol lacto-glycerol (PVLG) on microslides. We determined species richness and calculated the frequency of occurrence. Relative abundance was calculated as the number of spores of each species divided by the total number of spores. We also calculated the Shannon diversity index and the Pielou evenness index.

Results

Nine species of AMF were found in the experimental sites, eight belonging to *Glomus* and only one to *Scutellospora*. Some differences in species occurrence and frequency were observed: *S. calospora* spores were more frequent in the organic plots than in the conventional ones, and *G. rubiforme* spores were more frequent in conventional plots. (Fig.1).

Species richness and other diversity indexes in the two agricultural systems did not differ statistically.

The organic and conventional farming systems did not show statistical differences in EE-GRSP, whose values were 172.5 to 170.3 □g g^{-1} soil, respectively.

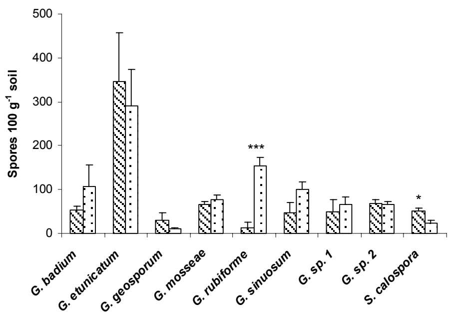

Figure 1: Distribution of fungal spores per AM fungal species, in organic (hatched bars) and conventional (dotted bars) plots. *, *P*<0.05; *, *P*<0.01**

Discussion

The analyses of AM fungal spores of the experimental plots show a quantitative and qualitative uniformity of AM fungal populations in the conventional and organic farming systems, 5 years after the beginning of the experiment. Our data are in agreement with previous reports showing only slight differences in AM fungal populations between conventional and organic farming systems a few year after conversion (Purin et al., 2006). Slight differences in the levels of diversity between the two systems were found after 15 years of cultivation (Franke-Snyder et al., 2001). By contrast, in a long-term comparison trial in central Europe, higher species richness and diversity of AMF were reported (Oehl et al., 2004), while other authors found an increase of AM fungal inoculum in organic farmed soils (Bending et al., 2004). Overall we assessed the occurrence of nine AM fungal morphospecies. Such level of biodiversity is lower than that found in other organically farmed soils, while it is consistent with data from conventional agriculture (Oehl et al., 2003).

A few differences were also recorded in GRSP concentrations, in agreement with previous observations concerning conventional versus organically managed soils (Purin et al., 2006; Wright et al., 2007). Our present data contradict previous findings obtained in a 50-year-old corn monocrop subject to conventional high-input agriculture, where GRSP concentration was 7.5-fold lower than in an organically grown grassland (Bedini et al., 2007).

On the basis of the present results we can hypothesize that in our experimental system, only recently converted from conventional to organic farming (5 years), there was not enough time to allow the establishment of differentiated AM fungal populations. Further investigations are needed to understand whether other factors, such as residual phosphate from previous conventional management, or organic farming management practices such as tillage for weed control and the use of copper-based fungicides, may be detrimental to AM fungal populations.

Conclusions

Our data on the characterization of AM fungal spore populations and on GRSP content of two differentially managed field trials, 5 years after conversion from conventional to organic farming, represent the reference point for future assessment of putative AM fungal population shifts.

Acknowledgments

This work was funded by the MIUR-FISR Strategic Project SIMBIOVEG 2005-2008 “Food quality and health”.

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Biological profitability of maize inoculation with selected rhizosphere micro organisms (*Pseudomonas fluorescens* and *Glomus intraradices)* under Water Deficit Stress

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Key Words: Maize, *Pseudomonas fluorescens*, *Glomus intraradices*, Phosphorus, Water Deficit Stress

Abstract

This research focused on evaluating the usefulness of an arbuscular mycorrhizal fungus (Glomus intraradices) and a plant growth-promoting rhizobacterium (Pseudomonas fluorescens) to maize growth under water deficit stress. Field experiment was conducted at Soil and water research institute, Karaj Station, Iran, during 2006 growing season. Biological positive effects of the micro organisms on plant growth, nutrient uptake, grain yield and yield components in maize plants was recorded in the treatment receiving mixed inoculums of G. intraradices and P. fluorescens. Maize shoot P content, grain yield, yield components, harvest index, grain N and P, soil available P, root colonization percentage and water use efficiency increased significantly with the G. intraradices inoculation and P. fluorescens, alone or in combination under water deficit stress. The highest profitability was observed in the combined treatment of inoculation with G. intraradices and P. fluorescens, which synergistically increased plant growth compared with other treatments.

Introduction

Co-inoculations of beneficial rhizosphere microorganisms into soils, reducing the inputs of environmentally deleterious agro-chemicals required for optimal plant growth, are gaining increased attention in sustainable agroecosystems (Barea *et a*l., 1997). There are several groups of beneficial rhizosphere microorganisms. Inoculation with AM fungi is an effective method of enhancing the ability of the host plants to become established and to cope with stress situations such as nutrient deficiency, drought and soil disturbance (Caravaca *et al*., 2003a). In fact, several authors have indicated that mycorrhizal fungi may improve the performance of seedlings, by stimulating water uptake (Auge, 2001) or increasing nutrient uptake by the plant, particularly N and P (Jeffries et al., 2003). Beneficial free-living soil bacteria are usually referred to as plant growth-promoting rhizobacteria or PGPR (Kloepper et al., 1989). Particularly, the so-called mycorrhiza helper bacteria are known to stimulate mycelial growth of mycorrhizal fungi or to enhance mycorrhizal formation (Toro *et a*l., 1997). The microbiologically solubilised phosphate could, however, be taken up by a mycorrhizal mycelium, thereby developing a synergistic microbial interaction (Barea *et al*., 1997). The combined inoculation of selected rhizosphere microorganisms has been recommended for maximising plant growth and nutrition (Probanza *et al*., 2001). The study of the antagonistic or synergic effects of the different microbial inoculants when co-inoculated is a crucial step in the development of effective host-microorganism

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combinations. It has also been reported that dual inoculation with *G. intraradices* and *Bacillus subtilis* promoted the establishment of the introduced AM fungus and increased plant biomass and tissue P accumulation (Toro *et a*l., 1997).

Materials and Methods

This experiment was conducted at the Karaj station of Soil and Water Researches Institute of Iran, with a loam soil during 2006 growing season. Soil available P and K content were 6.2 and 170 mg/kg respectively. Also organic C and N content were 0.34 and 0.07 percent respectively. The experiment design consisted of four randomized complete blocks in a split-factorial arrangement having 15 treatments in every block. The main-plots consisted of three water regimes, which were achieved by scheduling cumulative pan evaporation in mm. The irrigations were scheduled for various treatments, when the cumulative pan evaporation readings reached at 70, 100 and 130 mm. The sub-plots included of the application of microbial inoculants [*G. intraradices; P. fluorescens* strain 173; *G. intraradices* + *P. fluorescens* strain 173 (50%-50%)] and not [triple super phosphate; without fertilizer (control)]. Each plot consisted of 4 rows, 7 m long and 75 cm apart. Chemical P treatment received some super phosphate fertilizer to increase soil available P up to 15 mg/kg. No P given in AM and Pf treatments. Water treatments began after maize 8-leaves stage. In this stage, plants were exposed to intensities of water deficit stress (severe, moderate and no water deficit). Specific strain of *P.fluorescens* (strain 173) was isolated from the rhizosphere of wheat (*Triticum aestivum* L.) by Soil Biology Laboratory in Soil and Water Researches Institute of Iran. The inoculum of *G. intraradices* consisted of AM propagules. This inoculum was uniformly mixed into the apatite (in order to facilitate incubation), which was prepared by Mycorrhiza Laboratory in mentioned Institute. Maize seeds were inoculated according to Sharma *et al*. (2003) and then placed in the furrow. In end of maize growth season grain yield, yield components, harvest index, grain N and P, soil available P, root colonization percentage and WUE were determined.

Results

- Conversely, *G. intraradices* (AM) and *P. fluorescens* (Pf) bio-inoculants enhanced the maize grain production regardless of intensities of water deficit stress. The dual inoculation showed significant difference in grain yield of maize when compared with fertilizer and control (uninoculated) treatments. Inoculation with AM + Pf and AM increased the grain yield compared with other treatments. The highest increase in 100-grain weight, of row number per ear and grain number per row was recorded in AM + Pf treatment. In the presence of AM+Pf and AM treatments, yield components enhanced significantly compared with P fertilizer and control, when plants were exposed to water deficit conditions. The water deficit treatment significantly ($P<0.05$) decreased yield components of control (uninoculated) and P fertilizer treatments. There was no significant differences between Water deficit stressed AM + Pf and AM treatments and well-watered and fertilized plants. Single inoculation with Pf had more effect compared with fertilizer and control treatments too. Harvest index was also higher in plots supplied with co-inoculation that this difference was significant. The water deficit treatments decreased HI for inoculated and non-inoculated plants, but HI values were higher in co-inoculants. The HI values for water deficit stressed AM+Pf and AM plants were comparable to well-watered treatments. Phosphorus concentration in plant tissue were increased in plants by inoculation with AM+Pf and AM under well-watered and water deficit stress condition. The inoculation with AM+Pf significantly ($P<0.05$) increased the P contents of maize plants and had higher than control and P fertilizer plants under varying intensities of water deficit stress. P uptake by plant was also more with the application AM under moderate stress in our study. The concentration of P in control plants was significantly ($P<0.05$) lower than that in plants grown under treatments AM+Pf and AM (table 1). The dual inoculation of Pf and AM resulted in a significant increase of grain P and N concentration (table 1). The inoculation with AM and Pf had a more stimulating effect on the assimilation of P and N in comparison with fertilizer and control treatments. However, AM performed better than P fertilizer, but was less than AM + Pf in stimulating N and P uptake.

- The highest soil available P was associated with plants grown under AM+Pf co-inoculation treatment. This value was significantly ($P<0.05$) higher than that of plants grown under all other treatments under similar conditions. Our study showed that inoculated maize plants by AM + Pf are much more efficient in taking up soil P than non-inoculated plants. All inoculation treatments significantly improved available P content of soil (table 1).

Tab. 1: Maize shoot and soil P content in phosphate fertilizer (P), *G. intraradices* (AM), *P. fluorescens* (Pf), co-inoculation (AM+Pf) and no fertilizer (Control) plants exposed to varying intensities of water deficit stress (70, 100 and 130 mm cumulative pan evaporation)

-	-	-	- Parameters			-
- Treatments	- Grain P (%)	- Grain N (%)	- Plant's tissue P (%)	- Soil available P content (mg/kg soil)	- Root Colonization (%)	- WUE - (Kg ha mm-1)
P + 70	0.3525 c	1.725 cd	0.2675 ab	4.7 d	1.84 fg	33.77 bcd
AM + 70	0.61 ab	1.975 ab	0.3375 ab	6.12 b	65.13 ab	42.55 ab
Pf + 70	0.5575 ab	1.86 bc	0.315 ab	5.56 bc	62.01 ab	37.63 abc
AM + Pf + 70	0.645 a	2.138 a	0.3475 a	8.72 a	79.5 a	43.23 a
Control + 70	0.12 ef	1.09 h	0.1 cde	1.8 fg	1.732 fg	17.2 f
P + 100	0.205 de	1.452 ef	0.2325 abc	2.62 ef	1.643 fg	27.21 d
AM + 100	0.515b	1.742 bcd	0.27 ab	4.76 cd	50.08 bc	34.81 abcd
Pf + 100	0.34 c	1.717 cd	0.2575 ab	2.82 e	41.12 cd	32.68 cd
AM + Pf + 100	0.535 ab	1.847 bc	0.305 ab	5.04 cd	60.17 b	36.31 abc
Control + 100	0.1175 ef	1.048 h	0.09 de	1 gh	0.8725 g	15.6 f
P + 130	0.1225 ef	1.145 gh	0.21 bcde	2.32 ef	1.29 fg	17.49 ef
AM + 130	0.3025 cd	1.55 def	0.2475 ab	2.72 e	20.94 e	31.75 cd

Pf + 130	0.1975 de	1.358 fg	0.225 abcd	2.42 ef	19.52 ef	26.45 de
AM + Pf + 130	0.3075 cd	1.67 cde	0.255 ab	2.775 e	30.28 de	32.05 cd
Control + 130	0.0725 f	0.98 h	0.075 e	0.9 h	0.545 g	15.12 f

Means with different superscript letters are significantly different at $P<0.05$ according to LSD test

- The trend of grain P and N accumulation under different treatments of water deficit stress was similar to well-watered conditions. The lowest P and N concentration of grain was detected in plants grown in uninoculated and unfertilised treatments. Treatment of AM+Pf , AM and Pf inoculation resulted in a significant increase in P and N uptake to different degrees of water deficit stress when compared with the control, respectively (table2). The percentage of root colonization was significantly higher in the treatments containing co-inoculants than AM and Pf treatments. The highest increase in the percentage of root colonization was recorded by co-inoculated treatments. Our results showed water deficit stress decreased the percentage of root colonization (table 2). The WUE of inoculated treatments was higher than non-inoculated treatments in moderate and severe intensities of water deficit stress. In spite of no significant difference between inoculation treatments, inoculation with AM+Pf and AM under well-watered conditions increased WUE compared with other treatments (table 2).

Conclusion

In summary, AMF and PGPR bio-inoculants improved drought tolerance of field grown maize plants as a consequence of enhanced nutritional status especially of P. AMF and PGPR bio-inoculants response was more pronounced under water deficit stress than well-watered conditions. The data revealed that mentioned bio-inoculants enable the host plant to withstand varying of water deficit stress under field conditions. Indeed, these bio-inoculants were adapted to their environment in terms of soil characteristics, plant genotype and climate. Meanwhile, this research must be proactive and the field trials must be established across a broad range of soil and

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Role of forage legumes mixed cropping on biomass yield and bacterial community composition

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Key words: Mixed cropping, legume crops, free-living N_2-fixing bacteria, rhizosphere bacteria population, *Azotobacter* spp

Abstract

*Intercropping berseem clover (Trifolium alexandrinum L.) may increase forage yield and free-living N2-fixing bacterial species community. Berseem clover was mixed with Persian clover (Trifolium resupinatum L.) at ratios of 1:0, 3:1, 1:1 and 1:3 and with Persian clover/ annual medic (Medicago regidula cv. Regidula) at ratio of 1:1:1 at Field Crops Department, Faculty of Agriculture, Tarbiat modares university, Tehran, Iran in 2007. Mixed ratio had significant effect on total forage yield. Total forage yield was greatest with a 1:1:1 ratio of clovers to annual medic. Total intercrop yields with clovers/ annual medic at 1:1:1 plants m–2 was 214.37g m–2 DM yields. Mixed cropping increased rhizosphere microorganisms viz. bacteria, free-living N_2-fixing bacteria and Azotobacter counts. Free-living N_2-fixing bacterial species and Azotobacter populations of 96 g-1 soil*103 cells and 24 g-1 soil*102 cells, respectively, obtained from mixed cropping with 1:1:1 clovers to annual medic ratios.*

Introduction

Forage legumes can be important components of sustainable crop rotations. Forage legumes access atmospheric N2 through symbiosis with a group of soil bacteria collectively called rhizobia and so require minimal N fertilizer inputs. When part of this `free' N is made available to a subsequent crop, the use of legumes in a rotation can lead to a reduction in fertilizer-N use. Berseem clover (*Trifolium alexandrinum* L.) is an annual leguminous forage or cover crop species well adapted to semi-arid conditions of the Mediterranean areas. It is a high-yielding, nutritious, cool-season forage crop thought to have originated in the Middle East (Knight, 1985). It is grown in pure stands or in mixtures with annual grass species for over winter grazing and for harvested forage in the spring (Martiniello, 1999; Stringi et al., 1987). Intercropping gives a greater stability of yield over monoculture (Willey and Reddy, 1981). Besides, mixed or intercropping is widely practiced by the farmers because it often gives higher cash return and total production per hectare than growing one crop alone (Kurata, 1986) and ensure greater resource use efficiency (Herrara and Harwood , 1974). Although the study of mixed or intercropping benefits and rhizosphere microbial dynamic is well established, recent research has revealed a third interaction (cropping system) that appears to be significant in terms of overall soil microbes. The objective of the present study was to measure the rhizosphere microbial changing associated with monoculture and mixed cropping of Persian/berseem clovers and annual medic to evaluate the potential mixed cropping on forage yield and soil microbes.

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Materials and methods

Field experiment was conducted at the at Field Crops Department, Faculty of Agriculture, Tarbiat Modares University, Tehran, Iran (about1323 m Alt, 35° 48' N Lat) in 2007. The soil type at site was silty clay loam. The field plots were maintained under transitioning to organic production. Experiments followed tilled fallow, and fields were disked and harrowed before seeding. The experimental design was a randomized complete block and stand ratios of 1:0 3:1, 1:1, and 1:3 0:1 of Berseem clover: Persian clover (BP), respectively, and stand ratios of 1:1:1 of clovers to annual medic (M) were treatments. Plots were 3 by 5 m and there were three replications. The mixedcropping design was based on the replacement principle. Samples were cut from an inner plant area of 2 m2 by hand at 5 to 7.5 cm above soil level. Shoot samples were oven dried at 70 ˚C until daily checks indicated no further decreases in weight.

Colony form unit (CFU) numbers of various groups of rhizosphere micro-organisms viz. bacteria, N2-fixing bacterial species and Azotobacter were estimated by plate counts of aliquots from serial 10-fold dilutions. The root systems of 10 plants were gently separated from the bulk soil and the soil adhering to the roots was considered rhizosphere soil. Rhizosphere soil was shaken in Ashby's liquid medium minus carbon source, and suitable dilutions were plated on N-deficient medium to give a count of Azotobacter. TSA and Jensen's agar used for plating of two groups of microbes, micro-organisms viz. bacteria, N2-fixing bacterial, respectively. Three replicate plates were inoculated from each dilution and one dilution series was prepared per soil suspension. The plates were incubated at room temperature in the dark and the colonies emerging were counted. The morphology of the colonies on the plates was checked and the numbers of CFU were counted.

All measured variables were assumed to be normally distributed and statistical analyses by ANOVA were performed using SAS software (SAS, 1990). The significance of difference between treatments was estimated using the LSD range test with a 0.05 if a treatment was significant.

Results

Berseem clover was roughly 3.1 times taller than Persian clover regardless of the stand ratio. The average rates of plants height were 17 and 54 cm for Persian and berseem clover, respectively. The average rates of annual medic plants height was 41.3 cm in mixed and sole cropping. Clover ratios significantly increased total fresh weight (TFW) and total dry weight (TDW). As berseem clover:persian clover ratios change from 1:0 to 1:3 TFW and TDW yield decreased from 843.3 to 753.3 and 160.63 to 97.0 g m–2 , respectively (Table 1). Clover mixed cropping with annual medic significantly ($P<0.001$) increased both TFW and TDW. Total forage Dry weight m-1 was greatest with a 1:1:1 ratio of berseem/ Persian clovers to annual medic. The greatest TFW and TDW of 1383.3 and 214.37 g forage m-1 were in the berseem clover:persian clover:annual medic ration treatment of 1:1:1 (Table 1). Result indicated that rhizosphere in Persian sole cropping compared to berseem and annual medic sole cropping has a greater Colony form unit (CFU) numbers of Free-living N2-fixing bacteria and Azotobacter (Table 1). Result showed that the effect of mixed cropping affected bacteria, N2-fixing bacteria and Azotobacter colony forming unit (CFU) numbers. CFU counts of bacteria, N2-fixing bacteria and Azotobacter were increased with mixed cropping compared with monoculture of berseem clover species and annual medic. bacteria, N2-fixing bacteria and Azotobacter CFU counts were the greatest with 1:1:1 clovers/annual medic ratios (86×105, 96 × 103 and 24 × 102 CFU g-1 rhizosphere soil, respectivily) (Table 1).

Tab. 1: fresh weight (g m^{-1}), dry weight (g m^{-1}), CFU, MPN of free – living nitrogen fixation bacteria and Azotobacter spp.from the rhizosphere of Persian clover (P), berseem clover (B) and annual medic (M) in sole and mixed cropping system

Treatments	Total Fresh weight (g $^{-1}$m)	Total Dry weight (g $^{-1}$m)	Bacteria (CFU) (g-1 soil* 10^5)	MPN of N2 fixers (×10^3 cells)	Population of azotobacter (x10^2 cells)
B(1:0:0)	843.3^d	160.63^b	50^c	61^c	10^c
P(0:1:0)	520^c	101^c	79^b	91^a	20^a
M(0:0:1)	746.7c^d	153.18^b	25^e	40^e	30^f
BP(3:1)	1063.3^b	175.43^{ab}	50^c	61^c	10^c
BP(1:1)	933.3b^c	164.97^b	20^e	26^f	71^e
BP(1:3)	753.3c^d	97.0^c	36^c	51^d	93^b
BPM(1:1:1)	1383.3^a	214.37^a	86^a	96^a	24^a
MS	226787.3	5113.3	1914.04	1976.38	165.21
F. value	10.29	7.72	209.35	181.24	191.87***
significant	***	***	***	***	***

*** Significant for P<0.001

Discussion

In agreement with other studies (Evans, 1960; Grimes and Quasem, 1992; Kurata, 1986), intercrooping improved the growth of both berseem and Persian clovers. Both clover species had a greater herbage dry weight m-2, which may have made both clovers more competitive for light, water and nutrients when grown in the mixture with another clover species. Persian clover just produce three leaflets with long petiole that grow upright, 25-35 tall when this species of clover developed as a summer or spring annual. Therefore high supply of carbon serving in tap root in absence of the stem permit Persian clover to has a greater exudation of organic substance from the root (data not shown). The influence of plant assimilation on microbial communities has been defined in relation to the rhizosphere (Hiltner, 1904) and microbial activity stimulated by the leakage and exudation of organic substance from the root (Grayston 1997). The experiment indicated that various legumes had different influence on composition of microbial population. Plant diversity may had a greater potential on biochemical diversity of root exudates and therefore select for more diverse microbial communities. It is known well that root exudation changes the population of rhizosphere bacteria. Therefore sufficient supply of carbohydrates of plant, special root, may be able to have a greater effect on soil micro-organisms. Persian clover and berseem clover display a simple structure consisting of central tapering main root, which bears a number of branching fibrous root (Taylor,1985) but tapering main root of Persian clover is much thickened compared with berseem clover and annual medic and then has a greater supply of carbohydrates than two other legume.

Conclusions

The present experiment shows that biomas production and the population of the rhizosphere bacterial were affected by both plant species and kind of cropping system. We conclude that probably various root exudations of the different plant species caused the alteration of the composition of microbial population. Studying the diversified agricultural production systems association with soil micro organism would provide more information to obtain improved crop, increased productivity and development of sustainable management of soil fertility.

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Mycorrhization of winter wheat cultivars in organic farming

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Key words: Arbuscular mycorrhiza, root colonisation, root length density, plant morphology, drought tolerance

Abstract

The root length density, arbuscular mycorrhizal (AM) colonisation and the total AM root length density of 12 winter wheat cultivars have been studied at seven sites in eastern Austria under organic farming. Root length density did not differ between the cultivars whereas AM colonisation and total AM root density did. Site effects were more pronounced than cultivar effects. All three traits generally were on a higher level in calcaric Phaeozems than in Cambisols. The AM colonisation and total AM root density decreased with increasing plant height and were positively correlated with crop yield. On calcaric Phaeozems, root length density in the subsoil was obviously more important for drought tolerance than AM colonisation in the topsoil.

Introduction

In organic farming, the choice of adapted cultivars and healthy seedlings are very important. Although management is quite different from conventional farming e.g. with respect to use of fertilisers and chemical plant protection, mostly the same cultivars are used in Austria and other countries. Appropriate cultivars are characterised by characteristics like their adaptation to the soil fertility management of organic farming, a high and stable yield, and an effective nutrient uptake under low-input conditions. Root characteristics like high root length or surface area, and symbioses between crop plants and micro-organisms help achieving these aims. Arbuscular mycorrhizal (**AM**) fungi play a key role in water uptake, availability of sparingly soluble nutrients like phosphorous (P), and crop health in low-input farming systems (Jeffries et al. 2003). For many crops, however, it is not sufficiently known if cultivars differ significantly in their ability to establish a symbiosis with AM fungi. Regarding their above mentioned functions, mainly the total AM root length density is ecologically relevant.

The objectives of this study were to compare root length density, AM colonisation, and AM root density of 12 winter wheat cultivars under field conditions in organic farming, and to test relations with plant morphology, crop yield, and drought tolerance.

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Materials and methods

Mycorrhizal colonisation was assessed in field trials in 3 replicates at 7 sites in eastern Austria. The sites represent acidic and calcaric Cambisols from the pre-alpine region and calcaric Phaeozems from the pannonian dry region. Available P contents in the Ap horizon were in a medium range (Table 1). Soil samples were taken in spring 2006 and 2007 during shooting of winter wheat with an auger from the topsoil at 0 – 30 cm depth. Roots were washed out of the soil and stained (Vierheilig et al. 1998). Root length density (**RLD**) was assessed with the gridline intersect method (Tennant 1975). AM colonisation (**MYC**) of the roots was assessed by microscopy (McGonigle et al. 1990). Multiplying RLD and MYC yielded AM root length density (**MYC_RLD**).

Crop yield was assessed as mean values of the 3 replicates at each site. At two of the sites (Sitzendorf and Oberweiden) additional experiments determined yield depression through induced drought stress generated by sheltering the plots from rain. Experimental traits were tested for cultivar and site effects by a 2-way analysis of variance and Tukey test.

Tab. 1: Site characteristics

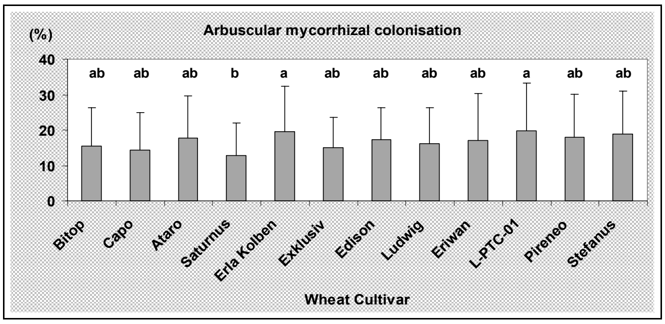
Site \ Trait	Precipitation (mm)	Soil type	pH_{CaCl2}*	P_{CAL}* (mg kg^{-1})
Moidrams	610	Ca	4.4	88
Gießhübl	938	Ca	7.1	17
Edelhof	610	Ca	6.0	69
Sitzendorf	508	Ph	7.4	63
Dörfles	540	Ph	7.5	118
Oberweiden	543	Ph	7.4	53
Obersiebenbrunn	532	Ph	7.6	92

P_{CAL}: available, calcium acetate lactate-extractable phosphorous; ***:** in the Ap horizon, 0 – 30 cm; Ca: Cambisol; Ph: Phaeozem; n.a.: not analysed.

Results

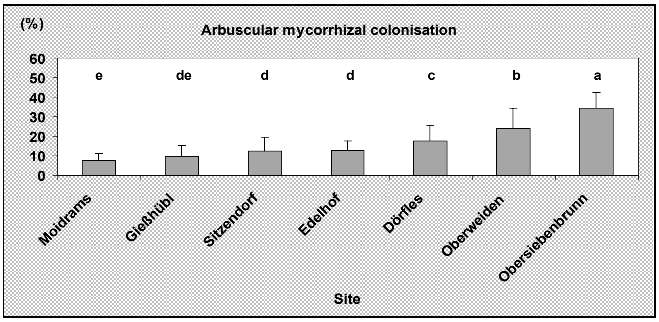
The RLD in the topsoil did not differ between cultivars and amounted to 3 – 4 cm cm^{-3} on average (data not shown). AM root colonisation ranged from 14 to 20 % on average (Fig. 1). Highest degrees of AM colonisation were found in both old (Erla Kolben, cultivar registration in 1961) and new (L-PTC-01, not yet registered) cultivars. AM root length density varied around 0.5 cm cm^{-3}. It was least for Bitop and highest for Stefanus, the other cultivars did not differ from one another (data not shown). The standard deviation was high for all traits of the wheat cultivars due to significant site effects. AM root colonisation (Fig. 2, Table 1), RLD and MYC_RLD (data not shown) in general were lower on Cambisols than on calcareous Phaeozems.

AM root length density was correlated ($P < 0.01$) to RLD and AM colonisation. Both MYC and MYC_RLD decreased with increasing plant height and were correlated ($P < 0.01$) to crop yield (Table 2). The relative yield depression through induced drought stress on two of the Phaeozems increased with increasing AM colonisation and MYC_RLD (Table 2).



Mean values with the same letter are not significantly different ($P < 0.05$).

Figure 1: Arbuscular mycorrhizal root colonisation of the 12 tested wheat cultivars in the topsoil in 2006. Average values of 7 sites.



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Mean values with the same letter are not significantly different ($P < 0.05$).

Figure 2: Arbuscular mycorrhizal root colonisation in the topsoil at 7 sites in 2006. Average values of the 12 tested cultivars.

Discussion

For AM colonisation and AM root length density, only two groups of cultivars could be distinguished. Site effects, however, were considerable. In a study of Yao et al. (2001), mycorrhizal dependency was very low but varied significantly among wheat genotypes and was presumably affected by the carbohydrate partitioning between shoot and root. The general negative effect of soil available P contents on AM colonisation was not apparent. This was most probably due to an overriding pH effect on the study sites where pH values varied over a wide range (Table 1).

Taller plant genotypes presumably allocate more carbohydrates in shoot compared to root growth and vice versa. Carbohydrate partitioning in favour of the roots in shorter plants obviously furthered AM root colonisation in the studied genotypes. The increasing relative yield depression through induced drought stress with increasing AM colonisation seems contradictory to other studies showing a drought alleviating effect of AM colonisation (Jeffries et al. 2003). First results of Schweiger (2007) indicate that root length density in the moister subsoil may be decisive for drought tolerance of wheat cultivars on the calcaric Phaeozems of this study. In our study it was obviously more important for drought tolerance than AM colonisation in the topsoil. The specific combination of traits in the studied genotypes could have overcompensated for a generally existing drought alleviating AM effect.

Tab. 2: Correlations (Pearson) between root length density, AM colonisation, AM root density, plant height, grain yield, and yield depression through induced drought stress.

Trait	N	RLD	MYC	MYC_RLD
MYC	**84**	0.252 (0.021)	-	-
MYC_RLD	**84**	0.538 (0.000)	0.928 (0.000)	-
Plant height	**72**	-0.282 (0.016)	-0.328 (0.005)	-0.404 (0.000)
Grain yield	**84**	0.087 (0.429)	0.385 (0.000)	0.387 (0.000)
Relative yield depression	**24**	0.564 (0.004)	0.686 (0.000)	0.776 (0.000)

Abbreviations see text. Significance level in brackets.

Conclusions

Differences in AM colonisation and AM root length density between the 12 tested wheat cultivars were only small but related to plant yield. Site effects were mainly due to differing soil acidity. Wheat P responsiveness to AM colonisation should be assessed to understand the agronomic importance of differences in AM colonisation.

Highest degrees of AM colonisation were found irrespective of the age of the cultivar. AM root length density decreased with increasing plant height.

Acknowledgments

We thank C. Gabler, E. Lang, P. Rederer and S. Zeidler for their help in field and laboratory. This study was supported by the funds of The Federal States of Austria and The Austrian Ministry of Agriculture.

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Preliminary Findings on the Arbuscular Mycorrhizal Colonization of Organic Wheat

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Key words: Spring wheat, arbuscular mycorrhiza, heritage wheat, phosphorus

Abstract

Arbuscular mycorrhizal fungi aid many crop plants in the uptake of phosphorus, which is one of the most limiting nutrients in organic crop production. Genotypic variation for mycorrhizal colonization exists in wheat cultivars. Mycorrhizal colonization and yield were studied in 5 modern wheat cultivars and 5 older wheat cultivars to investigate if differences in colonization exist between the cultivars. Cultivars that may be better suited for organic production are identified.

Introduction

Modern wheat varieties that have been bred under conventional management systems may not be the best suited varieties for organic production. Although modern crop varieties are high yielding under optimal conditions, some researchers have reported that modern varieties suffer greater yield losses than ancestral varieties when grown under stressful conditions (Mason and Spanner 2006).

In many regions of the world phosphorus (P) is one of the most important nutrients limiting crop production (Zhu *et al.* 2001). Due to increased nutrient deficiencies in organic systems, arbuscular mycorrhizal fungi (AMF) are important for the uptake of nutrients, especially P.

It has been reported that genotypic variation for mycorrhizal colonization exists between cereal cultivars (Baon *et al.* 1993; Zhu *et al*. 2001; Kaeppler *et al.* 2000). Dependency upon mycorrhizal colonization also varies between crop cultivars. Hetrick *et al.* (1992) found landraces have a greater benefit from mycorrhizal symbiosis then modern cultivars, suggesting mycorrhizal dependence is stronger in older populations of wheat. It has been hypothesized that selection of germ plasm under fertilized conditions may have reduced that frequency of genes that promote mycorrhizal associations (Hetrick *et al.* 1992).

The objective of this study was to determine if selecting wheat varieties under conventional management has reduced their ability to colonize with AMF. A second objective of this study is to identify cultivars that may be better adapted to organic conditions due to higher levels of mycorrhizal colonization.

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Materials and methods

This experiment was conducted at two long term organic locations, Glenlea and Carman, Manitoba, Canada. The experiment was established in the spring of 2007. The experimental design is a randomized complete block, with four replicate blocks at each site. Soil samples were collected in early spring and showed 9 ppm or 77 kg/ha of available P at Glenlea, and 14 ppm or 155 kg/ha of available P at Carman. The seeds of five older and five modern bread wheat varieties (*Triticum aestivum* L.) were obtained (Table1). Plot size was 3 x 0.6 m at Glenlea and 4.5 x 0.6 m at Carman. Both locations were seeded in early May and were harvested in late August using a plot combine. To estimate root colonization by AMF 3 soil cores plot^{-1} were obtained at the 4 leaf stage. The soil cores were bulked to give one sample per plot. Roots were washed by hand, root mass was measured, then the roots were stored in 70% ethanol. A random subsample of roots was cleared with 10% KOH, then stained using chlorazol black E. The magnified intersections method (McGonigle *et al.* 1990) was used to score 100 root intersections for colonization by hyphae, arbuscules, vesicles, and spores. All data were statistically analyzed using the mixed model (P<0.05) with the SAS statistical package.

Results

Percent colonization by arbuscules varied from 5.75% (Neepawa) to 11.25% (Mida) at Glenlea and from 12% (Neepawa) to 21% (McKenzie) at Carman (Table 1). Although colonization did not appear to follow a trend at Glenlea, percent colonization generally decreased from the most recently released cultivars to the oldest cultivars at Carman. At Glenlea there was no statistically significant (P>0.5) difference between the modern and older cultivars. As shown in Figure 1, at Carman the modern cultivars had a significantly higher (P<0.5) level of colonization then the older cultivars.

Tab. 1: Year of release, percent colonization by arbuscules, and yield (kg/ha) for the 10 wheat cultivars at Glenlea and Carman, Canada, in 2007.

Cultivar	Year of Release	Arbuscular Colonization		Yield (kg/ha)	
		Glenlea	Carman	Glenlea	Carman
FBC Dylan	2006	9.75[z]	19[z]	1381.60cd[y]	2306.54a[y]
5602 HR	2004	8	13.25	1859.06a	2053.67a
McKenzie	1997	8.5	14	1793.30ab	1729.13b
AC Barrie	1994	6	14.5	1137.05d	1112.86e
CDC Teal	1991	8	19.5	1477.90bc	1424.46cd
Neepawa	1969	5.75	12	1350.52cd	1317.63cde
Selkirk	1955	7.75	13.25	1313.64cd	1210.09de
Mida	1944	11.25	11.25	1283.27cd	1588.88bc
Marquis	1918	8.25	10.25	1442.80cd	1218.29de
Red Fife	1886	9	13	1892.00a	1515.68bc

[y]Means within the same site year followed by the same letter within a column are not significantly different (P>0.05) according to Fischer's protected LSD.
[z]Means are not significantly different (P>0.05) according to Fischer's protected LSD.

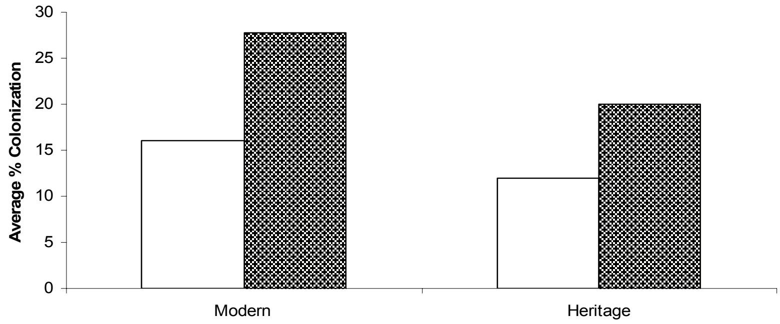

Figure 1: Average % colonization by arbuscules (white) and by hyphae and arbuscules (dark) for modern varieties (1991-2006) and for heritage varieties (1886-1969) at Carman, Manitoba, Canada.

There was no general yield trend at Glenlea, while yields generally decreased with year of release at Carman. Yields ranged from 1137.05 kg/ha (AC Barrie) to 1892 kg/ha (Red Fife) at Glenlea and from 1112.86 kg/ha (AC Barrie) to 2306.54 kg/ha (FBC Dylan) at Carman (Table 1).

Discussion

Variation in mycorrhizal colonization was observed at both locations. The results at Carman are in agreement with the findings of Zhu *et al.* (2001), where the modern cultivars had higher colonization than the older cultivars in the study. All cultivars were found to be mycorrhizal in this study. In general, mycorrhizal colonization is known to increase the uptake of P per unit weight of root (Baon *et al.* 1993). Colonization was shown as arbuscular colonization because it is thought that most nutrient exchange occurs at the arbuscules (Peterson *et al.* 2004). Although it may seem that cultivars with higher colonization by arbuscules should have the ability to take up more nutrients this may not be the case.

Hetrick *et al.* (1993) found no relationship between the degree of root colonization and the degree of benefit from AMF symbiosis. Some researchers have found that efficiency or response to mycorrhiza is greater in older cultivars than modern cultivars (Hetrick *et al.* 1993; Zhu *et al.* 2001). Therefore, although modern cultivars were found to have higher levels of colonization than older cultivars at Carman, more research is needed to assess the benefit the cultivars are receiving from symbiosis with AMF.

It was hypothesized that heritage cultivars may be better suited for organic production. At Glenlea, a site which had high weed and disease pressure, Red Fife (1886), a heritage variety, had the highest yield. At Carman the highest yielding cultivar was FBC Dylan (2006), an organically bred variety. The high yields may be associated with mycorrhizal colonization since FBC Dylan had high colonization at Carman and Red Fife had moderately high colonization at Glenlea. AC Barrie, a variety commonly grown by conventional farmers in Canada had the lowest yield at both sites under organic management.

Conclusions

The objective was to identify cultivars that may be better suited to organic conditions due to higher levels of mycorrhizal colonization. No significant differences in arbuscular mycorrhizal colonization were found between cultivars, although there were significant yield differences at both locations. The yields of the individual cultivars provide an opportunity to identify cultivars that were better suited to organic conditions in this year, although yields were different between sites. More research needs to be done to determine the benefit the cultivars are receiving from mycorrhizal colonization.

Acknowledgments

We gratefully acknowledge financial support from Agriculture and Agri-Food Canada; The Canadian Wheat Board; and Manitoba's ARDI program.

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Soil fertility in Mediterranean organic farming systems I

Poliennal results on soil N management and maize N nutrition by green manuring

Benincasa, P.[1], Tosti, G., Boldrini, A., Tei, F. & Guiducci, M.

Key words: green manure, maize, nitrogen, fertilisation

Abstract

*Several field trials were carried out in 5 years in Central Italy to study the effect of green manuring on soil N management and N availability for grain maize as a succeeding crop. Hairy vetch, field bean, rapeseed and barley were grown in autumn-winter as pure crops or mixed in leg-non leg couples. Maize was sown in early spring just after green manure incorporation. The amount of N supplied by green manures, as well as the maize N uptake and the estimated N effect (i.e. the N taken up by maize that actually derives from green manure N) depended on species used, but with a high between-year variability. The N effect at harvest over 3 years was found to depend on the amount of incorporated biomass (DW) and its N content (N%) according to a multiple linear regression (Neff = -3.9*DW + 47.8*N%, R^2 = 73%).*

Introduction

Winter catch crops of legumes and non legumes, pure or mixed, can be grown to both prevent soil N leaching and incorporate N (either N absorbed from the soil or legume N derived from atmosphere via symbiotic fixation, Ndfa) to the soil for spring-summer cash crops (Odhiambo and Bomke, 2001; Thorup-Kristensen et al., 2003). However, the predictability of green manure N fertilisation efficacy is low, since the amount and release of incorporated N varies much year by year. This paper reports data from 5 years of experiments aimed to study green manure N accumulation and N availability for succeeding grain maize.

Materials and methods

Several field trials were carried out in the 5 years 2001/2002-2005/2006 in Central Italy (165 m a.s.l.) on clay-loam sub-alkaline soils with 1.2-1.5% SOM, quite high N fertility, low available P and high exchangeable K contents. Depending on the year, some or all of the pure crops of hairy vetch (V), field bean (F), rapeseed (R) and barley (B), and the mixtures leg-non leg (Table 1) were sown in autumn and incorporated in early spring, just before the soilbed preparation for irrigated grain maize as succeeding crop. Plot size (50 to 80 m^2) and replicates (3 to 4) varied year by year. Seed rates (kg ha^{-1}) were 300 for F, 90 for V, 10 for R, 200 for B in pure crops and half for each species in mixtures. In any year, the experimental design included bare soil plots in winter where then maize was not fertilised (unfertilised control, N0) or fertilized with urea at 300 kg N ha^{-1} (mineral control, N300). For green manures we measured aerial biomass and N accumulation (Kieldahl method) at incorporation date. For maize from green manure plots we measured the N uptake ($Nupt_{GM}$) at shooting, flowering and final harvest and estimated the N effect (Neff), i.e. the amount of

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uptaken N that actually derives from incorporated green manure N (Thorup-Kristensen et al., 2003). In fact $Nupt_{GM}$ includes, besides N released from green manure biomass, also soil mineral N at maize sowing (Nmin) and N released from soil o.m. during maize growth. We assumed as the best estimate of Neff: Neff= $Nupt_{GM} - Nupt_{N0}$ + Nmin; where $Nupt_{N0}$ is the maize N uptake of the unfertilised control (a pooled estimate of Nmin + N mineralised from soil o.m.). Since we did not measure Nmin, we assumed N accumulated in barley at incorporation as the best estimate of Nmin, provided N-leaching was risible in our clay-loam soils when autumn-winter was not too rainy (Thorup-Kristensen et al., 2003). Actually, we calculated Neff only for the first 3 years, because in 2005/2006 the much rainy and cold autumn-winter compromised barley growth and N uptake and thus the estimate of Nmin, while in 2004/2005 the unespectedly high soil N fertility ($Nupt_{N0}$= 233 kg ha^{-1}) masked the effect of treatments.

Results

Data in table 1 show a great inter-annual variability. As an average, N accumulation was highest in legumes, lowest in non legumes, and medium to high in mixtures, mainly due to differences in N% content of dry matter. At any growth stage, the maize N uptake in the 5 years (table 2) and N effect in the first 3 years (table 3), in most cases (except for in one year after V and V+B) were high after legumes and N300, low after non legumes and N0 (lowest after barley), intermediate after mixtures. One-year data for Neff at each crop stage were related to the amount of incorporated dry biomass and to its N% content according to multiple linear regressions with R^2 always higher than 91% except for the 2nd year (R^2= 84% at shooting, 67% at flowering and 68% at harvest). However each of those relationships did not fit well to data from other years. Weak common relationships plotted over all 3 years data were found at shooting (R^2=45%) and flowering (R^2= 52%), while the regression found at harvest (Neff= -3.9*DW + 47.8*N%) fit pretty well to observed data (R^2= 73%) (Fig. 1).

Tab. 1: Poliennal ranges and means for biomass and N accumulations and N% content in d.m. of pure crops and mixtures grown for green manuring.

Green manure	Years	Dry matter (t ha^{-1})		N % content in d.m.		N (kg ha^{-1})	
		range	mean	range	mean	range	mean
Field bean (B)	3	4.5÷8.6	5.9	3.22÷3.95	3.54	150÷295	208
Hairy vetch (V)	5	4.2÷9.3	5.9	3.05÷4.72	3.89	166÷370	229
Rapeseed (R)	3	2.6÷9.1	5.6	1.39÷2.15	1.77	44÷127	95
Barley (B)	5	2.1÷8.8	5.3	1.13÷1.49	1.27	28÷111	67
F+R	3	5.6÷9.2	7.2	2.81÷3.79	3.32	205÷261	241
V+B	5	3.6÷8.1	6.1	1.89÷2.98	2.62	99÷241	162
F+B	1	6.7	-	2.74	-	181	-
V+R	1	9.0	-	3.23	-	289	-

Tab. 2: Poliennal ranges and means for maize N uptake at 3 growth stages after green manures and in controls (N0= unfertilised; N300= urea at 300 kg N ha^{-1}).

Green manure and controls	Years	Maize N uptake (kg ha^{-1})					
		Shooting		Flowering		Harvest	
		range	mean	range	mean	range	mean
Field bean (B)	3	73÷92	81	141÷168	152	259÷281	267
Hairy vetch (V)	5	52÷104	87	76÷231	150	162÷326	244
Rapeseed (R)	3	35÷64	54	82÷132	115	126÷181	155
Barley (B)	5	20÷45	31	46÷95	68	99÷155	123
F+R	3	65÷81	76	105÷160	146	196÷269	225
V+B	5	29÷96	71	48÷198	120	126÷262	192
F+B	1	77	-	143	-	190	-
V+R	1	106	-	214	-	246	-
N0	5	15÷62	40	50÷152	101	104÷233	164
N200	5	52÷105	82	141÷255	189	252÷316	282

Tab. 3: Poliennal ranges and means for maize N effect at 3 growth stages in green manure treatments.

Green manure	Years	N effect (kg ha^{-1})					
		Shooting		Flowering		Harvest	
		range	mean	range	mean	range	mean
Field bean (B)	2	46÷99	72	85÷86	85	151÷177	164
Hairy vetch (V)	3	-8÷108	57	16÷148	83	102÷222	161
Rapeseed (R)	2	7÷71	39	26÷49	37	22÷48	35
Barley (B)	3	-40÷39	-3	-13÷12	0	12÷56	38
F+R	2	37÷89	63	50÷77	63	92÷101	97
V+B	3	-31÷103	38	-11÷115	54	66÷153	102
F+B	1	84	-	60	-	82	-
V+R	1	113	-	131	-	137	-

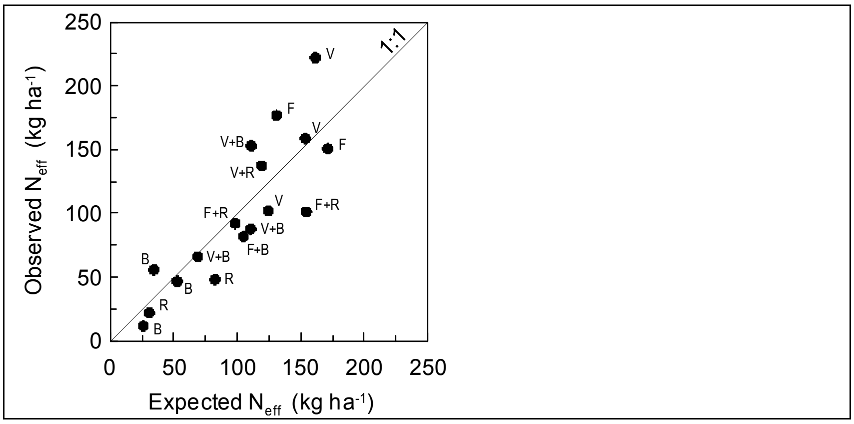

Figure 1: Observed vs expected Neff from the relation Neff = -3.9*DW + 47.8*N% (R^2=73%). Letters: V= hairy vetch, F= field bean, R= rapeseed, B= barley.

Discussion

Notwithstanding the great between-year variability, green manure species showed a clear effect on soil N management. Legumes supplied a high amount of easily releaseable N that could meet the high crop N demand of irrigated grain maize at any growth stage. Indeed, in most experiments, maize N uptake and grain yield were not statistically different from that of the mineral control (N300) (data not shown). It is worth to notice that amounts in table 1 do not take into account roots. Of legume N, the 50-83% was estimated (by difference between N accumulation in legumes and in barley) (Muller and Thorup-Kristensen, 2002) to be Ndfa and therefore added ex-novo to the system. The amount of N absorbed by non legumes is environmentally considerable as it is N temporarily withdrawn from the risk of winter leaching. However that N could not meet maize N requirement in terms of both total amount and timing of release, due to the low N concentration (and thus the high C/N ratio) in biomass. The negative values of Neff mainly recorded after barley indicate that barley caused a high pre-emptive competition (i.e. the depletion of soil Nmin) during its growth and a high soil N immobilization after its incorporation. Indeed, in most experiments maize N uptake and grain yield after barley were lower than in the unfertilised control (N0) (data not shown). However, a negative Neff was also recorded in one year in V+B and even in V at shooting, indicating that even with legumes pre-emptive competition can be high and counteract partially/temporarily the nutritional benefits of green manuring. Mixtures were generally very efficient in accumulating biomass and N, especially with unfavourable (i.e. cold and rainy) seasons, thanks to the ecological complementarity of mixed species, and in most cases the N they supplied and released was able to meet maize needs. Despite the between-year variability of Neff, the common relationship found for Neff at final harvest allows a good predictability for the N actually available from green manuring. Unfortunately, the fit of common relationships is not good at early stages, when the predictability of Neff would be more important, as maize growth and yield depends mainly on the nutritional status at that time. The better fit at final harvest is justified, because the effects of annual soil and climate conditions on green manure biomass decomposition and on maize growth could integrate and compensate over a longer time.

Conclusions

Results suggest that green manure N fertilisation efficacy for irrigated grain maize can be foreseen with good approximation on the basis of parameters (amount of incorporated biomass and its N% content) that are easy to be determined. This should help make of green manuring a more precise and reliable fertilisation technique.

Acknowledgments

Research funded by the Project FISR SIMBIO-VEG (2005-2008).

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Effects of green-manure and organic fertiliser on organic maize (*Zea Mays L.*) in south Tuscany

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Key words: green manure, organic fertiliser, maize, Mediterranean organic farming

Abstract

Green-manure in Mediterranean stockless organic farms is a useful tool to improve nitrogen availability, reduce production cost and conserve soil fertility. A 2-year on farm research was carried out in Tuscany (Italy) to evaluate the effect of 3 different green manures (Hordeum v. + Avena s. mixture, Trifolium s. + Avena s. mixture, Vicia faba var. minor) and 2 levels of organic N fertilization (0 and 120 Kg N ha⁻1) on maize in 2004 and 2005. Green manures were ploughed into the soil in April 2004 and organic fertiliser was applied before sowing; neither green manure nor fertilizers were applied in 2005 to evaluate the residual effect of the treatments. The effect of the distribution of organic fertilizer was not efficient in comparison to green-manure. Field-bean increased maize productivity in both the years thanks to an increase in N availability as suggested by its total N uptake that exceeded the uptake of maize after control by 19.5 and 14,3 Kg N ha^{-1} in the first and second year. In our experimental conditions, with low organic matter and nitrogen content in the soil, the use of grasses as green-manure caused temporary immobilisation of N and maize yield reduction.

Introduction

Italian organic farms, as typical of Mediterranean areas, are often managed without animal husbandry. Even though the exclusion of animal husbandry turns into simplification of farm management, stockless farming systems often suffer from insufficient nitrogen availability to crops. For these reasons organic nitrogen fertilisers application is very common under Mediterranean conditions. Generally farmers prefer to use these fertilisers instead of to introduce green manure in their crop rotations. In this context, the use of green manure together with adequate residue management and crop rotation could be useful to conserve or increase soil fertility, promote nutrient cycling at farm scale and reduce the external inputs (Melero et al., 2006). The aim of this study, partly funded by ARSIA, was to evaluate the effect of 3 different types of green manure crops interacting with 2 levels of organic fertilization on the productivity of maize in 2004 and to assess the residual effect on the same crop repeated in the following year (2005).

Materials and methods

The field experiments were carried out at a farm located in Grosseto province (Tuscany, Italy), under organic management since 1989. The soil has the following characteristics: sand 57%, silt 25%, clay 18%; pH 6,1, organic matter 1,8%, total N 0,9

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‰, available P 8,3 ppm. The experimental plots (15x25m) have been realized within a farm field that has followed a 7 year crop rotation (alfa-alfa 3y - hard wheat – annual mixed grass – field bean - maize). The management of soil fertility includes recourse of commercial organic fertilisers. The field trial was laid out in a strip-plot block design with two replicates; the main factor was the green-manure specie (*Hordeum vulgare*+*Avena sativa* mixture, *Trifolium suarrosum*+*avena sativa* mixture, *Vicia faba var. minor*, control without green manure) and the secondary factor was the nitrogen fertilization: 0 and 120 kg N/ha distributed before seeding using a commercial fertilizer based on vegetable and animal organic matter material. The green-manure crops were sown the 2/10/03 after a harrowing at the following seed density: barley+oat at 100+50 Kg ha^{-1} respectively, clover+oat at 100+35 Kg ha^{-1} respectively and field faba at the rate of 200 Kg ha^{-1}. The burial of green-manure crop was done on 23/04/04 using a disk-harrow and subsequent ploughing at 35 cm deep. The sowing of maize (cv *Campanero*) took place on the 26/04/04 with an investment of 7 plant m^{-2} (70 cm inner row). Mechanical weeding has controlled weeds. None protection treatment was done, while 1500 m^3 of irrigated water was provided in 5 times. The maize was harvested the 15/10/04. At the following spring, the maize was sown the 28/04/05 after preparation of sowing bed and grown without any input of fertilizer. The green manure biomass production (DM) and N content (%) was determined before their burial; maize total biomass, grain and residue production (DM) N content were measured. Analysis of variance (ANOVA) was applied to crop yield, N concentration and uptake data using SAS statistical procedures. A strip plot design was used and least significant differences (LSD) were calculated at P≤ 0.05 to evaluate difference between means.

Results and discussion

The characteristics of green-manure crops before incorporation are shown in table 1.

Tab. 1: Green-manure crop characteristics as determined in spring 2004

	biomass (DM t ha^{-1})	N concentration (%)	N content (Kg ha^{-1})	C/N
barley + oat	9.0	0.8 *b*	72.6 *b*	49.8 *a*
clover + oat	9.3	0.8 *b*	71.6 *b*	51.9 *a*
field bean	7.4	1.6 *a*	116.7 *a*	25.4 *b*
	n.s.	*(*)*	*(*)*	*(*)*

(*) significant for P<0.05

The biomass production was not different among green-manure crops even if mixtures had a tendency to be more productive. Field bean showed a statistically higher nitrogen concentration that directly affected the N content (116 kg ha^{-1}) and the C/N ratio that was more balanced respect to the mixture. The poor results of clover+oat have to be related to the poor stand and development of the clover. The results of maize production in relation to green manure species and nitrogen fertilization in 2004 are shown in table 2. The interactions between the two factors (green-manure and nitrogen fertilizers) did not highlighted differences statistically significant between treatments. However, maize grain yields and residues productions, was positively influenced by the field bean green-manure at both levels of nitrogen fertiliser, especially at N0. Looking at the mean effects, nitrogen fertiliser had no significant influence on maize production, nitrogen concentration and uptakes. On the contrary, the effect of green-manure was decisive and meaningful for all these parameters, except for the average nitrogen concentration in maize cob. Compared to control, field bean green-manure increased maize total biomass and grain production of about 30%

and 37% respectively, while it has not produced significant increases in tissue N concentration, except for crop residues. The total N uptake of maize after field bean was much higher than the other treatments. Respect to control, the difference in N uptake was 19,5 kg N ha^{-1}. The other green-manure (barley+oat and clover+oat) have had a negative effect on maize productivity, N concentration and uptake; this effect was more evident in the barley+oat mixture. Comparing total N uptake of maize after mixtures with control (-15,9 and 22,8 kg N ha^{-1} for clover+oat and barley+oat respectively), it is possible to assume that, in our experimental context, more grass species are included in the green-manure mixture more nitrogen availability is reducing for maize. The reason for these results could be identified in the high C/N values of the green-manure biomass, which has prevented a rapid attack by the soil micro-organisms, reducing N availability for the cultivation of maize during the demanding phases of its development cycle. These assumptions are confirmed by the results of the second succession harvested in 2005 (Tab. 3).

Tab. 2: Effects of green-manure and fertilisation on maize in 2004

	DM (t ha^{-1})			N concentration (%)			N content (Kg/Ha)		
	R	G	tot	R	G	cob	R	G	tot
N0xG1	1.7	2.4	4.1	0.6	1.3	0.5	10.5	31.8	42.3
N0xG2	1.9	2.6	4.5	0.6	1.4	0.6	11.7	37.5	49.2
N0xG3	3.3	4.1	7.4	0.8	1.5	0.5	24.9	59.8	84.7
N0xC	2.6	2.8	5.4	0.7	1.7	0.6	18.7	46.4	65.1
N120xG1	1.8	2.5	4.2	0.6	1.4	0.4	10.4	35.5	45.9
N120xG2	2.3	2.7	4.9	0.6	1.4	0.5	14.2	38.5	52.7
N120xG3	2.9	4.0	6.9	0.8	1.7	0.5	21.0	67.2	88.2
N120xC	2.5	3.1	5.7	0.7	1.6	0.5	17.8	50.8	68.6
	ns	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
N0	2.4	3.0	5.4	0.7	1.5	0.5	16.4	43.9	60.3
N120	2.4	3.1	5.4	0.7	1.5	0.5	15.8	48.0	63.9
	ns	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
G1	1.7 *d*	2.5 *c*	4.2 *c*	0.6 *b*	1.4 *c*	0.5	10.4 *d*	33.7 *c*	44.1 *c*
G2	2.1 *c*	2.6 *bc*	4.7 *c*	0.6 *b*	1.4 *bc*	0.5	13.0 *c*	38.0 *c*	51.0 *c*
G3	3.1 *a*	4.1 *a*	7.2 *a*	0.8 *a*	1.6 *ab*	0.5	22.9 *a*	63.5 *a*	86.4 *a*
C	2.6 *b*	3.0 *b*	5.5 *b*	0.7 *a*	1.6 *a*	0.6	18.3 *b*	48.6 *b*	66.9 *b*
	(*)	*(*)*	*(*)*	*(*)*	*(*)*	*ns*	*(*)*	*(*)*	*(*)*

(R:residues; G:grain; G1:barley+oat; G2:clover+oat; G3:field bean; C:control; * signif. for P<0.05)

In the second year, the lack of positive interaction between green-manure and organic nitrogen fertilisation was confirmed as well as the lack of any positive effect of organic fertilisation on maize. According to the previous year results, the only treatment that has provoked significant effects on maize was the green-manure confirming the existence of a “residual effect”. In particular, only field-bean has shown to be able to increase maize production, N concentration and uptakes in comparison with the control and the other mixture. Looking at the total nitrogen uptake, the difference between maize after field bean and the control was 14,3 kg N ha^{-1}. Considering that in the previous year this difference was 19,5 kg N ha^{-1}, it is possible to conclude that field-bean has increased nitrogen availability by about 34 kg N ha^{-1} respect to control; 58% of this amount has been used by maize the first year and 42% in the second year. The total N uptakes of the other green-manures were not different from the control while in the first year they had a lower result. This evidence would reinforce the hypothesis of N reduced availability in the short-period when high C/N biomass are incorporated into the soil.

Tab. 3: Residual effects of green-manure and fertilisation on maize in 2005

	DM (t ha^{-1})			N concentration (%)			N content (Kg/Ha)		
	R	G	tot	R	G	cob	R	G	tot
N0xG1	3.7	3.5	7.2	0.6	1.3	0.5	22.9	45.1	68.0
N0xG2	3.5	3.4	7.0	0.6	1.3	0.5	21.3	44.4	65.7
N0xG3	3.8	3.7	7.5	0.8	1.4	0.4	28.6	52.2	80.8
N0xC	3.0	2.9	5.9	0.7	1.4	0.4	21.0	41.4	62.4
N120xG1	3.7	3.6	7.4	0.6	1.5	0.5	22.5	54.2	76.7
N120xG2	3.4	3.4	6.8	0.6	1.6	0.5	21.5	53.2	74.7
N120xG3	3.8	3.6	7.4	0.8	1.7	0.5	28.5	60.9	89.5
N120xC	3.2	3.1	6.4	0.7	1.6	0.5	22.1	49.0	71.1
	ns	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
N0	3.5	3.4	6.9	0.7	1.4	0.5	23.5	45.8	69.2
N120	3.5	3.4	7.0	0.7	1.6	0.5	23.7	54.3	78.0
	ns	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*	*ns*
G1	3.3 *bc*	3.3 *b*	6.7 *b*	0.6 *c*	1.4 *b*	0.5	20.5 *b*	46.3 *b*	66.7 *b*
G2	3.5 *ab*	3.4 *b*	6.9 *b*	0.6 *c*	1.4 *b*	0.5	21.4 *b*	48.9 *b*	70.3 *b*
G3	3.7 *a*	3.6 *a*	7.3 *a*	0.8 *a*	1.6 *a*	0.5	28.1 *a*	56.6 *a*	84.7 *a*
C	3.2 *c*	3.1 *c*	6.3 *c*	0.7 *b*	1.5 *a*	0.5	22.9 *b*	47.5 *b*	70.4 *b*
	(*)	*(*)*	*(*)*	*(*)*	*(*)*	*ns*	*(*)*	*(*)*	*(*)*

(R:residues; G:grain; G1:barley+oat; G2:clover+oat; G3:field bean; C:control; * signif. for P<0.05)

Conclusions

The results show the high value of the green-manure for the soil fertility of Tuscan stockless organic farms. The green-manure, in fact, is able to improve the availability of nitrogen for cash crops in succession even in the absence of fertilization. The effect of the distribution of organic fertilizer was not efficient in comparison to green-manure, showing small increases of production even at the highest level. In our experimental conditions, characterised by low organic matter and nitrogen content in the soil, the use of grasses as green-manure caused temporary immobilisation of N. The proper choice of the green-manure species adapted to the local environment is very important for organic farming both from the scientific and the technical point of view.

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Natural biofertilizers for organic agriculture: productivity and nutrient uptake of *Medicago sativa* inoculated with different arbuscular mycorrhizal fungi

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Key words: arbuscular mycorrhizas, *Glomus mosseae*, *Glomus intraradices*, phosphorus uptake, nitrogen uptake

Abstract

Arbuscular mycorrhizas are symbiotic associations that play a key role in plant nutrition by absorbing and translocating mineral nutrients from soil to host plants. Arbuscular mycorrhizal fungi, which are considered natural biofertilizers, show diverse levels of performance, depending on the ability of different isolates to promote plant growth and health. Here we investigated the performance of geographically different isolates of two fungal species, Glomus mosseae *and* G. intraradices*, by assessing plant growth responses and P and N uptake in* Medicago sativa*, in order to select the most efficient fungi for this host plant. The four selected* Glomus *isolates significantly increased shoot dry weights and shoot N and P content of mycorrhizal plants, but their performances were different. In particular,* G. intraradices *IMA6 significantly differed from* G. mosseae *IMA1 in inducing larger growth responses relative to all parameters measured.*

Introduction

Arbuscular mycorrhizas are symbiotic associations established between fungi belonging to the Phylum Glomeromycota and the roots of most land plants. They play a key role in plant nutrition, since plants receive mineral nutrients, such as P, N, S, K, Ca, Fe, Cu, and Zn, that are absorbed and translocated by extraradical hyphae of these fungi, which spread from mycorrhizal roots into the surrounding soil. Thus, arbuscular mycorrhizal (AM) fungi are considered natural biofertilizers (Smith & Read, 1997). However, AM fungi show diverse levels of performance, depending on the ability of different isolates to promote plant growth by improving mineral nutrition and by increasing tolerance to biotic and abiotic stresses (Giovannetti & Avio, 2002; van der Heijden et al., 1998; Avio et al., 2006). Therefore, selection of mycorrhizal endophytes based on their physiological characters represents a fundamental step for practical utilization of AM fungi. Here we investigated the symbiotic performance of four geographically different isolates of two globally distributed AM fungal species, *Glomus mosseae* and *G. intraradices*, by assessing plant growth responses and P and N uptake in *Medicago sativa* (lucerne), a mycotrophic plant species highly dependent on mycorrhizal symbiosis, particularly in nutrient-poor soils.

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Materials and methods

The AM fungi used were: *G. mosseae* (Nicol. & Gerd.) Gerdemann & Trappe, isolate IMA1 from UK and isolate AZ225C from USA, and *G. intraradices* Schenck & Smith, isolate IMA5 from Italy and isolate IMA6 from France. The plant species used was the forage legume *Medicago sativa* cv. Messe.

Seeds of *M. sativa* were planted into 600 ml plastic pots containing a mixture (1:1) of a sandy loam soil and Terragreen (a calcinated clay). The mixture was steam-sterilized to kill naturally occurring AM fungi. Pots were inoculated either with 90 ml of crude inoculum (mycorrhizal roots and soil containing spores and extraradical mycelium) of one of the four fungal isolates, or with 90 ml of a sterilized mixture of them (non-mycorrhizal control). All the pots received 120 ml of a filtrate obtained by sieving a mixture of the four inocula and of agricultural soil from a *M. sativa* field, through a 50-μm diameter pore sieve, to ensure a common microflora for all treatments. After emergence, seeds of *M. sativa* were thinned to 10 per pot. Plants were grown in the greenhouse, supplied with tap water as needed and with a weekly fertilization of half-strength Hoagland's solution (10 ml per pot). The experiment was a completely randomized design with 5 inoculum treatments (fungal isolates and the control) and 5 replicates. Three months after emergence, plant shoots were harvested by cutting them 1 cm above the soil level, and *M. sativa* dry weights determined after drying at 95° C for 48 h. Percentage of AM colonisation and total root length were assessed on half of each root system after root staining, using the gridline intersect method.

P concentrations of shoots were measured after sulphuric/perchloric acid digestion using the photometric method. Tissue N concentrations of shoots were assessed using the Kjeldahl method. The total P and N contents were calculated by multiplying P and N concentration values by dry weights.

Analysis of variance (ANOVA) was performed with SPSS 11.0 software after the necessary transformations, and differences between means were determined by the appropriate test. Tukey's B procedure was used for comparing means.

Results

The four *Glomus* isolates successfully established mycorrhizal symbioses with *M. sativa*, while no colonization was observed in the uninoculated plants. Shoot dry weights (SDW) were significantly higher in mycorrhizal plants, and since nutrient concentrations were also higher in inoculated plants, shoot N and P contents of inoculated plants increased by much more than did SDW (Fig. 1). In fact, the mean increase of SDW in mycorrhizal plants was 105%, while increases of N and P content were 135% and 216%, respectively. Although all AM fungal isolates used in this study produced positive growth responses in *M. sativa*, they affected the host differently: *G. intraradices* isolate IMA6, which was the best-performing fungal endophyte, produced increases in shoot dry weight and N and P content that were consistently higher than with *G. mosseae* isolate IMA1 (Fig. 1).

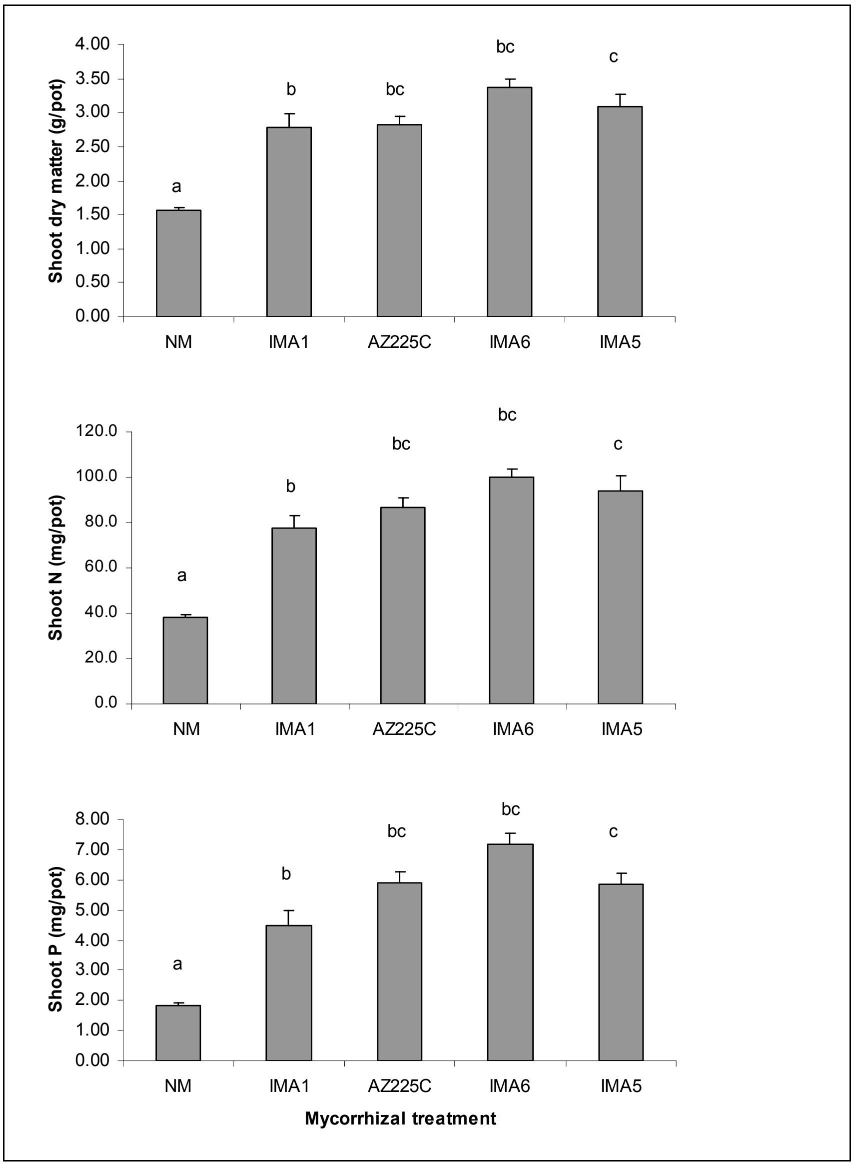

Figure 1: Shoot response variables of *Medicago sativa* inoculated with isolates of *Glomus mosseae* (IMA1 and AZ225) and *Glomus intraradices* (IMA6 and IMA5) or not inoculated (NM). Different letters above bars indicates significant difference, P < 0.05. Error bars show ± SEM.

Discussion

This work shows that different AM fungal isolates differ in their ability to increase the growth and P and N nutrition of *M. sativa* plants, thus contributing to enhanced nutritional quality of this forage crop. In particular, a *G. intraradices* isolate (IMA6) showed a better symbiotic performance than a *G. mosseae* isolate (IMA1). Interestingly, the latter isolate, in a previous comparison with the same isolate of *G. intraradices* on a different lucerne variety, was the less-performing endophyte (Vasquez et al., 2001). The isolates of *G. intraradices* and *G. mosseae* used in this work have different patterns of extraradical mycelial growth, as measured by hyphal length and density or by the number of anastomoses (Avio et al., 2006). Interestingly, *G. intraradices* IMA6 produced the highest values for all parameters related to extraradical fungal growth (Avio et al., 2006). These data are in agreement with the suggestion that size and developmental patterns of soil-exploring mycelium are important factors in AM fungi efficiency (Jakobsen et al., 1992), although other fungal traits may play a role, such as spatial distribution of hyphae or uptake efficiency of hyphal Pi transporters (Smith et al. 2000; Munkvold et al., 2004).

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How Perennial Grass has Modified Distribution of Organic Carbon in a Peach Orchard in Emilia-Romagna Region (Italy)

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Key words: Organic Carbon, Humification Parameters, DRIFT, TG-DTA

Abstract

In this study, the distribution of the total and humified organic carbon in a peach orchard tilled-irrigated on the row and perennial grassed on the inter-row space after 16 years of cultivation were evaluated. The TOC has shown differences not statistically significant in the 0-20 cm horizon, whereas the difference in the row vs. inter-row 20-40 cm horizon was significant. The highest content of humic substances was found in the 0-20 cm of the inter-row with perennial grass vs. row tilled soil: the absence of tillage increases the accumulation of humified compounds. DRIFT and TG-DTA analysis pointed out only some small structural variation in the humic fraction of the samples taken from the layer at depth 20-40 cm.

Introduction

Cultivation practices in agricultural systems have remarkable influence on dynamic of soil organic carbon (Francioso et al., 2000; 2005a; Gioacchini et al., 2006). Sowings, perennial grass species and irrigation, among the others, are the major factors affecting the dynamic of the organic carbon in orchards. Perennial sods prevent soil erosion, improve traffic conditions, enhance water infiltration into the soil, suppress pests, interact with beneficial organisms, modify orchard temperatures and light conditions for improved fruit quality, reduce dust and mite infestations, and provide substrate or food and habitat for a multitude of soil-borne organisms. The adoption of different soil management can contribute to the soil carbon sequestration and distribution in soil profile (Lal, 2002) to mitigate the greenhouse effect (Lal, 2003). Perennial grass species can contributes to the formation of a soil horizon reach in organic carbon in the top layer (Wedin et al., 1995).

Aim of this study was to measure the distribution of the total and humified organic carbon in a peach orchard tilled-irrigated on the row and perennial grassed on the inter-row space after 16 years of cultivation using chemical analysis, infrared spectroscopy and thermogravimetric (TG) and differential thermal analysis (DTA).

Materials and methods

Soil samples (Typic Xerochrept) were taken in a 16-years peach orchard farm located in Roncadello (Forlì-Cesena province), Emilia-Romagna Region (Italy). Samples were collected in August 2005, after harvest, from plots at two depth (0-20 and 20-40 cm) along the row (tilled soil) and in the inter-row space (perennial grassed with different

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Graminaceae species). Soil samples were air dried, crushed to pass a 2 mm sieve and stored in sealed bags. In the last decade the mean annual fertilisation added was 40 kg N ha^{-1} of organic N fertiliser. The main physical-chemical characteristics of the soil were: pH (in water) 7.24; texture: sand 25%; silt 35%; clay 40%; total calcium carbonate ($CaCO_3$) 110 g kg^{-1}; cation exchange capacity 25 cmol$_c$ kg^{-1}; TOC 9.5 g kg^{-1}; TKN 1.3 g kg^{-1}; Olsen-P 18 mg kg^{-1}; Exchangeable-K 170 mg kg^{-1}.

Total (TOC), extracted (TEC), humified (HA+FA) and non humified organic carbon (NH) were determined according to Ciavatta et al. (1997) method. DRIFT and TG-DTA analysis were performed on humic acids extracted from soil samples. DRIFT spectra were recorded with a Nicolet Impact 400 FT-IR Spectrophotometer (Madison, WI) equipped with an apparatus for diffuse reflectance (Spectra-Tech. Inc., Stamford, CT), according to Francioso et al. (2001) method. TG-DTA curves were carried out simultaneously using the TG-DTA92B (Setaram- France) device. Sperimental conditions: heating rate 10°C min^{-1} from 30 to 750 °C, in air atmosphere and calcinated kaolinite was used as reference material.

Results and discussion

TOC, TEC, HA+FA, NH, the degree of humification [DH% = TEC/(HA+FA) x 100] and the humification rate [HR% = TOC/(HA+FA) x 100] are shown in figures 1-2. The TOC has shown differences not statistically significant in the 0-20 cm horizon, whereas the difference in the row *vs.* inter-row 20-40 cm horizon was significant (Fig. 1). The phenomenon can be reasonably due to the irrigation that induces a higher microbial activity that increases the amount of TEC as well. On the contrary, a highest content of humic substances (HA+FA) was found in the 0-20 cm of the inter-raw with perennial grass *vs.* row tilled soil: the absence of tillage increases the accumulation of humified compounds. The values of humification parameters DH and HR were higher in the 0-20 cm horizon of the inter-row with perennial grass *vs.* the row (Fig. 2): similar differences were observed at 20-40 cm depth. The role of perennial grass, among the others agronomic properties, is to increase the TOC and the humification level, as well shown by the increase of the DH and HR in the top layer (0-20 cm). From a quantitative point of view, it can be calculated that a concentration of 1 g kg^{-1} of soil humic C corresponds to 2.5 tons ha^{-1}, assuming a soil depth of 20 cm and density of 1.25 kg dm^{-3}.

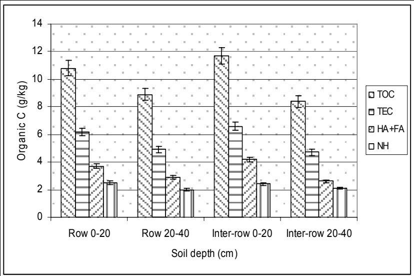

Figure 1: Total (TOC), extracted (TEC), humified (HA+FA) and non humified C (NH) of soil samples taken at 0-20 and 20-40 cm depth (row andin

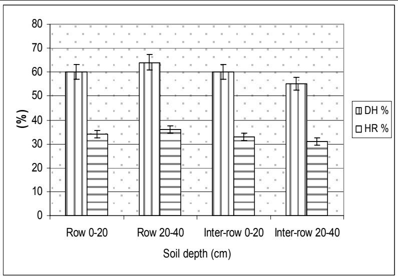

Figure 2: Degree (DH) and humification rate (HR) of soil samples taken at 0-20 and 20-40 cm depth (row and in the inter-row

inter-row space).	**space).**

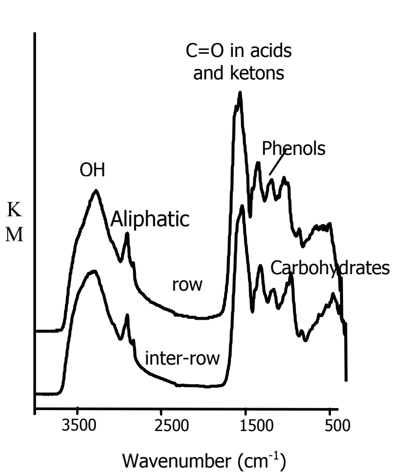

Figure 3: DRIFT spectra of the humic fraction of samples taken from the layer 20-40 cm along the row and in the inter-row space.

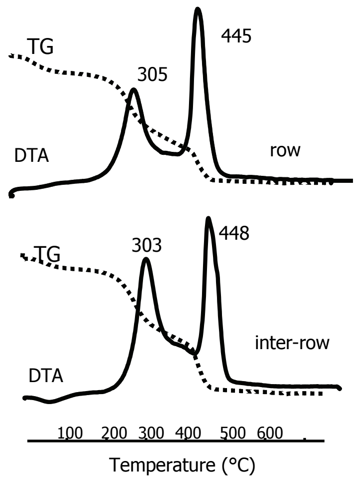

Figure 4: TG-DTA curves of the humic fraction of samples taken from the layer 20-40 cm along the row and in the inter-row space.

DRIFT spectra of humic fraction (HA) of soil taken from the top layer at depth 0-20 cm along the row and inter-row space did not show significant structural modifications due to treatment (data here not shown). Instead some small structural variation can be observed in the humic fraction from the samples taken from the layer at depth 20-40 cm (Fig. 3). The main modification might be assigned to different amount in carbohydrates content (Francioso et al., 2001). These results were supported by TG-DTA analysis (Fig. 4) as revealed by higher exothermic reaction at around 300 °C in inter-row sample (20-40 cm) than that found in row samples. This peak was mainly produced by the combustion of carboxylic groups and carbohydrates suggesting the formation of recent organic carbon (root exudates, microbial cells). The second peak at around 450 °C was typical of high resistant temperature components such as aromatic structures (Francioso et al., 2005b).

Conclusions

After 16 years of cultivation the distribution of TOC in a peach orchard tilled-irrigated on the row and perennial grassed on the inter-row space did not show statistically significant differences in the 0-20 cm horizon, whereas the difference in the row *vs.* inter-row 20-40 cm horizon was significant. The highest content of humic C was found in the 0-20 cm of the inter-row with perennial grass *vs.* row tilled soil suggesting that the absence of tillage increases the accumulation of humified carbon. Moreover the presence of slight structural modifications in the humic fraction from the layer 20-40 cm along the inter-row space may suggest the influence of the activity of the roots.

Acknowledgments

Activity carried out within the biennal project "Qualità e Mercato della Frutta Prodotta con Sistemi Biologici e Sostenibili: Innovazioni Tecniche, Rintracciabilità – *Quality and Market of the Fruits Produced in Organic and Sustainable Systems: Technical Innovation, Traceability*" (acronym: BIOFRUIT II) funded by *Alma Mater Studiorum* University of Bologna (2004).

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The effect of green manure on root development and cotton yield under Mediterranean conditions

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Key words: green manure, cotton, vetch, faba bean, organic agriculture, roots

Abstract

Two experiments were conducted in Greece, during the years 2005 and 2006, in order to evaluate the effect of two legumes (vetch: Vicia sativa and faba bean: Vicia faba) on the root development and yield of the following cotton. Concerning the cotton cultivation the Organic Agriculture guidelines were followed. In both years the higher values of the root characteristics of the cotton were found in the plots where vetch had been incorporated. The seed cotton yield for vetch was 2850 and 3137 kg ha^{-1} in 2005 and 2006, respectively. Furthermore, in both years, a statistically important factor of correlation, between the nitrogen quantities of the soil and the seed cotton yield, had been appeared.

Introduction

The conventional agricultural methods created a lot of environmental problems. For solving these problems different approaches have been developed, such as organic farming (Scofield 1986), which consists of a rapidly developing agricultural sector.

The use of green manure is one of the basic cultivation techniques of Organic Agriculture (OA). The legumes can be used as green manure thanks to their ability to fix atmospheric nitrogen (Hardarson and Atkins 2003). Rochester et al. 2001 reported the positive effect of legumes used as green manure to the yield of various crops. Cotton (*Gossypium hirsutum*) is one of the most profitable irrigated summer plants in Greece, thus it has high economic value (Karamanos et al. 2004).

During this study the effect of two legumes used as green manure (vetch: *Vicia sativa* and faba bean: *Vicia faba*) on root development and yield of the following cotton, in an organic farming system, has been examined.

Materials and methods

The experiments were carried out in 2005 and 2006 at the organic research farm of the Agricultural University of Athens. The experimental design was based on a randomized complete blocks design consisted of three treatments and four replications. The three treatments were: fertilization (green manure) with vetch, faba bean and control (no fertilizer). Moreover the soil type was clay loam.

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The cotton seeds (*G. hirsutum cv*. Fantom) were hand sown in rows of 80 cm apart, at the recommended seed rate, vetch (*V. sativa cv*. Alexandros) and faba bean (*V. faba cv*. Grande Aquadulce) and had been incorporated into the soil as green manure for the cotton plants. The nitrogen quantities which were added to the soil, due to the legumes, are presented in Tab. 2. The total nitrogen was determined by using the Kjedahl method (Bremer 1960).

All plots were harvested manually at the recommended seed cotton moisture percentage in order to determine the seed cotton yield. Root samples were taken 104 and 94 days after the cotton sowing, during the years 2005 and 2006, from the 0-12.5 cm soil layer using a cylindrical auger. The roots were dried, weighted for their dry matter and put into a high resolution scanner to determine their root characteristics.

The data was subjected to the analysis of variance appropriate to the experiment design. Significant differences between the treatments means were separated by means of the least significant difference (LSD) at the 5% level of probability, using the “Statistica” program for windows.

Tab. 2: Total nitrogen (from shoots and roots) added to the soil by legumes for the culture of cotton during 2005 and 2006.

Treatment	Total nitrogen in $Kg.ha^{-1}$ (Shoots+Roots)	
	Year 2005	Year 2006
Vetch	211	230
Faba bean	205	217
$LSD_{(5\%)}$	5.87	12.7

Results and Discussion

During both years, in 0-12.5 cm soil surface depth, the highest values of root dry weight, surface area and density of cotton plants (tab. 3 and tab.4) were observed in the plots where vetch had been incorporated. On the other hand the lowest values were observed in the control plots. The results indicated significant differences between control and green manure, but no significant differences between vetch and faba bean. The interaction between the two years was not statistically significant.

Same tendencies were observed regarding the seed cotton yield. Specifically during 2005 and 2006 the highest values of seed cotton yield were observed in the plots where vetch had been incorporated (2850 and 3137 kg ha^{-1} for 2005 and 2006, respectively) followed by faba bean (2647 and 2958 kg ha^{-1} for 2005 and 2006, respectively) and control (2185 and 2337 kg ha^{-1} for 2005 and 2006, respectively) plots in decreasing order. Between green manure types there were no statistically significant differences observed in contrast to the green manure and control which indicated statistically significant differences (Table 4). The interaction between the two years was not statistically significant.

Tab. 3: The effect of green manure type on root dry weight (kg ha^{-1}), length density (cm cm^{-3}), diameter (mm) and surface area (cm^{-2} cm^{-3}) of cotton plants, in 0-12.5 cm soil depth, for 2005.

Characteristic (cotton)	Green manure type			
	Control	Faba bean	Vetch	LSD(5%)
Dry weight of roots	2819	3737	3986	695
Length density of roots	2.90	3.51	3.84	0.54
Diameter of roots	0.40	0.44	0.48	0.045
Surface area of roots	0.061	0.089	0.107	0.026

Tab. 4: The effect of green manure type on root dry weight (kg ha^{-1}), length density (cm cm^{-3}), diameter (mm) and surface area (cm^{-2} cm^{-3}) of cotton plants, in 0-12.5 cm soil depth, for 2006.

Characteristic (cotton)	Green manure type			
	Control	Faba bean	Vetch	LSD(5%)
Dry weight of roots	2777	3875	4170	831
Length density of roots	2.79	3.65	3.88	0.65
Diameter of roots	0.45	0.61	0.58	0.10
Surface area of roots	0.057	0.097	0.102	0.028

The seed cotton yield appears to be related to the nitrogen that was added in the soil by the green manure. Furthermore the nitrogen added to the soil by vetch was 211 and 230 kg ha^{-1} for 2005 and 2006, respectively (Tab. 2). Moreover, during 2005 and 2006, a statistically important factor of correlation (r=0.95 and r=0.96*, n=3), concerning the quantities between the nitrogen in the soil and seed cotton yield, was observed.

In most of the root characteristics the supremacy of cotton plants that have been cultivated after the incorporation of vetch, was explicit thanks to the larger quantity, and perhaps better availability, of nitrogen in the first stages of their growth (tab.3 and tab. 4).

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* Significant at the 0.05 probability level

Tab. 5: The effect of green manure type on seed cotton yield (kg ha^{-1}) of cotton plants, for 2005 and 2006.

Cotton yield	Green manure type			
	Control	Faba bean	Vetch	$LSD_{(5\%)}$
2005	2185	2647	2850	387
2006	2337	2958	3137	475

The larger root surface area of the cotton plants after the vetch incorporation is related to the absorption of more water and through this of nutritious elements (Russell and Clarkson 1976). Karamanos et al. (2004) reported that the growth of the cotton crop root system was due to the positive effect of legumes used as green manure, as their incorporation improved the chemical and physical properties of the soil. Moreover the positive effect of the legumes on the subsequent crop yields was due to the soil enrichment with nitrogen after the incorporation of legume plant residues (Senaratne and Hardarson 1988).

Conclusions

In conclusion, the application of the green manure had a positive effect on the root growth and yield of the following cotton crop, for both years, but the differences between the cropping systems (vetch-cotton and faba bean–cotton) were not significant.

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Quality assessment of citrus-processing industry waste compost for organic and conventional farming

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Key words: Compost, Organic Farming, citrus-processing,

Abstract

The aim of the work was to verify the potential of citrus by-products for the production of a quality compost to be used in both conventional and organic farming. Two different composts were produced utilizing Pastazzo (mixture of citrus pulp and skins). One of them, to be used in conventional farming, was prepared adding sludges obtained from citrus industry waste water treatment to pastazzo. The other one, whose final destination was organic farming, was produced without the addition of sludge as starting raw material. Chemical parameters were used to evaluate the characteristics of the final product. Results obtained demonstrated that organic residues from citrus-processing industry could be considered as raw materials for the production of quality composts for both conventional and organic farming.

Introduction

In Italy, citrus-processing industry has increased its importance during the last ten years. The main product of the industrial process is the juice (35-45% of total weight of fresh product), while the main by-products are represented by pastazzo, a mixture of citrus pulp and skins (60% of fruit weight), and a significant amount of sludges obtained by industrial waste water treatment.

In order to solve the economic and environmental problem connected to the large amount of by-products obtained (600.000 t of pastazzo y-1) a sustainable approach to waste management should be identified. Compost processing is a potential technology to recycle organic matter component of these by-products.

The main aim of the work was to verify the potential of citrus by-products for the production of a quality compost. Moreover, since in organic farming sludges are not allowed, we wanted to verify the technical feasibility of compost production by the utilization of pastazzo and pruning materials.

Materials and methods

The composting trials were performed in the Experimental farm of CRA-ACM. Two different compost heaps were set up. The first one, to produce compost for conventional agriculture (C-conv), was prepared mixing pastazzo (40%) (w/w), sludge (20%) and pruning materials (40%). The other one, to be used in organic farming (C-

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org) was obtained mixing pastazzo (60%) and pruning materials (40%), without the addition of sludge.

Compost samples were taken from each pile at prefixed time. In details: just after the mixing of the raw materials, at starting of compost process(T0) and after 29 (T1), 67 (T2), 89 (T3), 130 (T4) e 165 days (T5). Samples were dried in oven at 50°C, ground and sieved at 1 mm and then stored for subsequent analysis.

Each sample was analyzed to determine total N, total organic carbon (TOC), total extractable carbon (TEC) and humic and fulvic like carbon (CHA+FA) In addition, the isoelectric focusing (IEF) in a polyacrylamide slab gel with a preformed pH gradient was performed in order to separate organic compounds, according to their isoelectric point and their electrophoretic mobility (Govi et al., 1994).

In order to determine the humic and fulvic like carbon (CHA+FA) and to perform the IEF profile, organic matter was extracted from samples in a solution of NaOH/Na4P2O7 0.1 N (2g in 100 mL) for 48 hours at 65°C. The humic acids were then precipitated by 0,5 N H2SO4 at pH 2. The fulvic acids were purified on a polyvynilpyrrolidone column and then joint to humic fraction (HA+FA) following the procedure proposed by Ciavatta et al. (1990). Degree of humification (DH%) and humification rate (HR%) were calculated according to Ciavatta et al. (1990) as follow:

$$DH\% = (CHA+FA \times 100)/TEC \qquad HR\% = (CHA+FA \times 100)/TOC$$

On T5 samples, obtained at the end of the composting process, the following parameters were determined: total P2O5 (%), total K2O (%), total Cd, Hg, Cu, Zn, Ni, Pb, Cr (VI) (mg kg-1) by atomic absorption.

Results

Table 1 reports the main physical-chemical characteristics of the two composts produced and, in order to allow an easy comparison of the values with the applicable legislative limits, the values imposed by Italian legislation (Lgs.D. 217/2006).

In table 2 quality and quantity parameters of compost organic matter, sampled during the composting process, are reported. The C/N ratio shows a decrease over time, while DH % and HR % presented an increasing trend. Figure 1 reports the IEF profiles of samples T0-T5 for C-conv and C-org. In C-conv the IEF profiles showed a sharp peak at pH 3.5 while in C-org its area decrease starting from T1 profile. For both the composts the IEF profiles, from T1 to T5, resulted better resolved in the pH range 4.2-4.7. Number and the area of the peaks focused at pH>4.7 increased over time.

Discussion

Both the composts produced complied with the limits imposed by Italian legislation concerning compost allowed in conventional and organic farming (table 1). The differences between C-conv and C-org regarding ashes and TOC could be explained considering that C-conv contained sludges, which are generally characterised by a high value of ashes and, consequently, a relatively low content of TOC. Similarly, can be explained the higher value in P_2O_5 of C-Conv. As far as heavy metals content is concerned, both composts presented low absolute values, complying with the national legislation. In addition, excluding Zn and Cd which are significantly higher in C-conv than in C-org, the two composts showed similar values.

Tab. 1: Chemical-physical characteristics of C-conv and C-org and limits of the Italian legislation.

Parameter	C-conv	C-org	IT Limits (Lgs.D. 217/06)
pH	8.4	8.5	6-8,5
Ashes (%)	37.5	24.6	-
TOC (%)	31.0	37.7	>25
Total N (%)	2.8	2.5	-
P_2O_5 (%)	2.3	0.7	-
K_2O (%)	0.8	0.7	-
C/N	12	14	<25
C_{HA+FA} (%)	14	18	>7
Total Cadmium (mg kg^{-1})	1.5	<0.5	<1,5
Total Mercury (mg kg^{-1})	<0.1	<0.1	<1,5
Total Copper (mg kg^{-1})	37	32	<150
Total Zinc (mg kg^{-1})	320	99	<500
Total Nickel (mg kg^{-1})	31	20	<100
Total Lead (mg kg^{-1})	10	13	<140
Hexavalent Chromium (Cr VI) (mg kg^{-1})	-	-	<0,5
Electric conductivity (dS m^{-1})	2.08	1.78	-

Tab. 2: Total organic carbon (TOC), humification rate (HR), humification degree (HD) and C/N ratio of the samples collected during the composting process.

	TOC (%)		HR %		DH %		C/N	
Sample	C-con	C-org	C-con	C-org	C-con	C-org	C-con	C-org
T0	45.0	49.8	22	23	57	64	31	37
T1	38.7	45.8	31	31	73	86	16	23
T2	37.2	43.5	34	36	78	88	14	17
T3	34.4	41.9	36	38	76	83	13	16
T4	35.2	38.5	40	42	72	85	12	14
T5	31.0	37.7	47	47	74	90	12	14

Results about C/N ratio and the different C fractions evolution during composting process (table 2) gives information about the appearance of more stabilised humic like substances. The C/N ratio decreased starting from T0, while DH% and HR % increase over time. In addition, DH% values were higher in C-org than in C-conv.

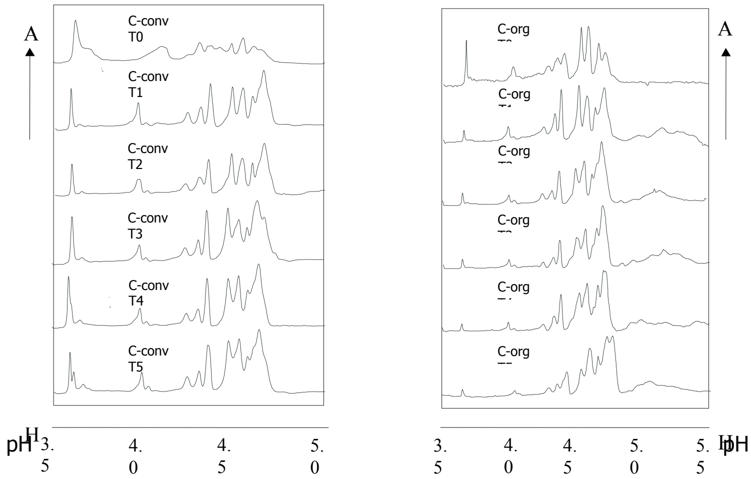

Figure 1: IEF profiles of investigated compost samples.

Isoelectrofocusing profiling technique, which allows evaluation of organic matter during the composting process from a qualitative point of view, showed an increase of complexity of organic fractions over time, as demonstrated by the larger size and number of peaks focused at pH higher than 4.7 (indicating more humified material) and by the decreasing of peaks focused at lower values of pH (Figure 1).

Conclusions

The low content of potential toxic elements and the positive properties of organic matter of the two composts produced allow affirms that the citrus-processing industry wastes can be utilized for a quality compost production (Tittarelli et al., 2007). Moreover compost obtained without sludges, depending on its qualitative-quantitative characteristics, can be utilized in organic farming.

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Controlling insect pests of stored organic chamomile by controlled atmospheres

Hashem, M. Y.[1]

Key words: Carbon dioxide, chamomile, modified atmosphere, population dynamics.

Abstract

Different stages of Trupanea stellata *and* Lasioderma serricorne *were exposed to four different gas mixtures differing in their CO_2 content (20%, 40%, 60% and 80% CO_2). In general, increase in carbon dioxide combined with decrease in oxygen resulted in increasing mortality. The gas mixture containing 80% CO_2 was the most effective mixture to control the different stages of* T. stellata *(most tolerant than the different stages of* L. serricorne insects*). The use of this gas mixture to disinfest chamomile for 7day exposure in 30 m^3 fumigation chamber under temperature range between 28.7-30.9^oC, resulted in complete control.*

Introduction

Chamomile (*Matricaria chamomilla L)* is produced in Egypt using the organic farming system. Most of this product is for export to the European and American markets, in which the major constraints for exportation are the detection of either insect infestation or pesticide residues, of any other chemical. Chamomile is exposed during flowering in the field to attack by the chrysanthemum fly *Trupanea stellata* (F.) and during drying, processing and storage to attack by the cigarette beetle *Lasioderma serricorne*

The classic way to control these insects has been and still by the use of fumigants such as methyl bromide (CH_3Br) and phosphine (PH_3), which are not allowed for treatment of organic products. Recent work in many countries has focused on the possibility of using the inert gases (CO_2 and/or N_2) as an alternative for chemical fumigants. This method of treatment is commonly termed modified atmosphere (MA) or controlled atmosphere (CA) (Reichmuth 1992).

This work reports on the population dynamics of *T. Stellata* under field conditions and tests of susceptibility of different stages of *L. serricorne* and *T. stellata* to different mixtures of CO_2, N_2 and O_2 under laboratory conditions and large scale conditions.

Materials and methods

The population dynamics of *T. Stellata* were carried out in Fayoum region in the winter season 2006/2007. Samples of 400 chamomile flowers were collected weekly, randomly for investigation. To examine the different stages found inside the flowers, each flower was examined under stereomicroscope after dissection. The number of larvae, pupae and infested flowers were recorded.

The Susceptibility of different stages of *L. serricorne* and *T. Stellata* to alterations of atmospheric gas concentration has been studied using the parental insects of *L.*

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serricorne, which were obtained from infested chamomile and reared on chamomile powder at 30°C □ 2°C and 70% □ 5% r.h. All stages except eggs were prepared for treatments. Trials were carried out on one week old adults, 3rd larval instars and 2-3 days old pupae of *L. serricorne*. The experimental unit for *L. serricorne* was 50 individual of each stage; and for *T. Stellata;* 50 dried chamomile flowers. Each unit of *L. serricorne* was prepared in a cylindrical cage (6 cm high and 1.5 cm diam.) made from 40 mesh stainless-steel wire gauze closed with rubber foam. Each 50 dried chamomile flowers was placed in small paper bag. Cages containing the different stages were introduced into a bottle of dressel flask (Hashem 2000).

The tested atmospheres were prepared from CO_2, O_2, and N_2. This component was monitored using a paramagnetic oxygen analyzer (SERVOMEX/ England). To improve distribution of the components, the cylinders with gas mixtures were kept at room temperature for two days before starting the experiment. The gas mixtures tested were: a. 20% CO_2, 64% N_2 and 16% O_2; b. 40% CO_2, 48% N_2 and 12% O_2; c. 60% CO_2, 32% N_2 and 8% O2; d. 80% CO_2, 16% N_2 and 4% O_2. Different stages in gastight connected dressel flasks were exposed to the gas mixtures from mixture cylinder through copper tubes and a humidifying unit containing saturated NaCl/H_2O solution in flasks, to create 70% R.H. At the outlet of the containers the O_2 content was determined continuously by an oxygen analyzer. After about 15 min. (time for about 10 replacements of total container volume by gas mixture) the outlet concentration became identical with the inlet concentration. After different exposure periods ranging from 1-4 days, each bottle was aerated and the insects transferred from the cages to Petri-dishes and held at 30°C□2°C and 70%□5% R.H. The adults were examined for mortality, and the pupae of *L. serricorne* were examined for adult emergence. Also the chamomile flowers were examined for adult emergence of *T. Stellata*. Each sample was accompanied by an untreated control. The experiments were designed to provide time-mortality regression lines for the different stages in various combinations of atmospheric gases and different exposure periods. Moralities of *L. serricorne* adults were corrected by Abbotts formula (Abbott, 1925), and Data was subjected to probit analysis (Finney, 1971) to calculate the slopes of regression lines and the values of LT_{50} and LT_{99},

The large scale application of the most efficient CO_2 -concentration carried out in 30 m^3 fumigation chamber (2.5 m high x 3 m width x 4 m long) which built at SEKEM Co. for biological products. The roof, walls and the interior side of the door were lined with aluminium sheets (150 □ thick) and the floor was covered with stainless-steel sheet (1mm thick). The door of the chamber has two openings; a lower opening for gas input and an upper opening for gas output. To ensure the air tightness of the chamber, all fill spouts, door margins and manholes, were sealed with duct tape. The pressure test to determine the efficacy of fumigation in the buildings, chambers and stores against stored product insect pests was applied before introducing CO_2 (Reichmuth, 1992).

A quantity of infested 1500 kg chamomile (in boxes) was put in the chamber. Twelve cages of different stages (50 individuals/ cage/stage) of *L. serricorne* were placed in wire cages to monitor insect mortality within the treated product. The same number of additional cages (prepared as described above) was pushed in untreated products to serve as controls. Small paper bags of 50 infested chamomile flowers with *T. stellata* each were placed also within the treated product to monitor the insect mortality after treatment. To measure the temperature and relative humidity throughout the test, a thermo-hygrograph was installed in the centre of chamber.

After exposure, each stage of the two insects was transferred from the cages to a Petri dishes and held at $30^{o}C$□$2^{o}C$ and 70%□5% R.H. At 48 hours after exposure, the stages were examined for mortality. The criterion of dead larvae and pupae was its failure to develop to adults. At the same time, the infested chamomile flowers samples were examined to evaluate the survival stages of *T. stellata*.

Results and Discussion

Fig. (1) shows population dynamics of larvae, pupae/400 chamomile flowers as percentage of infestation. The obtained results show that the variations in the population density of larvae and pupae of *T. stellata* fluctuated from time to another.

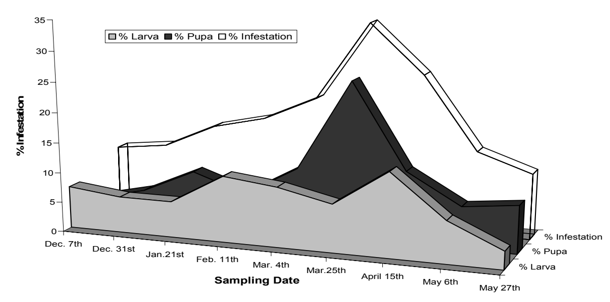

Figure 1: The percentage of infested chamomile flowers by larvae and pupae of Chrysanthemum fly *T. stellata*.

As indicated from Fig. (1), two peaks were obvious for the larval stage in Feb. and April, but in the case of pupal stage three peaks of abundance were obvious. The first peak of the pupal population was recorded on January 21st, after that of larvae with nearly of three weeks and almost equal to it. The second peak of pupae was recorded in the third week of March. This can be explained that the present larvae transferred to pupae representing the end of a generation with a decrease in oviposition during this time. The infestation rates were high during the season especially on March 25^{th} (34%). Knowing that import countries reject any product if the rate of infestation reached up to 5%, explains the importance of this pest attacking this crop.

LT_{50} and LT_{99} levels indicate the susceptibility of different stages of *L. serricorne* to alterations of atmospheric gas concentration (Fig. 2). At all gas mixtures, the stages of *T. stellata*, were more tolerant than the stages of *L. serricorne*. The LT_{99} values for larval stage (more tolerant than other staged of *L. serricorne*) were 4.80; 4.30; 2.82 and 0.6 days at the different gas mixtures. The LT_{99} values of *T. stellata* were 6.40; 5.60; 4.70 and 4.00 days. The LT_{99} values for pupal stage of *L. serricorne* were 3.50; 3.00; 1.60 and 0.51 days, and those for adult stage were 2.81; 2.00; and 1.00 days, respectively. Mortalities of insects exposed to the mixture containing 80% CO_2, were higher than those of the insects exposed to mixtures containing 20%, 40% and 60% CO_2 at all exposure periods ranging from 1 to 4 days. When, using the mixture containing 80% CO_2, mortality reached 100% after 1 to 2 days for adults and after 5-7

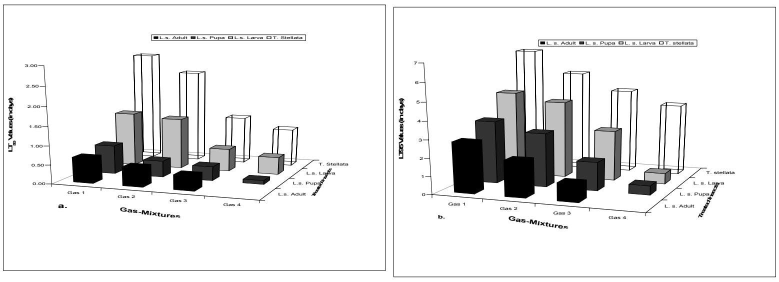

Figure 2: (a & b): LT50 and LT99 values (in days) of treated stages of *L. serricorne* and *T. stellata* exposed to 4 different gas mixtures.

days for the more tolerant stages of both insects. Hashem and Reichmuth (1994) have shown that decreasing the oxygen content in the mixture increases the mortality in shorter exposure period. The descending order of the treated stages according to the LT_{50} and LT_{99} values was as follows: Stages of *T. stellata* > Larva of *L. serricorne* > Pupa of *L. serricorne* > Adult of *L. serricorne* (Hashem, 2000).

The large scale application of the efficient CO_2-concentration for controlling stored chamomile insects was based on the results of the above mentioned tests (Fig. 2), the gas mixture containing 80% CO_2 against the different stages of *T. stellata* was applied. Free space conditions throughout the application were 28.7-30.9^{o}C and 65% R.H.

All treated stages of both insects were killed after 5 days exposure. Keever (1989) indicated that the pupae of the cigarette beetle are often more adversely affected during tests than the other stages.

Conclusions

The present findings indicate that the use of CO_2 in well sealed containers may be a method for disinfecting chamomile and other products as long as the exposure period is not less than 5 days and the temperature is not less than 28^{o}C.

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Soil fertility in Mediterranean organic farming systems II

N availability after long-term organic farming in irrigated and rain-fed Mediterranean semi-arid grassy crops

Romanyà, J.[1], & Rovira, P.[2]

Key words: soil fertility, farming practices, potentially mineralisable nitrogen

Abstract

The use of manures and rotation with legumes in organic farming systems does not always guarantee the adequate nutrient supply to crops. We studied post-harvest N availability in a series of Mediterranean semi-arid rain-fed and irrigated organic fields after 18 years of conversion and compared these with conventional fields nearby. In organic irrigated soils the use of legumes and the application of moderate amounts of manures resulted in higher amounts of soil organic C and potentially mineralisable N. In contrast, in organic rain-fed soils that did not incorporate legumes in their rotation and used low amounts of manures, soil organic C and potential mineralisable N were lower. In organic irrigated soils changes in organic matter quality resulted in a lower potential net N mineralisation per unit of SOC than in conventional irrigated soils.

Introduction

Organic farming systems have the potential to supply adequate amounts of nutrients to crops. However several studies suggest that in these systems soil fertility often limits crop productivity (Berry et al., 2002). Soil fertility management in organic farms is based on the enhancement of soil biological processes that are intimately associated to soil organic matter dynamics. In arable land the amount of fresh organic matter debris that is incorporated into the soil is associated with crop productivity, crop residue management and manuring programs.

Mediterranean arable soils often show levels of soil organic carbon of less than the 1% threshold proposed by Loveland and Webb (2003). Moreover, as a result of low cattle density occurring in dry areas, the availability of manures is normally low. These two factors may hinder the productivity of organic farming practices in the extensive agriculture of the Mediterranean area.

Organic farms rely heavily on soil biological activity to mineralise N and to enhance P availability. N availability in organic farms depends almost entirely on the ability of soil microorganisms to mineralise N that is mainly associated to soil organic matter turnover and quality.

In this paper we aim to study the changes in soil N availability occurring after 18 years of organic farming and to determine the factors that regulate soil N availability, paying special attention to the relationships between available N and organic C.

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Materials and methods

The study was carried out in a set of agricultural fields in the Ebro river depression (NE Iberian Peninsula; 41° 49' N, -0° 2' E). Some of the areas are irrigated by surface flooding while the rest of it is rain-fed. Mean annual temperature is 14.4°C and mean annual rainfall is 436.6 mm. Soil texture ranges between clay loam and sandy clay loam and pH ranges between 8.1 and 9.2. In the last 18 years, organic farming practices have been introduced in some rain-fed and irrigated fields scattered in the area of study. Organically managed soils received an application of 5 Mg ha^{-1} every two year of poultry manure for the rain-fed soils and 10 Mg ha^{-1} yr^{-1} for the irrigated soils. Conventional treatments did not use manures or legumes at all.

We selected 4 independent agricultural fields subject to organic farming practices in a rain-fed area and another similar set of 4 fields with conventional management within the same area following one factor randomized design. Similarly, we selected another set of 8 fields (4 with organic and 4 with conventional farming practices) in an irrigated area nearby. In each field three soil samples were taken and divided into two layers 0-10, and 10-20 cm. Soils were analysed for total organic C and N, mineral N (NO_3^- and NH_4^+) and for potentially mineralisable N by waterlogged incubation. The effects of the farming practices in each soil horizon were tested separately in rain-fed and in irrigated areas using a two level nested ANOVA. Differences between regression lines were tested using ANCOVA with C or C/N ratio as covariates.

Results and Discussion

Forms of available N

Post harvest soil mineral N content was mainly in nitrate form. In all studied organically managed soils nitrate content in the 10-20 cm layer was lower than in conventional soils thus reducing the possibility of leaching losses of N from organic fields. On the other hand, the amount of post harvest ammonia was higher in irrigated organically managed soils, in both studied layers, than in conventional soils receiving mineral fertilizer, suggesting that in this case the organic farming practices were likely to increase the supply of ammonia post harvest by enhancing the ammonification processes. Indeed these irrigated organically managed soils showed increased amounts of organic C (Table 1).

Potentially mineralisable N is a biological index that reflects the soil capacity to supply the N stored in labile organic forms. The effects of the farming practices on the potentially mineralisable N occurred mainly in the first 10 cm of soil. Irrigated organic fields that received large amounts of manures and rotated with legumes showed an increase in the mineralisation capacity of N. In contrast, rain-fed organically managed fields that received low amounts of manures and did not include legumes in their rotation showed the opposite trend as compared to soils receiving mineral fertilisers (Table 1). Moreover, this treatment showed a decrease in the mineral N forms that reached the 10-20 cm layer. It appears therefore that the management regime of the rain-fed organically managed soil did not improve the availability of N. Other authors have stated that low N contents in manures and its slow mineralisation rates can reduce N availability in organic farms (Berry et al., 2002) this does not seem to be the case in our irrigated farms but it may explain the low mineral and mineralisable N in rain-fed organically managed soils. A recent study on P availability carried out with the same soils also showed a large decrease in P availability in rain-fed organically managed soils (Romanyà and Rovira, 2007).

Tab. 1: Organic C, total N, C to N ratio and post harvest mineral N forms in the studied treatments. (n.s. refers to non significant (p>0.050)).

		Irrigated			Rain-fed		
Soil depth (cm)		Conv.	Organic	(p=)	Conv.	Organic	(p=)
0-10	C %	0.89	1.26	0.000	0.91	0.79	0.011
	N mg g^{-1}	1.02	1.30	0.004	1.05	0.85	0.05
	C/N	8.45	9.83	0.008	8.69	9.56	n.s.
	NO_3 mg kg^{-1}	14.70	16.67	n.s.	5.05	5.17	n.s.
	NH_4 mg kg^{-1}	2.56	4.40	0.005	2.09	1.75	n.s.
	NPM $mgkg^{-1}$	30.73	43.04	0.011	29.45	21.26	0.038
10-20	C %	0.69	0.86	0.000	0.85	0.72	n.s.
	N mg g^{-1}	0.88	0.95	n.s.	0.96	0.78	0.003
	C/N	7.93	9.38	n.s.	9.14	9.18	n.s.
	NO_3 mg kg^{-1}	9.57	6.91	n.s.	6.23	3.93	0.007
	NH_4 mg kg^{-1}	1.61	4.16	0.028	3.37	1.65	n.s.
	NPM $mgkg^{-1}$	18.04	18.66	n.s.	16.85	10.40	0.005

Soil organic matter and N availability

Soil organic C and total N contents after 18 years of organic farming were higher in both studied layers in irrigated organic soils. In rain-fed organic soils these measures were lower in the 0-10 cm layer (Table 1). Changes in potentially mineralisable N among treatments in the first studied layer showed a similar trend, suggesting that N mineralisation can be associated to the reserve of N and organic C. Indeed, the relationships between soil organic C and potentially mineralisable N were significant in all studied treatments (Figure 1) and the slope of the curves depended on the treatment. In rain-fed fields the organically managed soils potentially mineralisable showed higher sensitivity to soil organic C content than in conventionally managed soils, suggesting that the low N mineralisation observed in organically managed soils was intimately related to the soil organic matter content. Under these conditions increases in soil organic matter would likely result in increasing soil N supply.In irrigated fields organic management resulted in a decrease of net N mineralisation per unit of soil organic C, suggesting that in this case soil microbia can use part of the mineralised N and incorporate it into the soil organic fractions. In this treatment the organic matter quality index C to N ratio did not show any relationship with potentially mineralisable N. This fact contrasted with the close exponential relationship that we observed in conventionally managed irrigated fields. It is noteworthy that the range of C to N ratio in irrigated organically managed soils was much wider than in conventionally managed soils. It is likely that this was associated with the exogenous organic matter inputs applied to these soils during the last 18 years. In all studied rain-fed soils however, the range of C to N ratio was as narrow as in the irrigated conventional soils, and did not show in any case a relationship with soil mineralized N, suggesting that in these cases organic N was not the main limiting factor to N mineralisation.

Conclusions

N availability is sensitive to the organic farming practices carried out in the studied semi-arid area. Soils of rain-fed organic farms receiving low amounts of manures and not incorporating legumes in their rotation showed lower mineral N and potentially mineralisable N than conventional soils. In contrast, organic irrigated soils receiving moderate applications of manures and rotating with legumes showed higher N potential mineralisation than conventional soils and maintained the overall N availability. Furthermore, the organic management of the irrigated soils significantly changed SOM quality and quantity.

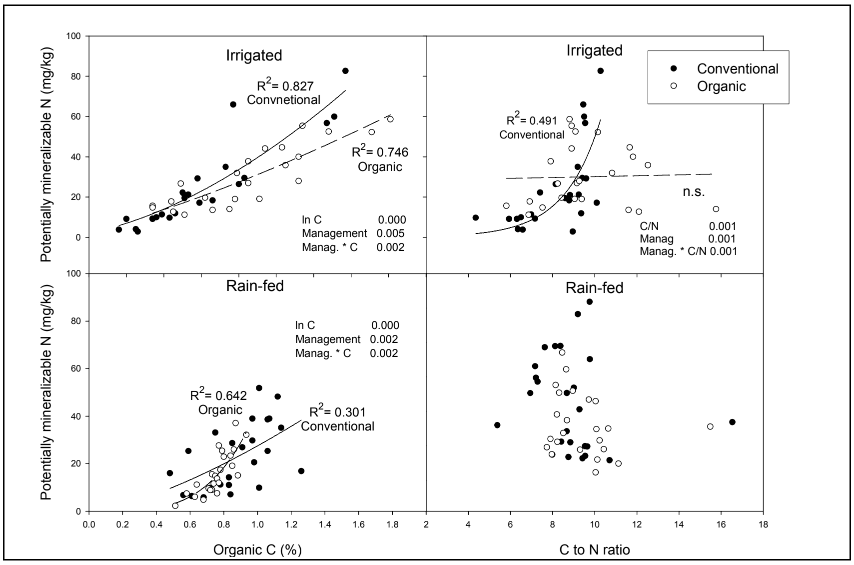

Figure 1: Relationships between organic C, C to N ratio and potentially mineralisable N in irrigated and rain-fed conventionally and organically managed soils. Solid regression lines refer to conventional while dashed lines refer to organic treatments.

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Organic vegetable production in Southern Italy: soil fertility management and fertilisation strategies.

Caturano, E.[1], Roccuzzo, G.[2], Canali, S.[2], Adamo, S.[1], Giuffrida, F.[1] & Leonardi, C.[1]

Key words: survey, fertilisation, vegetable, intensive cultivation, idrolised proteins.

Abstract

Despite the importance of the organic sector in Italy, there are still many difficulties in crop management amenable to weed control, plant protection and soil fertility keeping. Concerning this last aspect and focusing attention to the vegetables crops, the subject is even more complex for the intensive cultivations, the difficulty of rotations implementation, etc. To develop research programmes, we have in a preliminary phase carried out, in a representative area in the south of Italy, a survey aimed at better understanding the main characteristics of organic vegetable agrosystems in terms of plant nutrition and fertility maintenance.

Introduction

Italy, with more than 5% of agricultural land devoted to organic horticulture, is undoubtedly the first country in the European Union to operate in this area. Although the spreading and importance of the organic horticulture, the adoption of the European regulation still involves many problems due to weed control, crop protection and soil fertility management. Concerning this last aspect and with a particular attention to the vegetables crops, the subject is even more complex for the intensive cultivations (e.g.: protected cultivation), where there are difficulties for rotations implementation and for the high input of organic fertilizers (Leonardi and Noto, 2005); besides, climatic conditions and consequently dynamics of the fertilizers and their availability are peculiar. Considering those constraints and in order to obtain information useful to plan research activity aimed at the optimisation of plant nutrition under organic vegetable production, we have carried out a survey dealing with one of the most intensive vegetable production area in the country (i.e.: southern regions). The results concerning the plant nutrition and the fertility maintenance, as well as those concerning the characterisation of the most representative agrosystems are presented and discussed.

Materials and methods

The geographical area of interest has been identified in the south-eastern coast of Sicily and in particular in Ragusa province. The choice of this area was triggered by the high importance which it assumes for the vegetable intensive production at national and even more at the regional level. Fifty-three organic farms characterized by different extension were assessed during the 2006; attention was addressed to

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farms entirely on partially involved in intensive vegetable production. For all the farms, besides general information, data concerning pre-planting and post transplanting application of fertilisers was recorded, paying particular attention to timing, application typology, type of fertilizer, quantity used, etc. (Canali *et al.,* 2004); besides green manuring when carried out was recorded. The above information has been gained proposing to the growers structured questionnaire.

Results

Farm characteristics and produce destination

All the studied farms reached about 250 ha all together; 90 ha of these are devoted to grazing/grain/vegetables in open field, 109 ha in protected cultivation (74 ha in greenhouse and 35 ha under plastic net), 50 ha cultivated with tree crops (Table 1). Farm surface oscillates between 0.5 ha and more than 40 ha, with an average of about 5 ha. Among these, 30 farms have the cycle entirely under greenhouse, 7 farms adopt plastic nets only, 5 farms are involved in the production under protected cultivation (either greenhouse or plastic nets) and field as well, and 4 farms carry out their activities only in open fields.

Tab. 1: Distribution (% over 250 ha) of productive soil in the considered organic farms.

	(% /total)
Grazing/grain/vegetables crops in open	36
Tree crops	20
Greenhouse protected crops	30
Plastic net protected crops	14

Individual farmer provide their produce to some local collection centres (they are often members); then produce is transported in northern Italy platforms where the processing, packaging and the distribution will occur. The distribution is usually addressed to north European markets.

Agrosystems

According to crop requirement and production period, cultivation takes place under greenhouse (e.g.: tomato), under plastic net (e.g.: cabbages) or in open air (eg.: fennel). For some crops, according with the growing cycle and corresponding climatic conditions cultivation take place under greenhouse or in open air (e.g.: zucchini, pepper, eggplant). As far as crop rotation is concerned, under greenhouse sometimes monocropping is carried out (e.g.: tomato), on the contrary in open air crop rotations is usual among vegetables (e.g.: fennel and zucchini) or among different herbaceous crops (e.g.: wheat and

Tab. 2: Vegetable cultivar adopted in the considered farms.

Specie	Cultivar
Tomato	Shiren, Ovetto, Lacey, Zagor, San Marzano, Rubino top, Murano, Eldiez, Laetitia, Lady rosa, Portobello, Panarea, Alambra, Ambizioso, Italdor, Cuore di bue
Pepper	Estelle, Balico, Duke, Wakii, Pepita, Lucelt
Marrow	Tosca, Millennio, President, Thina
Melon	Magico, Dylan, Seven, Magenta

melon). Green manuring is seldom carried out either in greenhouse and in open air. In some cases intercropping under plastic net is achieved (e.g.: cabbages and table grape during winter). In open air, transplanting takes place according to crop requirement and market demand. For some crops in greenhouse cultivation (e.g.: tomato) starts in August-September and lasts (according to market demand and plant phytosanitary status) in May-June.

Biological profile

In our investigation 15 crops, mainly represented by *Solanaceae* (tomato, pepper, eggplant) and *Cucurbitaceae* (zucchini, melon, cucumber, watermelon) were recorded. Tomato holds the first position (cherry and truss as well) with about 50 ha invested, followed by zucchini (22 ha) and pepper (13 ha). As far as the cultivar is concerned, tomato with 16 cultivars shows the largest diversification, followed by pepper (6 cultivars) and by melon and zucchini (4 cultivars) (Table 2). Many of those cultivar are typical of conventional cultivation. Yields, as expected, vary according to species and cultivars adopted, the length of cultivation cycle and the cultivation techniques. For example, yields highlighted from the survey ranged between 80 and 120 t/ha for truss tomato, whereas for cherry tomato ranged between 50 and 80 t/ha. The production recorded for pepper varied between 40 and 60 t/ha and between 30 and 75 t/ha for zucchini. Of course, some of the variability derives from cultivation (either open or greenhouse).

Fertility management

Soil is solarised during the months of July-August; this period for some crops (e.g.: greenhouse ones) coincides with the period of rest. Soil fertility management is based on the use of off-farm fertilisers and soil conditioners. The fertilization before transplanting is almost the same in all the farms: manure, when available, is incorporated before solarization (if carried out), while sulphur, magnesium and potassium are distributed few days before the transplanting. In particular magnesium and potassium are spread in the form of sulphate with an average of 0.5 t/ha (Table 3).

Tab. 3: Before transplanting fertilisation (mean value)

	(t/ha)
Cow manure	5,5
Potassium sulphate	0,5
Magnesium sulphate	0,5
Sulphur	0,5

Concerning manure, the amount varies from 1 up to 9 t/ha; if good quality manure is used (N = 3%) amounts adopted is reduced. Only in small farms commercial seasoned and stabilized manure is used.

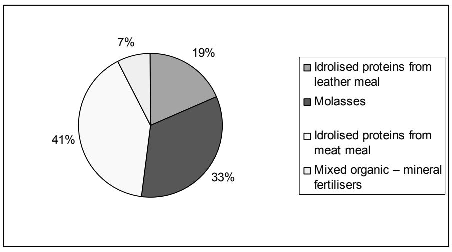

Figure 1: Percentage of fertilizer more adopted after transplanting.

After transplanting, fertilizers are distributed through fertigation once a week during spring-summer and once a fortnight during the winter. As a nitrogen source, molasses and idrolised proteins of animal origin obtained from leather meal of meat meal are used (Figure 1). From our investigation has been found that 15 farms use mixtures of molasses and idrolised proteins from leather meal, 8 farms mixtures molasses and idrolised proteins from meat meal, 8 farms only idrolised proteins from leather meal or other solid organic fertilizers, 3 farms mixtures of idrolised proteins from either leather and meat meal, 2 farms molasses, 2 farms idrolised proteins and a mix of other solid organic fertilizers. The amount of applied fertilizer is very variable in relation to different crops. Considering tomato, being the most representative crop, the total amount of fertilisers adopted pre and post transplanting is reported in table 4. The variability observed may be also due to the growing cycles and to different yields expected. However referring the data to the obtained yield and considering all the applied fertilizers (pre and post transplanting) the variability remains still very wide; besides, is some cases the inputs referred to the theoretical data of crop uptake per unit of produce harvested are very far.

Conclusions

The survey carried out has presented a picture expressing a great diversity of the vegetable organic agrosystems in Ragusa province. Those agrosystems are represented mainly by tomatoes (76% of the area) followed by zucchini and fennel. Information collected concerning soil fertility management indicate that seldom the basic principles of soil management in organic farming are fully respected and the following aspects can be highlighted:

- crop rotation is carried out mainly in open air being for some crops specialisation particularly enhanced;

- intensive crops cycle do not allow sometimes to have enough time for soil preparation (e.g.: solarization, manuring);

Tab. 4: Minimum, mean and maximum amount of nitrogen, phosphorus and potassium distributed in pre and post transplanting in tomato (CV = coefficient of variability).

kg/ha	N	P_2O_5	K_2O
Minimum	310.6	60.0	103.5
Mean	805.1	147.3	464.4
Maximum	1324.0	460.0	1626.0
CV	23.2	53.5	77.3
kg/t	N	P_2O_5	K_2O
Minimum	3.9	0.5	0.9
Mean	7.7	1.5	4.6
Maximum	11.3	5.1	18.1
CV	21.3	64.1	80.6

- soil fertility management is bases on the use of off-farm fertilisers and soil conditioners. Before transplanting manure, solid organic fertilisers, potassium and magnesium sulphates are utilised; whereas in post transplanting fluid fertilisers as idrolised proteins of animal origin and/or molasses are applied by fertigation;

- some of the growers choices (e.g. fertilisers typology and timing of spreading) are not related to clear criteria, but rather to market pressure;

- fertilization inputs not only differ widely between the different farms but also within the same crop; besides the inputs referred to the obtained yield sometimes differ considerably from the theoretical crop uptake.

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Leguminous cover crops: an important tool for improving resource use efficiency in organic arable cropping systems

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Key words: cover crops, nitrogen, mixtures, weeds

Abstract

*Cover crops are one of the most effective tools for organic farmers to improve the efficiency of their agro-ecosystems, while also reducing economic costs and environmental problems. The choice and usefulness of a cover crop species strictly depend on its adaptability to specific climate and soil conditions, but also on its relationships with other species (crops and weeds) and on the quality of farm management. Nine different pure species and three species mixtures were cultivated for two years as winter cover crops in a rainfed stockless arable organic cropping system as part of the MASCOT long-term experiment. Leguminous cover crops showed the highest level of biomass production in both years. Hairy vetch (*Vicia villosa*), either in pure stand or in mixture with grasses, was the most productive and stable species, and had the highest N uptake (ca. 200 kg ha^{-1}). Besides, leguminous species significantly increased the content of N (up to 100%) and P (up to 50%) in weeds and associated grass crops, probably as a result of increased nutrient availability in soil through root exudates.*

Introduction

Cover crops are one of the most effective tools for organic farmers to improve their agroecosystem efficiency without using expensive and environmentally risky external inputs, thereby enhancing the economic and environmental suitability of their farm management. Cover crops can play an important role in the improvement of soil organic matter content, in the supply of nutrients from biological fixation or surplus radical absorption to the following cash crops (Doran & Smith, 1991), and in weed control through competitive, physical, or allelopathic interference (Moonen & Bàrberi, 2006). Although several studies were carried out in the past 20 years on the characterisation of the most common cover crop species, there is still a lack of knowledge about their actual behaviour in the field, especially in Mediterranean environments. In fact, the benefits of cover crops strictly depend on their adaptability to specific soil and climate conditions and especially to their agronomic management.

Materials and methods

The so-called Green Manure Comparison Trial (GMCT) started in 2002 as a part of the MASCOT long-term experiment (Bàrberi & Mazzoncini, 2006), carried out at CIRAA E. Avanzi of the University of Pisa (lat. 43°41' N, long. 10°23' E). Climatic conditions are typical of Mediterranean areas, with a mean total rainfall ranging from

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550 to 1180 mm year^{-1}, mainly concentrated in autumn and spring. The soil is a silty-loam (Typic Xerofluvent) with low content of organic matter (OM), N and P. The aim of GMCT is to compare different species potentially usable as winter cover crops in a typical rainfed and stockless arable crop rotation (maize-durum wheat-sunflower-pigeon bean-common wheat). The main characteristics evaluated are the species adaptability to the specific soil and climate conditions, the amount and quality of biomass produced, the effect on soil nutrients and OM content, and weed suppression ability.
The GMCT was carried out in 2005/06 and 2006/07 on two organically managed MASCOT fields, with grain maize and sunflower as subsequent cash crops, according to a RCB design with four replicates. In the first year, a weedy control and eight different cover crops (*Avena sativa, Brassica juncea, Phacelia tanacetifolia, Secale cereale, Trifolium incarnatum, Trifolium squarrosum, Vicia faba* var. *minor* and *Vicia villosa)* were compared in pure stands. Two mixtures (*A. sativa* + *T. incarnatum* and *V. villosa* + *S. cereale*) were also included. In the second year, rye was replaced by barley (*Hordeum vulgare*), both in the pure stand and in mixture with hairy vetch. A mixture of *T. squarrosum* and *A. sativa* was also included. Cover crops were broadcast seeded in early autumn and ploughed under in early April by means of a disc harrow. Cover crops did not receive any fertilisation, crop protection or direct weeding measures. Dry matter biomass and N and P data were subjected to ANOVA (RCB design) and subsequent Duncan Multiple Range test at P ≤ 0.05 for mean separation.

Results and discussion

Tab. 1: Cover crops, weeds and total dry biomass (t ha^{-1}) production at the date of cover crop ploughing under (7 April 2006 and 12 April 2007)

Species[1]	2005/06 season			2006/07 season		
	Cover crop biomass	Weed biomass	Total biomass	Cover crop biomass	Weed biomass	Total biomass
A. sativa	1.57 de	0.55 c	2.12 cd	1.30 d	1.04 cd	2.34 e
B. juncea	1.82 d	0.81 bc	2.63 bcd	2.74 cd	1.81 bc	4.55 cd
H. vulgare	-	-	-	1.54 d	0.97 cd	2.51 e
P. tanacetifolia	0.86 de	1.18 bc	2.04 cd	1.55 d	3.15 ab	4.70 cd
S. cereale	0.57 e	0.64 bc	1.21 d	-	-	-
T. incarnatum	4.06 abc	0.95 bc	5.01 a	5.42 b	1.18 cd	6.60 ab
T. squarrosum	3.11 c	1.10 bc	4.21 ab	6.80 ab	0.92 cd	7.72 a
V. faba minor	3.33 bc	2.39 b	5.72 a	3.49 c	1.74 bc	5.23 bcd
V. villosa	5.25 a	0.32 c	5.57 a	5.69 ab	0.56 cd	6.25 abc
Mix 1	-	-	-	7.45 a	0.19 d	7.64 a
Mix 2	3.71 bc	0.25 c	3.96 abc	5.97 ab	0.22 d	6.19 abc
Mix 3	4.38 ab	0.33 c	4.71 a	-	-	-
Mix 4	-	-	-	7.37 a	0.11 d	7.48 a
Control	-	4.37 a	4.37 ab	-	3.51 a	3.51 de
F test [2]	**	**	**	**	**	**

[1] Mix 1: *A. sativa + T. squarrosum;* Mix 2: *A. sativa + T. incarnatum*; Mix 3: *V. villosa + S. cereale*; Mix 4: *V. villosa + H. vulgare*; [2] ** Significant at P ≤ 0.01. In each column, values with the same letter are not significantly different at P ≤ 0.05 (Duncan Multiple Range Test).

As shown in Table 1, for each parameter there were significant differences between treatments in both years. Leguminous crops produced the highest biomass, thanks to their not being affected by low soil N content. Among them, hairy vetch (*V. villosa*), either in pure stand or mixture, showed the highest biomass production in both years. In the second year, the *A. sativa + T. squarrosum* mixture also gave a good result. *S. cereale, H. vulgare* and *P. tanacetifolia* had some difficulties during emergence and early growth because of the suboptimum soil conditions, which resulted in lower biomass yield. Cover crop mixtures containing hairy vetch were the most weed suppressive.

Tab. 2: Cover crops and weeds nitrogen content and total N uptake at the date of cover crop ploughing under (7 April 2006 and 12 April 2007)

Species[1]	2005/06 season			2006/07 season		
	Cover crop N (%)	Weeds N (%)	Total N uptake (kg ha^{-1})	Cover crop N (%)	Weeds N (%)	Total N uptake (kg ha^{-1})
A. sativa	1.09 e	1.23 de	23.70 ef	1.15 d	1.62 cdef	31.80 d
B. juncea	0.90 f	1.63 c	28.77 ef	0.84 e	1.34 fg	47.27 d
H. vulgare	-	-	-	1.06 de	1.49 def	30.78 d
P. tanacetifolia	0.96 ef	1.53 cd	23.86 ef	0.80 e	1.08 g	46.42 d
S. cereale	1.41 d	1.62 c	18.22 f	-	-	-
T. incarnatum	3.04 b	1.77 c	139.65 bc	2.61 bc	1.42 efg	158.22 c
T. squarrosum	3.04 b	1.86 c	106.27 cd	2.46 bc	1.66 cdef	182.55 bc
V. faba minor	3.03 b	1.80 c	143.65 bc	2.82 b	2.01 bc	133.39 c
V. villosa	3.66 a	2.65 b	195.95 a	3.63 a	2.68 a	221.56 ab
Mix 1	-	-	-	2.38 bc	1.81 cde	180.75 bc
Mix 2	2.49 c	1.64 c	97.38 d	2.32 c	1.90 cd	142.68 c
Mix 3	3.75 a	3.15 a	175.60 ab	-	-	-
Mix 4	-	-	-	3.40 a	2.54 ab	253.37 a
Control	-	1.20 e	53.31 e	-	1.35 fg	47.39 d
F test [2]	**	**	**	**	**	**

[1] Mix 1: *A. sativa + T. squarrosum*; Mix 2: *A. sativa + T. incarnatum*; Mix 3: *V. villosa + S. cereale*; Mix 4: *V. villosa + H. vulgare*; [2] ** Significant at P ≤ 0.01. In each column, values with the same letter are not significantly different at P ≤ 0.05 (Duncan Multiple Range Test).

Hairy vetch and its mixtures were also the most effective treatments in terms of N uptake (Table 2). Weeds had a higher % N content in hairy vetch than in the other plots (by an average of +82% in 2005/06 and +66% in 2006/07), suggesting a consistent release of N to the soil from degradation of fallen leaves and from root exudates of hairy vetch. P content (data not shown) gave similar results. Nutrient release from leguminous species was also evident when looking at N and P content of companion grass species in the mixtures (Table 3). In 2005/06, only the hairy vetch effect was significant (increases of +81% and +45% respectively in N and P content of rye), while in 2006/07 T. squarrosum (+50% of both N and P content of oats) and T. incarnatum (+33 and +22% in oats respectively) also gave good results.

Tab. 3: Effect of mixture on biomass production (t ha^{-1} d.m.) and N and P content of cover crops species

Species[1]	2005/06 season			2006/07 season		
	Biomass	N (%)	P (%)	Biomass	N (%)	P (%)
A. sativa	1.57	1.09	0.28	1.30	1.15 c	0.27 c
A. sativa (Mix 1)	-	-	-	0.54	1.76 a	0.40 a
A. sativa (Mix 2)	0.98	1.45	0.32	0.80	1.53 b	0.33 b
S. cereale	0.57 a	1.41 b	0.31 b	-	-	-
S. cereale (Mix 3)	0.11 b	2.55 a	0.45 a	-	-	-
H. vulgare	-	-	-	1.54	1.06 b	0.21 b
H. vulgare (Mix 4)	-	-	-	0.51	2.49 a	0.41 a

[1] Mix 1: *A. sativa + T. squarrosum*; Mix 2: *A. sativa + T. incarnatum*; Mix 3: *V. villosa + S. cereale*; Mix 4: *V. villosa + H. vulgare*. For each species and its mixtures, values with the same letter are not significantly different at $P \leq 0.05$ (Duncan Multiple Range Test).

Conclusions

Leguminous cover crops gave the highest biomass yield in both years. Hairy vetch was consistently the best species in terms of biomass production and nutrient uptake, and also increased nutrient content in companion plants in mixtures. Cover crop mixtures exerted the highest weed control suppression.

Acknowledgements

Research funded by the MiUR-FISR SIMBIO-VEG Project.

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Compost enhances parasitization of *Brevicoryne brassicae* (L.) by *Diaeretiella rapae* (M'Intosh) in broccoli under different levels of crop diversification and plant competition

Ponti, L.[1], Altieri, M.A..[2] & Gutierrez, A.P.[3]

Key words: indirect effects of intercropping, crop biomass, buckwheat, mustard, organic fertilization.

Abstract

The effects of intercropping via competition on crop biomass, pest [cabbage aphid Brevicoryne brassicae *(L.)*] *abundance and natural enemy [the parasitoid* Diaeretiella rapae *(M'Intosh)*] *efficacy were studied in the* Brassica oleracea *L. var.* italica *system. From May to December 2004, insect populations and yield parameters were monitored in summer and fall in broccoli monoculture and polyculture systems with or without competition from* Brassica *spp. (mustard), or* Fagopyrum esculentum *Moench (buckwheat), and with addition of organic (compost) or synthetic fertilizer. Competition from buckwheat and mustard intercrops did not influence pest density on broccoli; rather, aphid pressure decreased and natural enemies of cabbage aphid were enhanced in intercropping treatments, but this varied with the intercropped plant and season (summer vs. fall). In compost-fertilized broccoli, increased seasonal parasitization rates of* B. brassicae *by* D. rapae *were observed along with the expected lower aphid pressure, when compared to synthetically-fertilized plants.*

Introduction

The role of crop diversification (e.g. intercropping) in reducing insect pest pressure has been extensively investigated in *Brassica oleracea* L. var. *italica* (broccoli) (Hooks and Johnson, 2003). However, the indirect role that inter-plant competition in intercropped systems plays in pest levels and dynamics is poorly understood (Ponti et al., 2007). Intercropping experiments have so far adopted additive designs (i.e., same density of target crop in monoculture and in polyculture) that implicitly introduce interspecific plant competition, which impacts crop growth and may also indirectly influence herbivore levels (Bukovinszky et al., 2004). In additive designs, plant competition is usually not an explicit experimental factor and thus its effects on pest levels cannot be separated from the effects of crop diversification alone (Hooks and Johnson, 2003). In addition, cultural methods such as crop fertilization can affect pest pressure, but the direct linkage to fertility is confounded by the increased abundance of natural enemies in organically-fertilized vs. conventional crops (Altieri et al., 2005).

Brassica crops including broccoli are cultivated year round in the moderate climatic zones of the central California coast, and are attacked by cabbage aphid (*Brevicoryne brassicae* (L.) (Homoptera: Aphididae), which is a specialist on the Brassicaceae. The aphid is an economic pest on broccoli as it infests the developing floral buds rendering

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the head they comprise unmarketable. Cabbage aphids are attacked by the polyphagous parasitoid *Diaeretiella rapae* M'Intosh (Hymenoptera: Braconidae).

In this study, an innovative additive intercropping model with broccoli as the target plant examines whether crop diversity per se influences aphid and natural enemies abundance with and without the effects of interspecific competition, and what effect organic (compost) vs. synthetic fertilizer has on aphid and natural enemies abundance.

Materials and methods

This study was carried out from May to December 2004 at the University of California Agricultural Research Station (Albany, California), where the same experiment was replicated twice: 1) May-August and 2) August-December (summer and fall experiments respectively). The experiment was a two-way factorial (5 × 2; i.e., cropping system fertilizer) in a completely randomized design, with treatments replicated three times and plot size 3 m × 3 m. Plots were separated by 1 m bare soil. The first factor consisted of five cropping systems: broccoli monoculture (Fig.1a); broccoli intercropped with mustard, *Brassica* spp., with or without competition; and broccoli intercropped with buckwheat, *Fagopyrum esculentum* Moench, with or without competition. Our additive design kept broccoli levels constant (50 × 50 cm row × plant grid; 54444 plants/ha) using two spatial arrangements that introduced intercropping and/or inter-specific competition (Fig. 1b and c). The second factor consisted of two types of fertilizer: synthetic fertilizer or compost applied at the rate of 100 kg N/ha. All plots and the 1 m inter-plot border were maintained weed-free by hand weeding.

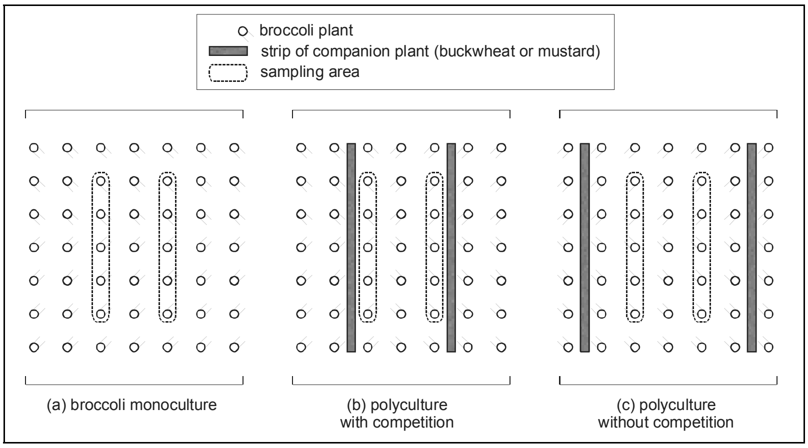

Figure 1: Schematic representation of the additive intercropping design used to separate effects of crop diversity from the effects of competition.

At the end of the season, the wet weight of experimental broccoli plants was estimated using an electronic balance (±1 g). In each of the 30 plots, aphids and natural enemies were counted directly on five broccoli plants at one-week intervals. Cumulative counts per plot on five dates were used as measure of season long aphid pressure and parasitization rates (%), allowing the analysis of untransformed data and making the analysis easier to understand. Multiple regression analysis was performed using dummy variables (values of 0 or 1 for absence or presence respectively) for compost (*O*), mustard (*M*), buckwheat (*B*), and competition (*C*) to assess their influence on dependent variable. Marginal analysis of the regression model was conducted to present a comprehensive synthesis of data, otherwise very difficult to accomplish within the required page limit. For further details on methods, see Ponti et al. (2007).

Results

Multiple regression analysis (*** $P < 0.001$; ** $P < 0.01$; * $P < 0.05$) shows that broccoli plant weight (*PW*) was reduced 292 g and 244 g by organic fertilization in the summer and in the fall experiments respectively (eqn. 1: $R^2 = 0.3617$, $F = 15.87$, $d.f. = 1,28$, $P < 0.001$; eqn. 2: $R^2 = 0.826$, $F = 41.15$, $d.f. = 3,26$, $P < 0.0001$).

$$PW_{\text{Summer}} = 795.8^{(***)} - 292.4\ O^{(***)} \quad (1)$$

$$PW_{\text{Fall}} = 1238.6^{(***)} - 244.3\ O^{(***)} - 289.0\ M^{(***)} - 281.7\ C^{(***)} \quad (2)$$

The fall experiment also showed a significant negative impact of mustard and competition on broccoli plant weight (eqn. 2).

Cumulative abundance of aphids (*Aphids*) in the summer was lowered by using compost as opposed to synthetic fertilizer, and when intercropped with either buckwheat or mustard (eqn. 3: $R^2 = 0.65$, $F = 9.07$, $d.f. = 5,24$, $P < 0.0001$). However, the interaction of intercropping plants with either buckwheat (*B*) or mustard (*M*) with composting (*O*) largely counteracted the effects of intercropping alone (eqn. 3).

$$\begin{aligned} Aphids_{Summer} &= 1579.7^{(***)} - 837.7\ O^{(***)} - 633.2\ B^{(***)} + \\ &\quad - 720.8\ M^{(***)} + 697.5\ OB^{(**)} + 568.3\ OM^{(*)} \end{aligned} \quad (3)$$

Partial derivatives with respect to single variables allow separating the effect of each significant experimental factor (i.e., marginal analysis). The presence of compost alone (eqn. 3a) decreased seasonal aphid pressure in the summer experiment, but this effect was reduced in buckwheat and mustard polycultures.

$$\frac{\partial Aphids_{Summer}}{\partial O} = -837.7 + 697.5\ B + 568.3\ M \quad (3a)$$

When broccoli was grown in polyculture with buckwheat (eqn. 3b), pest pressure was lower unless compost was present, in which case this positive effect was buffered:

$$\frac{\partial Aphids_{Summer}}{\partial B} = -633.2 + 697.5\ O \quad (3b)$$

As seen in equation (3a), broccoli/mustard polycultures (eqn. 3c) showed a similar situation, even though the buffering effect of compost was smaller:

$$\frac{\partial Aphids_{Summer}}{\partial M} = -720.8 + 568.3\ O \quad (3c)$$

In contrast, in the fall experiment no main effect resulted in a significant regression coefficient for predicting aphid cumulative counts. Composting significantly increased aphid parasitization rates (*Par*) (arcsine transformed) in both the summer (R^2 = 0.41, *F* = 9.69, *d.f.* = 2,27, *P* = 0.0006) and fall (R^2 = 0.17, *F* = 5.81, *d.f.* = 1,28, *P* = 0.022) experiments (equations 4 and 5 respectively). Competition significantly increased parasitization rates in the summer but not in the fall.

$$Par_{Summer} = 0.027\ (*) + 0.04\ O^{(**)} + 0.037\ C^{(**)} \tag{4}$$

$$Par_{Fall} = 0.005^{(**)} + 0.006\ O^{(*)} \tag{5}$$

Discussion and conclusions

No evidence was found that competition from intercropping influences pest abundance in broccoli. Although the observed yield reduction due to intercropping is not new, the effect of competition on aphid dynamics as mediated by reduced host-plant biomass had not been separated yet with a specific experimental design. Intercropping significantly reduced pest pressure only in the summer and we found that mustard is better than buckwheat at controlling aphids, probably due to mustard being able to serve as a trap crop. A positive effect of intercropping on natural enemies was evident in the summer experiment, when the proximity of flowers (i.e., polyculture with competition) significantly enhanced aphid parasitization rates on broccoli. Synthetically fertilized broccoli produced more biomass, but also recruited higher pest numbers. It is known that compost releases mineral nitrogen in the soil at a slower rate than synthetic fertilizer and this has been related to lower foliar nitrogen content leading to reduced pest incidence. Despite lower aphid densities, however, broccoli fertilized with compost consistently had higher parasitization rates than synthetically fertilized plants. In summary, intercropping and composting decreased pest abundance in broccoli regardless of interspecific competition from intercropped plants. In addition, depending on the intercropped plant and the growing season (summer vs. fall), intercropping enhanced natural enemies of cabbage aphid in broccoli. The seasonal effectiveness of natural enemies of *B. brassicae* was increased by composting despite lower aphid abundance in compost-fertilized broccoli.

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Inorganic nitrogen in soil green manured with biocidal crops

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Key words: green manure, biofumigation, soil texture, Brassicaceae

Abstract

The knowledge of the dynamics of inorganic N in soil may help to establish the most suitable timing for green manure (GM) incorporation, which leads to the improvement of crop N use efficiency in conventional as well as organic agriculture. The practice of green manuring with crop species belonging to the Brassicaceae family has recently expanded, in Italy and abroad, due to their demonstrated biocidal effect against soil-borne pathogens. In this plot-scale study we monitored the release of soil inorganic N in 3 soil types (1 clay and 2 loams), in the months following late-spring green manuring with plant material from Brassica juncea, Sinapis alba, and Raphanus sativus species. Soil inorganic N content increased and reached a maximum 2 months after GM incorporation (+14.4 mg N kg^{1} *dry soil, on average, over the initial inorganic N content), and subsequently declined. The inorganic N accumulation was higher in soil amended with R. sativus. We did not observe any significant influence of the soil type on the variation of inorganic N content in the period after GM incorporation. The inorganic N released after late-spring green manuring with Brassicaceae species may become available in the early growth phase of subsequent summer-autumn crops.*

Introduction

The practice of green manuring with biocidal crops, known also as biofumigation, has expanded in recent years as an alternative to methyl bromide for controlling soil-borne pathogens and pests, especially nematodes (Curto et al., 2005). These crops, besides having biocidal properties, when incorporated to soil supply it with nutrients, such as N, possibly competing as N sources with industrial fertilisers, in conventional as well as organic agriculture. To improve crop N use efficiency while containing the environmental impact of N losses it is important for the inorganic N release in soil, following green manure (GM) incorporation, to be synchronous with the N uptake by the subsequent crop.

The fertilising quality of GM has been studied mainly with reference to leguminous crop species (Cherr et al., 2006). Recent laboratory experiments on soils amended with plant material from Brassicaceae showed high values of potentially mineralizable N 3 months after GM incorporation, with differences depending on crop species and soil type (Marchetti et al., in this archive). We report here the results of an experiment

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we performed at plot scale with the goals of comparing crop yields and N removal for 3 crop species belonging to the Brassicaceae family, and of studying the dynamics of N release in soil, in the months following their late-spring incorporation into the soil as GM. In our Mediterranean environment this agricultural practice is even more frequently applied before the seeding or transplanting of horticultural crops characterized by a summer-autumn growth cycle (Lazzeri et al., 2004). During the sampling period the soil was kept without crops, to remove any interference of crop N uptake on soil inorganic N levels.

Materials and methods

The experiment was performed in 2005, at the I.S.A. experimental site of Modena (44 °39' N, 10°55' E), in lysimeters measuring 4 m^2 × 1.3 m depth, containing 3 soil textural types (USDA classification): a clay (13.8 g organic C and 1.7 g Kjeldahl N kg^{-1} dry soil), a loam with 38% sand (Loam I; 12.1 g C and 1.2 g N kg^{-1}), and a loam with 48% sand (Loam II; 9.4 g C and 1.1 g N kg^{-1}). The experimental design was a strip–split–plot with 2 replications (18 plots in total). The Brassicaceae species were: *B. juncea* (cv. 52), *R. sativus* (cv. Arena) and *S. alba* (cv. Concerta). Crops were seeded on March 23rd and harvested on June 1st, at full flowering. The aboveground biomass was incorporated on June 7th, after fragmentation of the plant material and hoeing of the top 20-cm soil layer. The inorganic N content in soil was measured, at 0–20 and 20–40 cm soil depth, before plant incorporation (June 6) and at days 31 (July 7), 65 (Aug 10), 127 (Oct 11), and 162 (Nov 15) after GM incorporation. Statistical analysis was performed using PROC MIXED for measurements repeated in time (SAS Institute, 1996). Inorganic N in soil was measured colorimetrically according to Keeney and Nelson (1982).

Results

N concentration in aboveground biomass and plant-N supply to soil. The total N concentration of the biomass of *B. juncea* at harvest was significantly higher than N concentration of *R. sativus* and *S. alba* (Tab. 1). However, the *B. juncea* yield having been lower, no significant differences were detected between crop species in the amount of N supplied to soil. Neither was there any significant effect of the soil type on the considered crop traits (data not shown).

Inorganic N dynamics in soil after plant incorporation. Significant differences of inorganic N content were observed between soils before GM incorporation (data not shown). In order to remove the effect of the soil type, instead of the absolute data values we analysed the differences between inorganic N content in soil samples collected 31, 65, 127 and 162 days after GM incorporation and inorganic N content in soil sampled the day before GM incorporation (net inorganic N content). Of the considered sources of variation, that is: block, soil (Soil), sampling depth, crop species (Crop), time (Time), only the following factor and factor-interaction effects were significant: Time ($P<0.001$), Crop ($P<0.05$) and Soil×Crop ($P<0.001$) (PROC MIXED results not shown). The increase of inorganic N was higher up until 65 days after GM incorporation, and declined in the following sampling dates (Tab. 2). The soil amended with *R. sativus* accumulated more inorganic N that the soil amended with *B. juncea*. In soil amended with *S. alba* there was a lower inorganic N increase, especially in the clay soil (significant soil×crop interaction).

Tab. 1: Plant dry matter (DM), nitrogen concentration in plant DM, plant biomass and N amounts incorporated with green manure.

Crop species	Plant DM (g m^2)	Plant Kjeldahl N (g kg^1 DM)	Incorporated plant DM (g m^2)	Incorporated plant N (g m^2)
R. sativus	330a	16.1b	299a	4.73a
B. juncea	200b	23.8a	161b	3.78a
S. alba	319a	15.9b	271a	4.38a
MSD[1]	105	5.6	103	1.85

[1] In each column, means followed by the same letters are not significantly different for P<0.05, according to the Tukey test for mean comparisons. MSD= Minimum Significant Difference.

Tab. 2: Net inorganic N content in the 40-cm top-soil from June until November for 3 soil types amended with different species of Brassicaceae.

Crop	Soil	Net inorganic N content (mg N kg^1 soil dry weight)				Means for Soil within Crop[1]	Means for Crop[1]
		Time from GM incorporation (days)					
		31	65	127	162		
B. juncea	Clay	8.0	14.7	3.6	1.7	7.0a	
	Loam I	4.4	17.4	~3.4	0.2	4.6a	
	Loam II	9.7	12.6	1.3	2.8	6.6a	
							6.1XY
R. sativus	Clay	8.3	12.8	1.7	3.9	6.7a	
	Loam I	5.3	16.7	1.2	4.7	7.0a	
	Loam II	7.2	13.8	5.9	3.6	7.6a	
							7.1X
S. alba	Clay	2.2	8.2	~3.8	~1.9	1.2b	
	Loam I	6.1	13.9	0.9	3.5	6.1a	
	Loam II	11.3	19.1	1.8	3.9	9.0a	
							5.4Y
	Means for Time[1]	6.9B	14.4A	1.0C	2.5C		

1 With reference to the significant sources of variation (see text), upper-case letters were used for comparisons of the mean effects, lower-case letters for the comparison of first order interaction effects. For each source of variation, means followed by the

same letters are not significantly different for P<0.05, according to the Tukey test for mean comparisons.

Discussion

The increase of soil N availability following GM incorporation, which had been already observed in a previous laboratory experiment, was confirmed in this experiment at plot scale.

The decrease of net inorganic N content 127 and 162 d after GM incorporation could be attributed to weed uptake, to immobilisation in the soil microbial biomass, or to leaching, as the cumulated rainfall from mid-August until mid-November, when the soil was free from growing crops, amounted to 434 mm.

Aboveground biomass yields and the relevant crop N removal were lower than those which it is possible to obtain in the field in our environment, probably due to the confining of the crops in the lysimeters. In the hypothesis of a direct relationship between the amount of organic N incorporated with GM and the amount of inorganic N formed in soil, at field level higher amounts of N supplied with GM could give rise to higher amounts of inorganic N than those observed in our experiment.

Conclusions

The late-spring incorporation of Brassicaceae plant material, resulting in a moderate accumulation of inorganic N in soil during summer, may favour crop nutrition when summer-autumn crops follow in the crop sequence.

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Annual self-reseeding legumes effect on subsequent crops into a rotation program in Mediterranean organic farming systems

Al-Bitar, L.[1], Wehbé, E., Ayoub, M. & Jamea, M. Key words: annual self-reseeding legumes, *Trifolium* spp*., Medicago* spp*., biological* nitrogen fixation, Mediterranean region.

Abstract

Biological Nitrogen fixation (BNF) should be the most important means for N supply in organic agriculture. This study aimed at assessing the effect of fifteen legume cultivars on subsequent crops in three consecutive growing seasons to identify the most efficient and suitable ones as building crops in rotation programs under Mediterranean environment. T. subterraneum cv. York and T. glanduliferum cv. Prima, induced the best effects on wheat, particularly on total biomass, number of grains, dry matter production and increased yield by 670% and 567% respectively more than the control.

Introduction

The adoption of BNF, an important process that comes second after photosynthesis (Brady, 1990) might be a solution for poor farmers in less developed countries (Hungria and Vargas, 2000; Dobereiner, 1994). Large amounts of atmospheric nitrogen are fixed in the soil-building crops (legumes), a fundamental pillar of a crop rotation program (Gresshoff, 1990) and a constitutional element of sustainability (Caporali, 2004). Legumes can improve soil quality through their beneficial effects on soil biological, chemical and physical conditions (Biederbeck *et al.,* 1996). This study aims at assessing the fertilization effect of legumes on subsequent crops comparing the results over three years and evaluating the performance of subsequent crops.

Materials and methods

This paper presents a three-year investigation program carried out in the framework of a PhD study (Al Bitar, 2005) aiming at introducing as soil-building crops 15 Mediterranean native legume cultivars grown from November 2002 to March 2004 then green manured. Subsequent crops succeeded over three seasons: Lettuce (April - June 2004) - Corn (June - October 2004) and Wheat (December 2004 – June 2005).

Legume cultivars were the following: *Biserrula pelecinus* cvs. Casbah and Mauro, *Medicago sphaerocarpa* cv. Orion, *Ornithopus compressus L*. cvs. Avila and Santorini, *O. sativus* cv. Cadiz, *Trifolium glanduliferum Boiss*. cv. Prima, *T. hirtum All*. cv. Hykon, *T. incarnatum L*. cv. Caprera, *T. michelianum Savi*. cvs. Bolta and Paradana, *T. subterraneum* cvs. Dalkeith and York, *T. vesiculosum Savi*. cv. Cefalu and *T. spumosum* cv. WCT36.

The trial was carried out at the Mediterranean Agronomic Institute of Bari (IAMB) located in Apulia, south of Italy, characterized by a Mediterranean climate with humid mild winter (precipitations 400 to 500 mm) and hot dry summer. Soil is characterised by: organic mater (1.56%), pH (8.48), N (502 ppm), P (95 ppm), K (650 mel l-1).

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Legume cultivars and control, a green fallow, were arranged in a randomised complete block design with three replicates, each plot of 10 m2; upon flowering in their second growing cycle they were green manured and three subsequent crops (lettuce, corn and wheat) succeeded. Biomass production (fresh and dry) was determined on green manures by sampling plant parts including roots on an area of 0.25 m2 per plot. Samples were oven-dried at 70 °C for 48 h, crushed and digested by H_2SO_4 and $HClO_4$ acid mixture. Total N was determined in the digested extracts by the standard semi micro-Kjeldahl procedure and Carbon content by Walkley and Black method (Jakson, 1967). Crop analyses were also made periodically to evaluate the subsequent crops performances by measuring several quantitative and qualitative parameters. Analysis of variance was done by the Statistical Analysis System (SAS, V8). The effects were tested using the General Linear Model, multiple comparison of means according to Duncan's multiple range test (Homogenous Groups, α = 0.05). Combined data for the three subsequent crops were calculated in order to compare the cumulative effects of the cultivars on the subsequent crops by ANOVA.

Results and discussion

Most of tested cultivars seemed to perform well. However, WCT36 was the most performing since it produced the highest amount of biomass (17.6 t ha^{-1}) with highest N content (600 Kg ha^{-1}). Cultivars of the genus *Ornithopus* were the less performing and *T. michelianum* died before fruit setting overgrown by weeds (*Orobanche* spp.). Relative results on the 3 subsequent crops (table 1) were calculated by the following formula: Relative result = (Cultivar– Control) values/ Control value*100 = Relative value in %. Thus, it refers to the increasing effect of the cultivar in comparison with the control on the concerned parameter of each of the three subsequent crops.

Tab. 1: Cumulative effect of legumes cultivars on the yield and plant nitrogen uptake of the three subsequent crops.

Legume cultivar	Plant nitrogen uptake	Marketable yield (fresh matter)		
	Relative value (%)			Relative value (%)
B. pelecinus Casbah	182,57 bc			275,48 abc
B. pelecinus Mauro	197,36 abc			276,43 abc
M. sphaerocarpa Orion	222,62 ab			254,63 bc
O. compressus Avila	170,77 c			237,31 bc
O. compressus Santorini	173,88 bc			250,27 bc
O. sativus Cadiz	165,9 c			220,43 bc
T. glanduliferum Prima	186,99 abc			324,85 ab
T. hirtum Hykon	202,1 abc			259,13 bc
T. incarnatum Caprera	173,59 bc			240,69 bc
T. michelianum Paradana	156,8 c			202,07 cd
T. michelianum Bolta	176,43 bc			254,56 bc
T. spumosum WCT36	194,11 abc			296,62 abc
T. subterraneum York	232,66 a			378,21 a
T. subterraneum Dalkeith	168,69 c			279,72 abc
T. vesiculosum Cefalu	173,86 bc			241,72 bc
Control	100 d	Lettuce	15.21 t ha^{-1}	100 cd
		Maize	6.61 t ha^{-1}	
		Wheat	0.23 t ha^{-1}	

The values that do not have the same letter are significantly different at α = 0.05 (Duncan test).

All cultivars (except Paradana) showed to induce a significant increasing effect on yield at long term. The overall yield for the three crops was higher than the control ranging from 120% (Cadiz) up to 278% (York). Significant difference was found also among cultivars. York, Prima, WCT36, Dalkeith, Casbah and Mauro were the best performing over the three-year experiment. Moreover, cultivars induced also a significant increasing effect on both plant height and nitrogen uptake of the three crops ranging from 13% to 26% and 66% to 132%, respectively.

Residual effect of legume cultivars on the three subsequent crops are shown in fig 1. The effect of legumes on plant height decreased significantly from one season to another following a normal trend. Nitrogen uptake was higher than the control in the three seasons by at least 58% as found by Ten Holte & Van Keulen (1989) and Schroder *et al*. (1997). The highest value, significantly different from the first and the third seasons, was reached during the second growing season. The increase in terms of nitrogen uptake by the second subsequent crop could be explained by the late release of nitrogen from the nitrogen-fixing bacteria, whereas, the decrease observed in the third growing season may be normally due to the decrease in soil nitrogen content after its use by the first and the second subsequent crops.

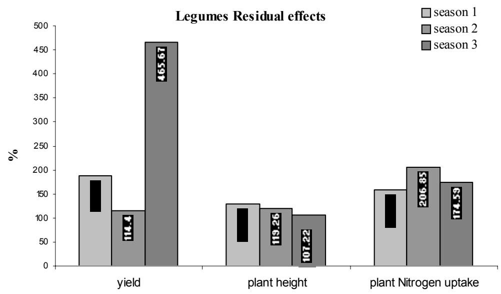

Figure 1: Beneficial residual effects during the three seasons. Values that do not have the same letter are significantly different at α = 0.05 (Duncan test).

The increase in crop yield following legumes was expected and it comfirmed previous results (Ten Holte & van Keulen, 1989; Schroder *et al*., 1997 and Breland, 1996). The positive effect of legumes decreased from the first to the second season, and then it increased drastically in the third. This may be explained by the fact that soil fertility in control plots decreased much faster than in the treated plots reaching very low levels in the third season; in other words, legumes have sustained soil fertility.

Different trends of plant nitrogen uptake and plant height might be due to plant behaviour and its physiology concerning the response to nitrogen; for instance, the difference in terms of soil fertility between treated and control plots, mainly soil nitrogen content, had clearer effect on wheat (third crop) yield than on plant height, due to the high nitrogen requirements for wheat grain formation in respect to its requirement for plant growth and development.

Conclusions

Most of tested cultivars showed to have a large potential to be used in sustainable Mediterranean agro-ecosystems in that they possess a large screen of characteristics making very wide their possible use (Talamucci, 1997).

Cultivars York and Prima were the best performing during the whole investigation program. WCT36 was the most performing in terms of biomass production and N fixation, making it highly recommended for green manuring.

The tested legumes showed also to induce a beneficial effect on the three subsequent crops in comparison to control by stimulating higher yields, higher plant height and better plant nitrogen content for the subsequent crops. The residual effect of legumes was still concrete even after three consecutive crops as was proved by Ten Holte & van Keulen, 1989; Schroder *et al*.,1997 and Breland, 1996. It could be concluded that the integration of annual self-reseeding legumes into Mediterranean organic cropping systems may contribute largely to sustain long-term soil fertility, to satisfy cash crops needs in N and to increase markedly production.

Although the results are very promising, they still very preliminary considering the short period of the experiment; in fact, further studies are being conducted to sustain the obtained results.

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Variety Recommended Lists of Organic Cereals in Emilia-Romagna

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Key words: variety trials, wheat, barley, corn.

Abstract

In order to meet the needs of Emilia-Romagna's technicians and farmers, specific trials on cereals (soft wheat, hard wheat, barley, corn) for organic production have been carried out since 1995. These trials helped draw up specific Variety Recommended Lists.

Introduction

Variety selection plays a main role in organic production and the best varieties in traditional production are not always the best solution for organic farming. Key features of organic production must be: high yield and rusticity, weeds competition and pest and disease resistance.

Specific trials on cereals for organic production have been carried out since 1995 in Emilia-Romagna. The investigation has started with soft wheat, later on corn (1999), barley (2000) and hard wheat (2004) have been involved, too.

Material and methods

Trials were carried out on a yearly basis in 1-2 organic certified farms in Emilia-Romagna (North Italy). The experimental layout consisted of randomised blocks with 3-4 replicates. The chosen varieties were among those achieving the best results in conventional farming trials and showing good resistance/tolerance to several pathogens. On the whole 111 varieties of soft wheat, 18 of hard wheat, 43 of barley and 132 of corn were compared. The following criteria were detected: yield, disease sensitivity and environmental stress, hectolitre weight, life cycle of the plant. Protein % and hardness on soft wheat and broken plants on corn were also detected.

The draft of the Variety Recommended Lists was made according to the following standards:

- this List is valid in Emilia-Romagna; data used derive from variety comparison trials in organic farming made in Emilia-Romagna and from additional information by technicians, farmers, millers and seed companies;

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- proposed varieties and hybrids of each species are divided according to the following criteria:
    - soft wheat: Synthetic Quality Index - ISQ (Foca G. et al. 2007)
    - corn: FAO maturity classes; flint corn fits in a separate group
    - barley : ear type

- varieties and hybrids have to be tested for at least a two-year period;
- productivity must exceed at least 5% the field average yield and must not drop below the field average yield for more than one year;
- less productive varieties/hybrids can be put in the list if suitable varieties in a particular group are missing;
- varieties/hybrids must be pathogen tolerant

Results

Tab. 1: Yield index (field average yield =100) for Soft Wheat Varieties included in Recommended Lists for Organic Production in Emilia-Romagna - Year 2007. Quality categories ISQ: FB (w. for biscuits), FF (improver w.), FP (ordinary bread making w.) and FPS (superior red making quality w.).

Variety	Synthetic Quality Index (ISQ)	2002			2003		2004		2005	2006	Mean 2002-2006	Years 's trials no.
		Modena	Parma	Ravenna	Parma	Ravenna	Parma	Ravenna	Parma	Parma		
ARTICO	FB	104	111	117	100	95	110	100	105	106	106	5
CRAKLIN	FB	121	111	117	101	125	107	115	110	114	113	5
EUREKA	FB	110	108	119	111	102	110	113	112		111	10
RAVENNA	FF	99	95	107					100	95	97	4
TAYLOR	FF	88	96	74							86	3
AGADIR	FP						107	123	99	100	107	3
ALCIONE	FP	109	117	123	101	110	111	114	99		111	4
AUBUSSON	FP								102	111	107	2
GUARNI'	FP								108	112	110	2
ISENGRAIN	FP						115	128	104	102	112	3
TIBET	FP	109	110	110	105	115	109	96	100		106	7
BLASCO	FPS						95	102	103	101	100	3
GUADALUPE	FPS	103	103	104	108	92	104	96	105		102	7
NOMADE	FPS								100	101	101	2
PALLADIO	FPS								98	104	101	2
SOISSONS	FPS	98	105	88	100	105	110	113	101		103	9
Average production of field t/ha		7.0	6.9	6.6	7.2	5.9	5.6	7.5	6.7	7.8		

Tab. 2: Yield Index (field average yield = 100) for Barley Varieties included in Recommended Lists for Organic Production in Emilia-Romagna. Year 2007.

Variety		2002	2003	2004	2004	2005	2006	Mean 2002/2006	Years's trials no.
		Parma	Parma	Parma	Ravenna	Parma	Parma		
BARAKA	Two row	110	99				99	102	4
KETOS	Six row			108	118	105	104	109	3
SIBERIA	Six row	122	127	98	106	99	104	109	5
MARADO	Six row			116	119	98	110	111	3
PASSPORT	Six row			114	126	111	110	115	3
AMILLIS	Two row	106	107			105		106	3
KELIBIA	Two row	108	106	98	110			106	4
NURE	Two row	99		107	116	102		106	4
ZACINTO	Naked	98	83	85	81			87	4
Average production of field t/ha		5.33	6.29	5.44	4.57	6.75	5.88		

Tab. 3: Yield Index (field average yield = 100) for Hard Wheat Varieties included in Recommended Lists for Organic Production in Emilia-Romagna. Year 2007

Variety	2004	2005	2006	Mean 2002/2006	Years 's trials no.
	Parma	Parma	Parma		
Claudio	117	106	104	109	3
Grazia	106	121	96	108	3
Iride	102	109	104	105	3
Simeto	102	104	115	107	3
Average production of field t/ha	4.66	5.82	6.10		

Tab. 4: Yield Index (field average yield = 100) for Corn Hybrids included in Recommended Lists for Organic Production in Emilia-Romagna. Year 2007.

Variety	Maturity classes FAO	2002	2002	2003	2004	2004	2005	2006	2006	Mean 2002/2006	Years 's trials no.
		Reggio Emilia	Ferrara	Reggio Emilia	Parma	Ferrara	Parma	Parma	Ravenna		
Anjou 450	300	89	119				83			98	4
DK 440	300			119	110	108	87			106	3
PR 36 B 08	300	112	82				95	106	106	99	3
DK C5353	400						119	119	94	119	2
Chalcao	500				107	115	98			107	3
DK C 5783	500				112	169	114	108	108	123	3
Helder	500	107	133	113	114	94				112	3
Karen	500				110	129	106	99	99	111	3
Keplero	500						108	119	98	113	2
Kult	500	121	139	118	133	91				114	3
Campodoro	600	123	120		89	100				106	3
Coventry	600						107	103	103	105	2
Larigal	600						104	117	117	111	2
Vertice	600	88	141		119	113				115	3
SIS Red	300			98	74	69		84	84	81	3
Roano	400			97	77	67	73			79	3
Average production of field t/ha		11.03	8.54	5.16	10.09	4.40	6.07	7.99	4.28		

Discussion and Conclusions

Soft Wheat: on the average, yield was more than satisfactory (Table 1) and in some years it was even higher than in traditional production (6.5-7.0 t/ha). Only in 2003 and 2004 crops were affected by Brown Rust and by Septoria spp., while Fusarium spp. and Powdery Mildew were quite absent. Protein level is 1% lower if compared to conventional fields (Corbellini M. et al. 2006), its average value varying between 12.7 and 13.5; some cultivars (Taylor, Ravenna, Blasco, Palladio) have maintained their protein values close to 14% in organic farming, too. Weight per hectolitre was good (slightly less than 80 kg/hl) in 2004 and 2006, but low in 2002

Barley: in addition to hulled barley types, naked varieties, being suitable substitute for coffee and soup preparation, were added in trials, too. In several cases cultivation after meadow-grass (alfalfa) has caused widespread lodging, lowering its yield (2004). Productive differences among varieties were not as evident as in wheat (Table 2).

Hard wheat: in the last few years an interest in this species has been increasing also in Emilia-Romagna. Yields were interesting, even if affected by Brown Rust and by Septoria attacks in 2004 (Table 3).

Corn: on the average, yields are lower than in conventional farming even though they can exceed 10 t/ha in optimal conditions (Table 4). From a productive point of view the most interesting FAO classes in organic cultivation are those reaching 400-500. While DK440, PR36B08, Karen, DKC5783, Larigal and Vertice are less sensitive to stem break.

Data obtained allow to identify, for every single species, a group of varieties to be grown in organic farming. At the beginning only soft wheat was in the recommended lists (C. Piazza et al. 2001), later on other species were included as well. According to the data obtained, the lists are updated every 1-2 years, the last update was carried out in 2007 (AAVV.,2007).

Acknowledgments

Activity carried out within project co-ordinated by CRPV (Vegetal Production Research Center) in collaboration with ProBER (Organic Producers of E. R.), funded by Emilia-Romagna Region (L.R. 28/98).

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Innovative crop and weed management strategies for organic spinach: crop yield and weed suppression

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Keywords: living mulch, cultural weed control, system approach, organic spinach

Abstract

*In organic agriculture, it is important to tackle crop and weed management from a system perspective to make it effective, especially in poorly competitive crops such as vegetables. For that reason, we developed two innovative integrated crop and weed management systems for a field vegetable crop sequence in a commercial organic farm that we have been comparing to a standard farm system from 2006 to 2008. The three systems are applied to a spinach-potato-cabbage-tomato two-year crop sequence and include different levels of technical innovation: Standard Crop Management System (SCMS); Intermediate Crop Management System (ICMS); and Advanced Crop Management System (ACMS). ICMS is based on a sequence of physical weed management treatments, whereas ACMS also includes a subterranean clover (*Trifolium subterraneum*) living mulch. In this paper we analyse the results obtained on spinach (*Spinacia oleracea*) in terms of crop yield and weed suppression. Both innovative systems increased total spinach fresh weight yield compared to SCMS, despite higher weed biomass. In ACMS, total weed biomass decreased linearly with increasing biomass of the subterranean clover living mulch.*

Introduction

In Italy, organic vegetable production has rapidly expanded in recent years. Organic spinach production has risen from 93 ha in 2005 to 347 ha in 2006 (www.sinab.it), but it still is much lower than the area of conventional spinach (ca. 7,000 ha in 2005). Vegetables, including spinach, are generally very sensitive to competition from weeds, so that the weed management component of any organic vegetable cropping system must be given high priority. However, management of short-cycle vegetable crops must necessarily be tackled from a whole system perspective because of the numerous interactions among agroecosystem components that take place under organic production (Bàrberi, 2002). It then is necessary to develop improved crop management systems that take into account two basic features of any successful organic vegetable cropping system: 1) timeliness of interventions, especially with regard to direct physical weed control measures (Peruzzi, 2006); and 2) inclusion of multifunctional elements, such as cover crops, that can suit the needs of soil, crop and weed management,. As to this latter point, use of legumes such as subterranean clover (*Trifolium subterraneum*) has proven to be beneficial in Mediterranean environments and elsewhere (Ilnicki and Enache, 1992; Bath et al., 2006).This study is part of a research project aiming to develop improved crop management systems

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for organic vegetables based on integrated and optimised use of crop rotations, cover crops/green manure, compost, and weed management strategies. Three crop management systems were then developed and compared on a commercial vegetable organic farm with the active involvement of the farm manager. The three systems correspond to increasing levels of innovation: standard (i.e. the usual crop management system practised on farm); innovative; and advanced. All three systems were applied to the same crop sequence (spinach-potato-cabbage-tomato) in the period 2006-08. This paper reports on crop yield and weed suppression results obtained on spinach, the first crop in the sequence.

Materials and Methods

An experiment was carried out in the 2006-07 season at the Colombini vegetable organic farm, located in Crespina (Pisa), central Italy (43°35' N; 10°34' E), on three different fields. The soil is a sandy loam with an organic matter content of 1% and a pH of 6.8. Three different crop management systems were tested: Standard Crop Management System (SCMS); Intermediate Crop Management System (ICMS); and Advanced Crop Management System (ACMS), allocated to the fields according to a randomised complete block (RCB) design with three replicates (each field corresponding to one block). Each plot was 160 x 3 m. Prior to spinach, the fields were disc harrowed at 25 cm depth, chisel ploughed at 70 cm, rotary hoed at 15 cm, and ripped at 50 cm. Subsequently, 1.4 m-wide ridges were created. The SCMS consisted of manual transplanting on biodegradable maize starch mulch (MaterBi®) of 40-60 plants per m^2 in plant units containing 2-3 plants per unit. No direct weed control measures were applied. In the ICMS, false seed bed technique was performed with a rolling harrow (Peruzzi et al., 2007). Spinach was sown on 5 October 2006 by means of a pneumatic drill (5 rows, 55 seeds/m^2). After seeding, a flame weeder and a precision hoe (two passes) were used. (For more information about ICMS strategies and machines see the article by Fontanelli et al. in the Proceedings of this Congress.)

This sequence of physical weed management operations was also used in the ACMS, where in addition a subterranean clover living mulch (cv. Clare) was broadcast interseeded in spinach on 20 November 2006, at a seeding rate of 30 kg ha^{-1}. In each plot, two 1.4 x 2 m control areas received no physical weed control. Spinach yield and weed biomass were sampled twice in four subplots of 1.4 x 2 m, on 28 November and 15 December 2006. Subterranean clover biomass was sampled on 5 March 2007. All data were subjected to ANOVA according to a RCB design with three replicates. Linear regression analysis was used to relate total weed biomass to subterranean clover biomass. Means were compared by LSD tests at $P \leq 0.05$.

Results and Discussion

Table 1 shows the effect of the three management systems on spinach yield. Total yield of spinach was significantly affected by management system: in particular, both ICMS and ACMS increased spinach yield compared to SCMS in terms of both total leaf fresh weight (+34%) and average fresh weight per plant (+46%). Compared to ICMS, inclusion of subterranean clover in ACMS did not result in statistically significant additional yield gain. No difference among systems was observed in the percentage of discarded leaves (on average ca. 20%). The better results of ICMS and ACMS over SCMS are related to higher yields at the second harvest date, when ICMS and ACMS achieved 44% and 43% of total spinach yield respectively vs. 36% for SCMS. This suggests that the innovative systems are likely to cause a more gradual yield accumulation, which should be seen favourably from a farmer's perspective. Yield gains in ICMS and ACMS were likely due to the concomitant effect of lower intra-specific competition in spinach sown with a regular crop spatial arrangement (single-row precision sowing instead of the 2-3 plants per unit transplanting of the SCMS), and to the overall positive effect of weed management strategies.

Tab. 1: Fresh weight yield (g m^{-2}) and unit f.w. (g per plant) of spinach at the first and second harvest dates and in total.

System[1]	28 November 2006			15 December 2006		Total harvest		
	Fresh weight yield		Unit f.w.	Fresh weight yield	Unit f.w.	Fresh weight yield		Unit f.w.
	g m^{-2}	sqrt				g m^{-2}	sqrt	
SCMS	333.22	18.26 ±4.74	20.97 ±6.61	189.11 ±44.41	10.24 ±2.66	522.33	22.97 ±4.09	15.61
ICMS	369.27	19.22 ±4.68	25.95 ±4.57	290.57 ±70.83	18.97 ±5.62	659.84	26.21 ±4.24	22.46
ACMS	421.86	20.54 ±2.42	26.85 ±3.81	318.37 ±42.67	19.30 ±3.84	740.23	27.20 ±2.46	23.08
F (P)	0.75 (.482)		3.07 (.065)	12.04 (.000)	9.66 (.001)	3.53 (.045)		5.91 (.008)
LSD 5%	4.00		5.72	61.55	5.13	3.61		5.33

[1]SCMS = Standard Crop Management System, ICMS = Intermediate Crop Management System, ACMS = Advanced Crop Management System. See text for details.

The SCMS had the lowest weed biomass (2.4 and 1.2 g m^{-2} at the first and second harvest dates respectively), thanks to the suppressive effect of biodegradable mulch. Total weed biomass did not differ between ICMS and ACMS, being on average 11.6 and 14.5 g m^{-2} at the first and second dates respectively. Therefore, higher spinach yield in the innovative systems cannot be explained by the weed biomass data. In the case of ACMS, this can partly be due to the lack of appreciable growth of the living mulch at spinach harvest dates because of delayed interseeding. However, in early March 2007 we observed a significant linear negative relationship between subterranean clover biomass and total weed biomass (Figure 1), which might be relevant from a cropping system perspective (e.g. for the subsequent potato crop).

Conclusions

The results show that there were differences among systems in crop yield and weed suppression, and that the two variables were unrelated. In fact, the SCMS showed the lowest weed biomass but also the lowest spinach yield, an effect likely due to the suboptimum crop spatial arrangement on biodegradable plastic mulch, which possibly increased intra-specific competition. No evidence was found that the living mulch-based system, applied as described in this paper, would give better weed control with respect to the system relying only on physical weed management. However, the negative linear relationship between biomass of weeds and of subterranean clover suggests that the latter has a weed suppression potential that was still unexpressed during the spinach growing cycle.

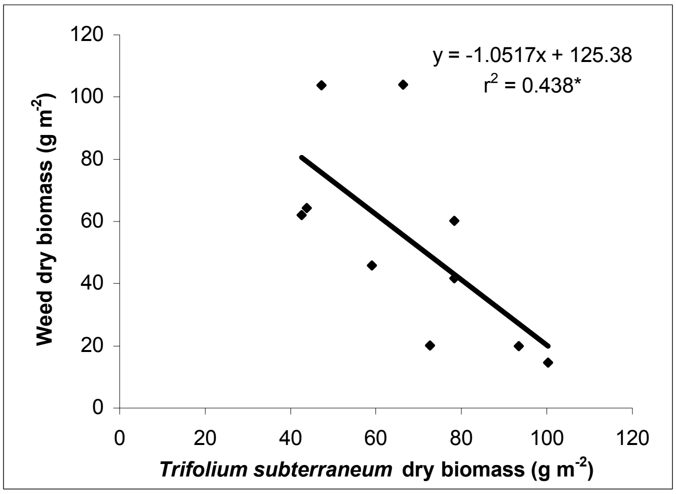

Figure 1: Simple linear regression of weed dry biomass on subterranean clover dry biomass (* significant at P ≤ 0.05)

Acknowledgements

We thank the CIRAA E. Avanzi staff and the farm owner, Mr Colombini, for their valuable help. This research was funded by the MiPAF FertOrtoMedBio Project.

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Innovative crop and weed management strategies in organic spinach: machine performances and cultivation costs

Fontanelli, M.[1], Frasconi, C.[1], Lulli, L.[1], Antichi, D.[2], Bigongiali, F.[2], Carlesi, S.[2], Bàrberi, P.[2] & Peruzzi, A.[1]

Key words: physical weed control, operative machines, vegetable crop rotation, fresh market spinach, biodegradable plastic mulch

Abstract

*Weed competition is one of the most serious problems in vegetable crops. Physical and cultural methods represent the only adoptable solutions in organic farming systems. A two-year (2006-08) on-farm research is being carried out to test innovative operative machines for physical weed control on a typical vegetable crop sequence in the Arno Valley (Pisa, Italy). In this work we present the first results, obtained on organic fresh market spinach (*Spinacia oleracea*). The new strategy is compared with the standard crop and weed management system, characterised by the use of biodegradable maize starch mulch, and with a system in which the use of improved physical methods is coupled with the use of a subterranean clover (*Trifolium subterraneum*) living mulch. Performances of the operative machines, labour time requirement and cultivation costs of the three crop and weed management systems are reported. The two innovative strategies showed interesting results, determining effective weed control and a significant reduction of costs for working and hand labour (-70%).*

Introduction

Weed management is one of the most serious problems in organic farming systems (Bàrberi, 2002). Crop development and yield can be significantly affected by weed competition, especially in vegetable crops (Fogelberg, 2007), that are often characterized by slow emergence (e.g. carrot), low competitive ability, and limited capacity to cover the soil (Peruzzi et al., 2004 and 2007).

Standard physical weed control machines (e.g. standard duckfoot share equipped hoe) can not successfully carry out effective intra-row crop weed control unlike herbicides. This implies that a high amount of labour time is required for intra-row hand weeding (Fogelberg, 2007). For this reason, the study of innovative strategies and tools for intra-row selective weed control is an important and relevant research area for European agricultural scientists (Dedousis et al., 2007).

Achieving a significant reduction in labour time in organic farming is a target that can effectively be reached by the use of purposely made operative machines and by the choice of a correct, integrated (holistic) weed strategy in which preventive, cultural and direct methods are concurrently used (Bàrberi, 2002).

Different low- and high-tech solutions for physical weed control are presently available on the market or are being studied as prototypes. Precision hand-guided hoes

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equipped with torsion weeders, vibrating tines or finger weeders belong to the first group (Peruzzi et al., 2004 and 2007), while more technologically-advanced hoes equipped with electronic devices for row detection belong to the second group (Dedousis et al., 2007). In this work we report the first results (on fresh market spinach) of a two-year on-farm research project aimed to develop improved crop and weed management systems for organic vegetable crops mainly based on optimised use of innovative operative machines for physical weed control.

Materials and methods

An ongoing field experiment started in October 2006 on a commercial organic farm located in Crespina (43°34' lat. N, 10°33' long. E), near Pisa (central Italy). Innovative machines for physical weed control are being tested on a two-year crop sequence composed of spinach (*Spinacia oleracea* L.), potato (*Solanum tuberosum* L.), cauliflower (*Brassica oleracea* L. var *botrytis* L.) and tomato (*Lycopersicon esculentum* Mill.). In this paper we report the data gathered on spinach, the first crop in the sequence.

Three crop and weed management systems are being compared, characterised by increasing levels of technological innovation: the standard crop management system practices on farm (SCMS), an intermediate crop management system (ICMS) and an advanced crop management system (ACMS). The SCMS is characterised by the use of a black biodegradable maize starch plastic mulch (Mater-Bi®), on which spinach was manually transplanted on 1 m-wide ridges. The ICMS is based on the use of innovative machines for physical weed control and by direct sowing (performed on 5 October 2006) on 1.4 m-wide ridges with a pneumatic 5-row drill. The ACMS has the same features of ICMS plus the inclusion of a subterranean clover (*Trifolium subterraneum* L.) living mulch, interseeded on 20 November 2006 during the last pass of machines for physical weed control (for more informations about agronomical data of the trial look the article Barberi *et al.* in the Proceedings of this Congress).

In ICMS and ACMS we made use of three innovative mounted operative machines: a rolling harrow, a flaming machine and a precision hoe. The rolling harrow is a new patent of the University of Pisa, equipped with spike discs placed in the front and cage rolls in the back (Figure 1). This machine can efficiently be used both for performing the false or stale-seedbed technique (exploiting its whole working width), and for precision hoeing (removing and adjusting the working tools to the inter-row distance). In this trial the rolling harrow was used just for pre-sowing interventions. The flaming machine performs weed control by means of an open flame (Figure 1). The flamer was equipped with three 50 cm-wide rod-burners and three commercial 15 kg LPG tanks. This machine can be used for pre-sowing, pre-emergence or post-emergence treatments (the latter only on tolerant crops), but in this trial it was used just before crop emergence. The precision hoe was equipped with a seat, steering handles and directional wheels. It is characterized by six working units, each one holding one rigid element with a 9 cm wide blade (for inter-row weed control) and two couples of elastic elements for selective intra-row weed control (torsion weeders and vibrating tines) (Figure 1). For spinach, the ICMS and ACMS included one pre-sowing pass with the rolling harrow (5 October 2006), one pre-emergence pass with the flamer (11 October 2006) and one post-emergence pass with the precision hoe (30 October 2006).

Performances of the operative machines, labour time requirement and cultivation costs of the three crop management systems were assessed. Data were not processed to statistical analysis because referred just to the operative aspects of the research.

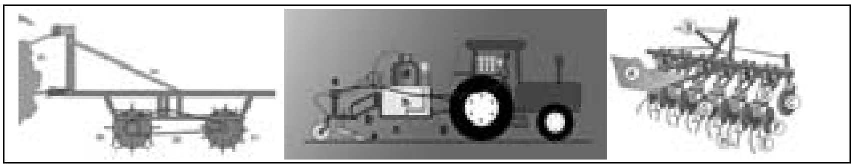

Figure 1: Innovative operative machines used for physical weed control: rolling harrow (left), flaming machine (middle) and precision hoe (right).

Results and discussion

The performances of the innovative operative machines utilised in ICMS and ACMS are shown in Table 1. The working width was the same for all the machines tested and was set at 1.4 m, corresponding to the ridge width. The highest working speed and work capacity was reached by pre-sowing treatments with the rolling harrow (ca. 8 km h^{-1}). Flaming was performed at 5 km h^{-1} while precision hoeing was the most expensive operation., since it was characterised by low speed (2 km h^{-1}) and the need of a back seated operator. All the operative machines require a low engine power (37 kW are almost exceeding); for flaming, LPG consumption was ca. 30 kg ha^{-1}.

Tab. 1: Performances of operative machines adopted for mechanical and physical weed control on spinach

Parameter	Unit of measure	Rolling harrow	Flamer	Precision hoe
Working width	m	1.4	1.4	1.4
Working depth	cm	3.1	-	2.5
Driving speed	km h^{-1}	7.9	5.0	2.0
Work capacity	ha h^{-1}	1.0	0.6	0.3
Working time	h ha^{-1}	1.0	1.7	3.3
Number of workers	-	1.0	1.0	2.0
Tractor power	kW	37.0	37.0	37.0
Engine load	-	0.2	0.2	0.2
Fuel consumption	kg ha^{-1}	2.0	3.4	6.6
LPG pressure	MPa	-	0.3	-
LPG consumption	kg ha^{-1}	-	33.3	

Total labour time requirement and total cultivation costs were considerably higher for the SCMS with respect to the two innovative systems (+225% for both parameters), mainly due to spinach planting operations (Table 2). Costs of the crop nursery phase plus manual transplanting were 11-fold that of mechanical precision planting. Sensible differences in the cost of weed management were also registered: the cost of SCMS (mainly due to biodegradable plastic mulch) was nearly double that of ACMS and triple that of ICMS (Table 2).

Tab. 2: Labour time and cost estimations (including cost of the technical means used but excluding cost of machines) of the three crop and weed management systems tested on spinach

System[1]	Soil tillage		Manual harvest		Planting		Weed management		Total	
	$h\ ha^{-1}$	€ ha^{-1}	$h\ ha^{-1}$	€ ha^{-1}	$h\ ha^{-1}$	€ ha^{-1}	$h\ ha^{-1}$	€ ha^{-1}	$h\ ha^{-1}$	€ ha^{-1}
SCMS	8	450	340	3,000	815	11,487	8	1,004	1,171	15,951
ICMS	8	450	340	3,000	5	1,042	6	317	359	4,809
ACMS	8	450	340	3,000	5	1,042	8	524	361	5,017

[1]SCMS = Standard Crop Management System, ICMS = Intermediate Crop Management System, ACMS = Advanced Crop Management System. See text for details.

Consequently, the estimated total cost per unit yield was appreciably higher for SCMS (3.24 € kg^{-1}) than for the innovative systems (on average 0.72 € kg^{-1}).

Conclusions

The comparison between the standard and the innovative systems gave very interesting and encouraging results. ICMS and ACMS showed considerable lower costs and hand labour requirements (on average -70%) with respect to the standard system practised on farm. The operative machines used in the innovative systems are cheap, versatile and well adapted to the farm context. Furthermore, soil incorporation of interseeded subterranean clover seeds did not interfere with physical weed control interventions. No appreciable cost differences were observed between the two innovative systems. Further experiments are ongoing to evaluate the feasibility of use of the innovative systems on other organic vegetable crops typical of the Arno Valley.

Acknowledgements

We thank the CIRAA E. Avanzi staff and the farm owner, Mr Colombini, for their precious help. This research was funded by the MiPAF FertOrtoMedBio Project.

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Physical Weed Control in Organic Carrot in Sicily (Italy)

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Key words: carrot, weed control, rolling harrow, flame weeding, precision hoe.

Abstract

Weeds are the major biotic factor that negatively affects organic carrot yield. As a matter of fact, weeds can reduce carrot growth from early stages to harvest because of the low competitive attitude of this vegetable. Innovative and conventional crop and weed managements were compared in an experiment carried out on farm in the Catania Plain (Sicily, Italy) in 2005-2006. Innovative planting pattern, operative machines (rolling harrow, flaming machine, precision hoe) and crop management increased carrot yield up to 8%, and also increased first category carrot yield and density, thus increasing production quality. Precision hoeing resulted in intra-row weed biomass decrease ranging between 55 to 97%, and in a total working time reduction up to 74%. Furthermore, the innovative crop and weed management systems reduced the costs for hand weeding and increased gross income.

Introduction

In Italy mean annual carrot (*Daucus carota* L.) harvested area is c.a. 13,400 ha, and total production is 620,000 t (Istat, 2006). Carrot is cultivated in many agricultural areas of Italy, and Sicily region accounts 24% of national production, with mean yield of 38 t ha^{-1}. Weeds are known to be one of the major biotic factors that negatively affect organic carrot yield. Carrot seeds have extremely slow emergence and the taproot is preferred as the photosynthate sink during the growth cycle at the expense of the above ground plant part. As a result, carrot canopy can only achieve a very scanty ground cover compared to most weeds (Li and Watkinson, 2000; Peruzzi et al., 2005). One of the main technical constraints to organic carrot growing is the limited range of effective direct weed control means capable of replacing chemical herbicides. Many researches have focused attention on preventive, cultural and direct post-emergence physical control strategies in order to provide the carrot crop with a competitive advantage during the entire cycle (Bàrberi, 2002; Hatcher and Melander, 2003). At present, the main limitation of direct mechanical means is the intra-row weed control. An effective post-emergence intra-row weed control could in fact reduce considerably the number of man-hours required for hand weeding, a practice that is indispensable in carrot production.

This research was planned to study the effects of an innovative organic carrot crop system in comparison with the conventional system of the Ramacca area, in order to increase organic carrot yield and quality as a consequence of the adoption of a new agronomic technique, based on the utilization of innovative operative machines.

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Materials and methods

The experimental trials were carried out in the 2005-2006 growing season at the organic farm “Terre del Sud” in Ramacca (Catania, Sicily) (37°23’ N, 14°42’ E). Soil tillage consisted in three passes with a cultivator at 18-20 cm depth during summer and autumn. In November fields were arranged in ridges 1.6 m wide and 25 cm high, then sowing was carried out. The conventional crop system for organic carrot was compared to an innovative crop system, differing in planting and weed control techniques. In the conventional crop system each ridge was divided before sowing in two strips 50 cm wide. Carrots were planted in two bands per strip 7 cm wide and spaced 30 cm. For early pre-emergence weed control a flaming machine was used. Afterwards intra-row weed control consisted in five manual interventions carried out during the entire crop cycle.

In the innovative crop system a false seedbed was carried out by means of a rolling harrow once the ridges were arranged. As described by Peruzzi et al. (2005), the action of this operative machine is characterized by the passage of spike discs that till the top 3-4 cm of soil, followed by the passage of gage rolls that work at a higher peripheral speed. This machine acts as a direct weeder, because it crumbles the soil superficially and detaches the weed seedlings, but also it stimulates weed emergence, in order to reduce as much as possible the potential weed flora with the subsequent physical treatments.

Then carrots were planted in 5 rows spaced 20 cm apart using a pneumatic precision planter. Before crop emergence, flaming was carried out over the ridges. The flamer was equipped with three 50 cm wide rod burners, set at 10 cm from the soil and at 45° slope, based on previous experimental evidence (Peruzzi et al., 1997). Pre-emergence flame weeding was operated at a mean working speed of 7 km h^{-1} and LPG pressure of 0.3 MPa.

Precision hoeing and manual weeding were carried out for post-emergence physical weed control. Precision hoeing operations in the innovative crop system differed in the number of treatments, while manual weeding was carried out twice (in April and May) in all plots. Two or three hoeing passes were performed with a six elements precision hoe realized in order to work on the ridge and equipped with manual driving system.

Carrots were harvested mechanically with a self-propelled equipment operating on a single row.

The determinations carried out during the filed tests were carrot yield and quality, carrot density, weed biomass and density, and work chains characteristics. A complete randomized block design was used, and data were treated by ANOVA. Means were compared by protected LSD test at $P \leq 0,05$.

Results

Carrot yield statistically differed between the two physical weed management, and innovative crop system resulted in higher vegetable production and quality (Tab. 1).

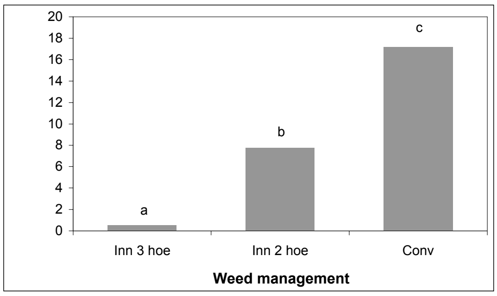
Tab. 1: Yield (t ha^{-1}) of the organic carrot with different crop system menagements.

Crop system	Total	1st cat.	2nd cat.	Ungraded
Inn 2 hoe	32.1 b	3.9 a	18.0 b	10.2 a
Inn 3 hoe	35.7 a	2.7 b	22.7 a	10.3 a
Conv	33.0 b	0.4 c	21.4 a	11.2 a

In the same column, values labelled with different letters are significantly different at *P*□0.05.

Innovative crop system with three precision hoeing operations increased total carrot yield of about 8% with respect to conventional management. Innovative crop system also increased carrot quality with both two and three precision hoeing treatments. Although both innovative and conventional systems resulted in most carrots being included in second marketable class, innovative crop systems with two and three hoeing operations increased about ten and seven fold the first category carrot yield. The same trend was observed for carrot density at harvest. Differences in total carrot density at the end of the crop cycle were not significant, but first category carrot density was markedly increased by innovative systems.

As a consequence of preventive weed control (rolling harrowing and flaming), weed density of innovative management was reduced of about 65% in comparison to the conventional management at early stages, and the following precision hoeing treatments allowed a further weed reduction up to 76%. If compared to the conventional system, the innovative managements allowed a more constant and effective weed control, as evidenced by the weed dry weight at harvest (Figure 1).



Inn 3 hoe: innovative weed management with three hoeing treatments;
Inn 2 hoe: innovative weed management with two hoeing treatments;
Conv: conventional weed management.
Columns labelled with different letters are significantly different at *P*□0.05.

Figure 1: Weed dry weight at harvest as influenced by different weed managements.

Innovative weed management with three hoeing interventions was the most effective among weed control treatments and allowed almost the total elimination of weeds at the end of crop cycle, while innovative management with two hoeing operations reduced weed biomass by 55%.

Total working time for innovative managements with two and three precision hoeing passes was respectively 60% and 74% lower than that relative to the conventional management, as a result of a lower manpower used for hand weeding.

Discussion

The present research showed that an appropriate physical weed management can effectively reduce weed density and working time needed for hand weeding, but it can also guarantee good yield and quality, and also high gross margin.

The false seedbed technique adopted in this experiment allowed a good weed control during the early stages, and provided the crop with a competitive advantage during the entire cycle. However, preventive strategies alone are not sufficient for an effective weed management, thus the utilization of specific machines like the precision hoe is crucial in order to perform a relevant intra-row post-emergence weed control. The single row crop arrangement was adopted in order to perform precision hoeing operations, that considerably reduced the amount of manpower required for post-emergence hand weeding and slightly increased total yield and yield quality. The higher root commercial quality obtained with the innovative system can be explained taking into account that the single rows, associated with precision planting, lead to a more rational arrangement of the space available for the crop plants.

Conclusions

As a conclusion, the results showed that the use of effective strategies and operative machines can increase yield and quality of organic carrot. Although further investigations concerning physical weed control are clearly needed, yet today organic vegetable producers can use innovative, simple, flexible, and not expensive technologies that allow to reach a good degree of weed control, high yield, quality, and gross margin in organic carrot production.

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Innovative Mechanization of Garlic in Vessalico (North Italy)

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Key words: garlic, physical weed control, organic farm, rolling harrow, flame weeding.

Abstract

Vessalico is a small village close to Imperia (Liguria region), where garlic is a typical crop. The garlic of Vessalico is a product that is very appreciated being one of the most traditional and top quality food in Italy. The division of Agricultural Machinery and Farm Mechanization of the Department of Agronomy and Agroecosystem Management and the CIRAA "E. Avanzi" of the University of Pisa, in collaboration with the Agriculture and Civil Defence department of the Liguria Region and the cooperative of farmers "A Resta", carried out a trial aimed to study the possibility of introducing a mechanization chain in order to solve the main agronomic problems of the garlic cultivation in this area, such as sowing, weed control and harvesting, thus improving garlic yield and quality. Ordinary organic garlic crop management was compared with an innovative system in which physical weed control was carried out using a rolling harrow, two flame weeding machines and a precision hoe. The innovative treatments increased whole plant and bulbs dry weight of about 38 and 78% respectively, and reduced weed biomass at harvest up to 77%.

Introduction

Vessalico is a village (Latitude 44°3 N, Longitude 7°58' E) in the district of Imperia, Region Liguria, NW Italy. The farms in this area are very small, and crops are grown in small terraced plots. As a result, operating machines must be handy and not cumbersome. Garlic is the main crop in this area, and it is sold as dried or processed high quality product, that is famous worldwide. Furthermore all the garlic cultivation of the area is organic, and it gives an added value to the crop. The division of Agriculture Engineering and Farm Mechanization Departement of Agronomy and Agro-Ecosystem Management and the CIRAA "E. Avanzi" of the University of Pisa, in collaboration with the Agriculture and Civil Defence department of Liguria and the Cooperative of farmers "A Resta", carried out an experimental test, aimed to study the possibility of introducing a mechanization chain to solve the main agronomic problems of the garlic cultivation in this area, such as sowing, weed control and harvesting, thus improving garlic yield and quality (Peruzzi et al. 2007).

Materials and methods

The research was carried out in 2006-2007 in Vessalico (Imperia, Italy). The ordinary organic garlic cultivation was compared with an innovative system. The farmers of Vessalico usually plant the bulbs using a "one row" potato planter, modified for garlic. This equipment allows a reduction in working time compared to hand sowing, but it

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places the bulbs too deep in the soil, making the emergence of the plants difficult. The inter-row space is 50 cm. Weed control is carried out with a self propelled cultivator between the rows and by hand in-row. This technique is very expensive and can damage the garlic root system if the weeds are too much developed.
Concerning the innovative system, three different equipments for physical weed control were used: a rolling harrow, two flame weeding equipments and a precision hoe, all having a working width of 1.4 m. (figure 1).
The rolling harrow is equipped with specific tools. The tools are spike discs placed at the front and gage rolls mounted at the rear. The front and rear tools are connected by an overdrive with a ratio equal to 2. The disc and the rolls can be placed differently on the axles: in close arrangement, in order to create a very shallow tillage (3-4 cm) of the whole treated area (for seedbed preparation and non-selective weed control after false seed bed) and in spaced arrangement, in order to create efficient selective post emergence weed control (for precision inter-row weeding) (Peruzzi, 2005 and 2006).
The flamer is an open flame machine equipped with five 25 cm wide rod burners. In the experimental field trials the operative machine was used at crop emergence treatment with a driving speed of about 3 km h^{-1} and different LPG pressures. During the trials a hand flamer, equipped with a one 15 cm wide rod burner and LPG pressure of 0.2 MPa, was also used.
The precision hoe is equipped with a seat and steering handles and directional wheels. The machine is equipped with six working units connected to the frame by means of articulated parallelograms. Each working unit is provided with a 9 cm wide horizontal blade and two couples of specific tools (elastic teeth suitable as vibrating tines and torsion weeder) in order to perform both inter and intra row weed control.

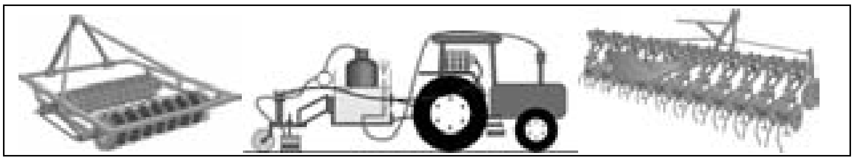

Figure 1: The equipments used for physical weed control: rolling harrow (left), flame weeding machine (middle), precision hoe (right).

The innovative weed control strategy consisted in a false seedbed technique performed with the rolling harrow, followed by flame weeding after crop emergence, as garlic can tolerate an exposure to thermal radiation for a few digits of second. Further interventions of weed control were performed by means of flame weeding or precision hoeing. Harvest was completely manual for both systems, because the garlic plants are dried with whole leaves, in order to twist them in the traditional strings (typical product manufacturing of the area).
During the experimental trials, physical weed control treatments were differentiated. Firstly, a false seed bed was performed with the rolling harrow on each experimental plot. Subsequently, garlic was manually sown in three rows spaced 20 cm apart. At early post emergence, an intervention of flame weeding was carried out at different working pressures (0.2; 0.3; 0.4; 0.5 MPa) using a 3 km h^{-1} driving speed. At the fourth leaf stage, three different secondary treatments for each working pressures were performed: precision hoeing with vibrating tines + torsion weeder, precision hoeing + torsion weeder and manual flame weeding (with a knapsack equipment and a working pressure of 0.2 Mpa). On some experimental plots, no secondary treatment was performed. Weed inter-row and intra-row density was determined on a basis of 25□30

cm^2 sampling area. At harvest crop production and weed biomass were determined. The experimental design was a strip plot with three replicates. Data collected were analysed by ANOVA. Treatment means were separated by Fisher's least square difference at P≤ 0.05 (Gomez e Gomez 1984).

Results

Data collected 29 day after the first flame weeding treatments showed that the most efficient working pressure in controlling inter-row weeds was 0.3 MPa. Weed density recorded 35 day after the secondary treatment revealed significant differences between the treated and untreated plots, but no significant differences were observed between the systems. The weed flora percentage reduction ranged from 24 to 57%.

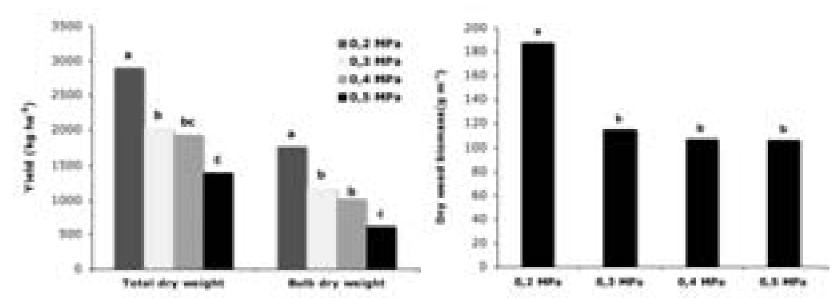

Figure 2: Effects of the different flame weeding working pressures on crop production (left) on weed biomass at harvest (right). Different letters indicate significant difference (LSD P≤0.05).

Significantly higher total dry weight and bulb dry weight were observed when using a working pressure of 0.2 MPa. No significant differences were observed between the secondary treatments. As with weed dry biomass, significant differences between the different working pressures used in the first flame weeding intervention were noticed, with higher values for 0.2 MPa (Figure 2).
Comparing the data collected on innovative experimental plots treated with a working pressure of 0.2 MPa with the ones obtained on field managed in a traditional way, a significantly higher production in terms of total and bulbs dry weight, and a significant lower value of weed biomass at harvest were observed.

Discussion

Weed control is the main agronomic problem of garlic crops in this area. Flame weeding seems to ensure good weed control. The working pressure of 0.3 MPa ensured the best weed control results both in terms of density and biomass at harvest. The working pressure of 0.2 MPa allowed to obtain the highest yield and to control the weed flora in a acceptable way, in comparison with the traditional weed management. In order to explain these results, it should be considered that, during flame weeding intervention (with constant driving speed), the higher LPG pressure resulted in higher transmitted energy.

Conclusions

The introduction of a mechanization chain in organic garlic in Vessalico seems to be feasible, using suitable operative machines available on the market, with opportune setting up and possible modifications. Regarding weed control, the experimental trials carried out by means of the equipments realized at the University of Pisa showed interesting results, that aim to identify a more precise definition of effective weed management and its practical applications.

Acknowledgments

The authors would like to thank Mrs Roberta Del Sarto, Mr Alessandro Pannocchia, Mr Paolo Gronchi, and Mr Calogero Plaia of the M.A.M.A.-D.A.G.A. and C.I.R.A.A. of the University of Pisa, and also all the members of the “A Resta” farmer cooperative for their precious collaboration and participation in the experimental work.

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Innovative strategies for physical weed control on processing tomato in the Serchio Valley (Central Italy)

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Key words: physical weed control, operative machines for weed control, processing tomato, stale seed-bed technique.

Abstract

An "on-farm" open field research on processing tomato weed control was carried out during 2006 in a conventional farm in the Serchio Valley (Pisa, Central Italy). The aim of the experiment was to test innovative strategies and operative machines for non-chemical (physical) weed control.The innovative strategy was compared with the farm traditional technique. The innovative strategy consisted in the application of the stale-seedbed technique (by means of a rolling harrow and a flaming machine in the pre-transplanting phase) and precision hoeing interventions in post-transplanting phase (with an innovative machine equipped with rigid elements, for inter-row weed control, and elastic tines for selective intra-row weed control). Traditional technique consisted in two chemical pre-transplanting interventions and two post-transplanting rotary hoe treatments.Innovative operative machines performances, weed density during the crop cycle, dry weed biomass at harvest and crop fresh yield were recorded.The innovative strategy allowed to reach significantly higher yield values (+18%), a good weed control and a relevant increase of gross marketable production with respect to traditional strategy (+4500 € ha-1 as net value of weed management costs).The experiment is still on-going and it will finish in 2008.

Introduction

Processing tomato is the most important Italian vegetable crop (ISTAT, 2007), although a significant reduction of tomato harvested area was observed in Italy in the last two years (-20%, from 113000 to 91000 ha). This trend is mostly due to political (uncertainty of CMO reform) and economical (high cultural fixed costs) reasons (ISTAT, 2007; Bazzana, 2007).

The production valorisation (for example by organic cultivation) could be a good strategy in order to follow the new policy trends and to guarantee accurate profits to the farmers. This aim could be easily reached by means of cultural practices that respect environmental and consumers health safety.

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The development of new strategies and operative machines for physical weed control (one of the most serious problems in organic summer crops), could represent a good way to reach the aims previously mentioned.

Actually physical weed control research field is mostly studied in Northern Europe, while processing tomato is a typical Mediterranean crop. Thus, with the exception of some recent Spanish field trials (Cirujeda et al., 2007), no scientific papers are at the moment available on this crop.

In this work, the preliminary results of a three year long (2006-2008) "on-farm" open field research are reported. It is still on-going and it is being carried out by the University of Pisa with the aim to develop and improve innovative strategies and innovative operative machines for an effective physical weed control in processing tomato.

Materials and methods

The experiment was carried out during 2006 on processing tomato in a conventional farm placed near Pisa. The tomato variety was called "Leader". The crop was mechanically transplanted on paired rows at the density of 33000 plants ha-1 (1.60 m of inter-pair space; 0.4 m of inter-row space; 0.25-0.30 m of intra-row space). Crop was irrigated by drip hoses placed in the middle of the inter-row space.

During this first year of experiment the traditional farm weed management system (FS) was compared to an innovative physical weed control system (PWCS). FS was carried out by means of two different chemical pre-transplanting treatments (1 kg ha-1 of "Stomp" – a.i. Pendimetalin – and 1 kg ha-1 of "Ronstar" – a.i. Oxadiazon) and two post-transplanting rotary hoe interventions (not able to till the soil in the intra-row space). PWCS was carried out by means of the stale seedbed technique (realized by one rolling harrow pass followed by one flaming treatment) and two post-transplanting precision hoeing interventions. "Superalba" organic-mineral fertilizer (9-12-21) was applied before crop-planting in both cropping systems at a rate of 1 t ha-1. Fertirrigation was carried out in post-emergence, using a 12-61-0 and a 13-0-40 fertilizers at the beginning and the end of the crop cycle respectively. The soil type was sandy-loamy and a four year rotation was adopted (tomato, wheat, maize and wheat).

The experimental design was a randomized block with four replicates. Data were analyzed by ANOVA. Innovative operative machines performances, weed density during the crop cycle, dry weed biomass at harvest and crop fresh yield were recorded. Three different innovative operative machines were used for physical weed management: a rolling harrow, a flaming machine and a precision hoe.

The rolling harrow was projected, built, tested and patented by Pisa University. It was set up both for pre-sowing (or pre-transplanting) and post-emergence hoeing (for inter-row and intra-row selective weed control) interventions. Working tools are spike disks (placed in the front) and cage rolls (placed at the rear), respectively mounted on two different parallel axles. The axles are connected by an overdrive with a ratio equal to 2. Spike discs till the soil very shallowly while cage rolls (rotating with a double peripheral speed) allow to separate weed seedling roots from soil (Peruzzi et al., 2007a and 2007b). In this case the treatment was carried out just before crop transplanting with a working speed of 7 km h-1 and a working depth of about 4 cm.

The flaming machine controls weeds by the use of an open flame. In this experiment it was equipped with three 50 cm wide rod burners, for a total working depth equal to 1,5 m. The treatment was performed just in the pre-transplanting phase, but if necessary, tomato may tolerate post-emergence selective flaming interventions (with the flame directed to the crop collar) (Peruzzi et al., 2007a and 2007b). Working speed was about 3 km h-1 and LPG consumption was about 35 kg ha^{-1}.

The precision hoe is characterized by a 3 m wide frame. It is equipped by rigid elements for inter-row cultivation (goose sweeps and side "L" shaped sweeps) and elastic elements for intra-row selective weed control (torsion weeders and vibrating tines). The operative machine is also equipped with a seat, steering handles and directional wheels (Peruzzi et al., 2007a and 2007b). By means of these tools, it was possible to till soil and control weeds even inside the crop pairs, without removing the drip irrigation hoses. Furthermore, the precision hoe was equipped by on purpose made "V" shaped elements, that allow to "open" crop vegetation during late hoeing interventions (Fig. 1). Average working speed was about 2 km h-1 and working depth was about 4 cm.

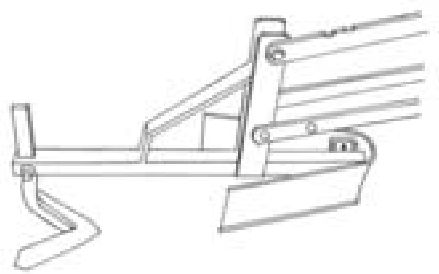

Figure 1: Scheme of a goose sweep and a "V" shaped tool used for late hoeing.

Results and discussion

The innovative physical control strategy allowed a good weed management and a fresh marketable yield increase of about 18%.

Tab. 1: Yield, weed biomass at harvest, total labour time requirement and gross marketable production weed management costs net value (GMP w.n.v.) registered during 2006 on processing tomato.

Weed management system	Yields (t ha^{-1})	Weed dry biomass at harvest (g m^{-2})	Total labour time (h ha^{-1})	GMP w.n.v.* (€ ha^{-1})
Farming system	59.4 b	102.9 ns	15.0 b	22790
Innovative system	72.1 a	126.1 ns	54.1 a	27298

Different letters on the same column mean significant differences for P<0.005 (LSD test), *Gross marketable production weed management costs net value. Data were not analysed by ANOVA

This result was probably due to the good "agronomical" effects of precision hoeing on crop development (Tab. 1). Conventional rotary hoeing, on the contrary, didn't till the soil into crop pairs, with worse consequences on crop roots development and soil water contents.

Concerning with weed control, no significant difference was observed on weed biomass at harvest between the two different systems (Tab. 1).

Otherwise conventional weed management system allowed a significant reduction of manual labour time for weed control with respect to innovative weed control system (-72%) (Tab. 1). This fact could be explained taking into account the good chemical treatments on weed control. However gross marketable production weed management costs net value (GMP w.n.v.) was higher for PWCS than FS. The estimated differences between the two systems was equal to 4500 € ha^{-1} (Tab. 1).

Conclusions

The innovative physical weed control strategy allowed to reach higher yields and gross marketable production values.

Furthermore, innovative operative machines for physical weed control appeared very versatile, suitable and adaptable to the processing tomato crop. Moreover, these machines can be easily utilized for weed control in organic agriculture, where herbicides use is not permitted. The results of this first year of experiment showed that the alternative cultural strategy could be convenient for environment and consumers health and also for farmers gross income.

However, further experimental work is obviously required in order to verify and improve the effectiveness of innovative strategies and machines for physical weed control on processing tomato.

Acknowledgments

The authors want to thank very much San Giuliano Terme and Vecchiano municipalities for their economical support and Mrs Roberta Del Sarto, Mr Calogero Plaia, Mr Alessandro Pannocchia, Mr Paolo Gronchi and Mr Silvano Toniolo of Pisa University for their precious collaboration and participation in the experimental work.

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Cropping systems

Influence of alleycropping microclimate on the performance of groundnut (*Arachis hypogaea* L.) and sesame (*Sesamum indicum* L.) in the semi-desert region of northern Sudan

Haider E. Shapo[1] & Hussein S. Adam

Key words: Irradiance, Semi –Arid, *Acacia stenophylla*, Evapotranspiration, Water use

Abstract

An alley cropping system was established at Hudieba Research Station (17.57'N and 33.8' E) on a loamy sand soil of the semi-desert region of northern Sudan. The objective of this study was to investigate the influence of modified microclimate in 6-m wide alleys formed by Acacia ampliceps and Acacia stenophylla on growth and yield of groundnut. and sesame. Above-ground interactions were determined by measuring air temperature, relative humidity, wind speed, solar energy and shade length and behaviour. Groundnut and sesame were evaluated for growth and yield by laying out sample plots at southern, central and northern part of the alleys and at control plots. Due to microclimatic modifications in the alleys, the yield of both crops in the alleys significantly (p=0.01) exceeded that of the sole crop. Yield reduction at the northern alley was fully compensated by high yield increase at southern and central alleys. The yield of groundnut increased by 37.7 and 19.6 % in the A.stenophylla and A.ampliceps alleys, respectively. On the other hand, the yield of sesame increased with the stenophylla-alley (+40.3%), while it decreased with ampliceps-alley (-51.5%). The results indicated that the competition for light was the major factor contributing to the increase or reduction of growth and yield of groundnut and sesame.

Introduction

The northern region of Sudan is viable for production of a number of food crops, however, desertification is a threat to the development of agricultural activities. Growing trees is a high priority for productive and sustainable agriculture. However, high cost of irrigation and lack of short-term incentives from the trees restrict plantation of pure tree stands. Trees for protective and productive role could be established on the base of alley cropping technology, which has been defined as " a production system in which trees and shrubs are established in hedgerows" on arable crop land, with food crops cultivated in the alley between the hedgerows (Kang and Wilson, 1987)" .

Alley cropping or tree-crop association has been advocated by several workers as a means to improve productivity, maintain soil fertility, control soil erosion, reduce environmental degradation, and offer better utilization of natural resources (Kang and Wilson, 1987; Kang et al., 1990). In the semi-desert of the northern Sudan, the soil is marked by the virtual absence of soil organic matter and extremely low nitrogen content. In addition, the area seriously suffers from desertification. Thus, alley cropping, using N-fixing trees, is sought of as a potential production practice that can

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provide several conservational and production benefits in the study area. Despite, the economic and nutritional importance of groundnut and sesame, both crops have received little attention in alley cropping research. The objectives of these trials were to examine the effect of alley cropping on microclimate and consequently on growth, yields and yield components of these two crops.

Materials and methods

An alley-cropping experiment was established on loamy sand soil during the period 1998 -2000 at Hudieba Research Station (HRS)., The study area lies within arid to semi-arid zones with mean annual rainfall ranging from 0 to 100 mm. The seedlings of Acacia stenophylla and Acacia ampliceps were planted in hedgerows, 3m within row spacing and 6.3 m between rows. Each hedgerow was 180 m long and arranged in an east-west direction. The groundnut and sesame were grown in the alleys formed by the two acacias assigned randomly in a spilt plot design replicated three times. The plot size was 3X6 m. The alley was divided into three zones: northern, central and southern alley. The central alley had the largest width (4 m), while the northern and the southern alleys were each 1.0 m wide. According to the orientation, and position of the sun at different times of the day and season, radiation varies in each zone. Groundnut (Arachis hypogaea, sub ssp hypogaea, var hypogae) and sesame (Sesamum indicum L.) seeds were sown between rows according to recommendations released by Agricultural Research Corporation in the Sudan. Plant samples were taken at harvest from an area of one square meter in the center of the northern, central and southern alleys and control plots to determine plant characters, yield and yield components.

The Stevenson screens (Meteorological Instrument, 19961) were positioned at a height of 2 m above ground level at each of the three zones of the alley and control plot. The readings of all thermometers were taken simultaneously between 8.00 – 9.00 LT every day and continuous measurements were made from June to October. Cup anemometers were used for measuring wind speed. Tube solarimeters were placed at ground level across the three zones of the alley to measure solar irradiance.

Statistical analysis was carried out using the computer program MSTAT package by SAS Corporation.

Results and Discussions

Table 2 shows that the average reduction in maximum temperatures and solar irradiance was 1.8 ˚C and 54% of the control, respectively. Relative humidity gave average increase of 12%. The southern alley had the highest reduction in maximum temperatures and the highest increase in relative humidity. Its transmitted radiation was higher than in northern alley. On the other hand, the northern alley gave higher reduction in maximum temperatures and higher increase in relative humidity than the central alley. Table 1 demonstrates that there was significant (P=0.01) differences in yields and yields components between the alley cropping and the control plots. Stenophylla–alley, gave higher significant (P=0.01) yields of groundnut and sesame than ampliceps–alley. Regarding the zones of the alley, the southern zone gave the highest yield and yield components.

In agroforestry systems, the tree canopy reduces and modifies the light availability to plants in the understory, with possible beneficial consequences for photosynthesis, water relations and morphogenesis (Bergez et al, 1997). In this study the stenophylla-alley with its relatively higher average radiation (62% of the control) remarkably increased the economic yield of both groundnut and sesame by 37.7 and 40.3%, respectively, compared to the control. On the other hand, ampliceps-alley, with its low radiation (46% of the control), increased the yield of groundnut by 19.6 %, while it decreased that of sesame by 51.5%. The southern zone of the alleys had intermediary radiation, and gave the highest yield. This indicates that the groundnut and sesame yields did not increase as light supply had increased as other environmental factors, seemed to be influential (e.g. temperatures, humidity and wind speed). The highest radiation in the central alley coincided with the least improvement in temperature and humidity, while the lowest radiation in northern alley was concurrent with the complicity of the co-existence of tree-crop roots competition.

Tab. 1: Yield and yield components of groundnut and sesame in the alley and control plots (1999-2000)

Treatments	Groundnut			Sesame		
	Plant height (cm)	weight of kernels kg\ha	Yield as % O f control	plant height (cm)	Wt. seed Kg/ha	Yield as % Of control
Control	17	437	-	136	747	-
Northern-stenophylla	20.6	546	+ 24.9	160	853	+ 14.2
Southern-stenophylla	26.2	676	+54.6	163	1426	+ 90.8
Central-stenophylla	26.8	584	+ 33.6	171	850	+13.8
A.stenophylla-alley	24.5	602	+ 37.7	165	1043	40.3
Northern-*ampliceps*	23.1	320	- 26.7	150	333	- 55.0
southern-*ampliceps*	26.9	681	+ 55.8	136	420	- 43.7
Central-ampliceps	24.7	570	+ 30.4	144	326	- 56.3
A.ampliceps-alley	24.9	523	19.6	143	359.7	-51.8
Sig. L	*	*	-	* *	*	-
S.E+\-	1.2	13.4	-	4.9	6.8	-
C.V %	9.4	10.4	-	2.0	115	-

*significant for $P<0.01$ * * significant for $P<0.001$

On the other hand, the yields of groundnut in the southern and central zones of the ampliceps increased by 55.8 and 30.4%, respectively, while it decreased by 26.7% in northern alley. In addition, the sesame yield in the southern, central and northern zones of the ampliceps decreased by 43.7, 56 and 55 %, respectively. The increase in groundnut yield and decrease in sesame yield in ampliceps-alley may not only be due to low radiation (42 – 50% of the control), but may also be due to competition for water. The severe reduction of yield in the northern and central alley of A.ampliceps may be due to complexity of the co-existence of the root of the tree – crop mixture. The competitive roots of the ampliceps extended laterally up to the central alley and compete with sesame for water. Sesame requires adequate moisture for early growth and before flowering, which have the greatest impact on yield (Weiss 1971). Therefore, water-use might be another factor in reducing sesame yield within ampliceps-alley.

Tab. 2: Differences in temperatures (˚C), relative humidity (%) and % of irradiance in various zones of the alley as percentage of control (kw /m^2)

	A.ampliceps-ally				A.stenophylla-ally				ā	Control
	S	N	Ce	x	S	N	Ce	x		
Max. temperatur	-2.7	-1.9	-1.3	-1.9	-1.8	-1.7	-1.5	-1.7	**-1.8**	41.5
Relative humidity	+18	+13	+10	+14	+12	+10	+8	+10	**+12**	42.0
Solar energy	46	42	50	46	58	54	75	62	**54**	0.354

*S= Southern alley *N=Northern alley *Ce=Central alley *Co= Control

* x = average * Am = Acacia ampliceps * St = Acacia stenophylla

* (-) Reduction in maximum temperature * (+) increase in relative humidity

* ms-1 = wind meter per second

Conclusions

Thus, the current conditions in the Northern Region of Sudan are favourable for adopting agroforestry technology in order to arrest environmental deterioration and to secure productivity and sustainability of agricultural crops. The study revealed that trees influenced the plant-environment-relationship in a way that conditions become more conducive for crop growth. Although, the micro-environmental variables were responsible for yield increase or decrease, but in reality, it seemed difficult to separate the complex interacting climatic factors involved in the system. Nevertheless, the obtained results indicated that the competition for light was the major contributing factors responsible for yield reduction or increase in the different alley' zones. Groundnut had proved to be shade tolerant and it gave the highest yield with *A.ampliceps* with low radiation (46% of control).

In high terrace soils of northern Sudan, groundnut is recommended to be alleycropped with *A.stenophylla* and *A.ampliceps* trees, while sesame is recommended to be alleycropped with Acacia stenophylla.

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The significance of mycorrhizal fungi for crop productivity and ecosystem sustainability in organic farming systems

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Key words: organic agriculture, plant-soil interactions, crop productivity, mycorrhizal symbiosis

Abstract

Mycorrhizal fungi are widespread in agricultural systems and are especially relevant for organic agriculture because they can act as natural fertilisers, enhancing plant yield. Here we explore the various roles that mycorrhizal fungi play in sustainable farming systems with special emphasis on their contribution to crop productivity and ecosystem functioning. We review the literature and provide a number of mechanisms and processes by which mycorrhizal fungi can contribute to crop productivity and ecosystem sustainability. We then present novel results, showing that mycorrhizal fungi can be used to suppress several problematic agricultural weeds. Our results highlight the significance of mycorrhizal fungi for sustainable farming systems and point to the need to develop farming systems in which the positive effect of these beneficial soil fungi is optimally being utilized.

Introduction

The 400 million year old symbiosis between the majority of land plants and arbuscular mycorrhizal (AM) fungi is one of the most ancient and abundant mutualisms on Earth. AM fungi form extensive hyphal networks in soil and provide plants with nutrients in return for assimilates (Smith & Read 1997). AM fungi can act as support systems for seedling establishment, provide resistance against drought and some pathogens, and AM fungi can enhance biological diversity in grassland (van der Heijden et al. 1998). Several studies have shown that AM fungi contribute to up to 90% of plant P demand (Jakobsen et al. 1992; van der Heijden et al. 2006).

AM fungi are especially important for sustainable farming systems because AM fungi are efficient when nutrient availability is low and when nutrients are bound to organic matter and soil particles. Many important agricultural crops can benefit from AM fungi, including maize, potato, sunflower, wheat, onion, leek and soybean, especially under conditions where nutrient availability is limiting plant growth. Moreover, AM fungi not only can promote via directs effects, but there are also a number of indirect effects such as a stimulation of soil quality and the suppression of organisms that reduce crop productivity (see Table 1 for an overview).

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Table 1: Direct and indirect effects of mycorrhizal fungi on crop productivity in organic farming systems

Direct effects on crops
Stimulation of plant productivity of various crops
Nutrient acquisition (P, N, Cu, Fe, Zn)
Enhanced seedling establishment
Drought resistance
Heavy metal resistance
Indirect effects
Weed suppression
Stimulation of nitrogen fixation by legumes (green manure)
Stimulation of soil aggregation and soil structure
Suppression of some soil pathogens
Stimulation of soil biological activity
Increased soil carbon storage
Reduction of nutrient leaching

Until now, most studies have investigated the effects of AM fungi on plant growth using pot experiments with single plants. However, in the field crops co-occur with weeds and some crops are grown together with other crops in mixtures. Hence, it is necessary to use a "system" approach in order to assess the significance of AM fungi for the functioning of agricultural ecosystems. Using such a system approach we explore in this paper whether AM fungi can suppress growth of several highly problematic agricultural weeds that coexist with crops.

Methods

42 microcosms simulating a sunflower cropping system were established in the greenhouse under controlled conditions. Sunflower and six weed species were grown together in microcosms (sunflower-weed mixtures) or weeds and sunflower were grown alone (weed and sunflower monocultures respectively). Half of the microcosms of each treatment were inoculated with a mixture of three AM fungal species and the other half of the microcosms received sterilized inoculum as a control. The microcosms were harvested after 14 weeks. Dry weights of sunflower and weeds were determined in each treatment and used to calculate the competitive balance index according to Wilson (1988). It was tested whether AM fungi reduce weed growth and alter competitive interactions between weeds and sunflower.

Results & Discussion

It is well known that AM fungi enhance plant growth. However, AM fungi are not only beneficial and interactions between plants and AM fungi can range from mutualistic to parasitic (van der Heijden 2002; Klironomos 2003). Studies performed with plants from natural communities show that AM fungi have a negative impact on several ruderal plants (Francis & Read 1995). Many important weeds have a ruderal lifestyle, suggesting that AM fungi have the potential to suppress weed growth. To test this we established microcosms in which sunflower was grown together with weeds (see methods). We observed a reduction in weed biomass when AM fungi were present in the microcosms supporting our expectations. Moreover, the presence of AM fungi significantly enhanced the competitive ability of sunflower relative to the weeds (Figure 1). Thus, our results show that AM fungi alter the interaction between weeds and sunflower, promoting sunflower and suppressing weeds.

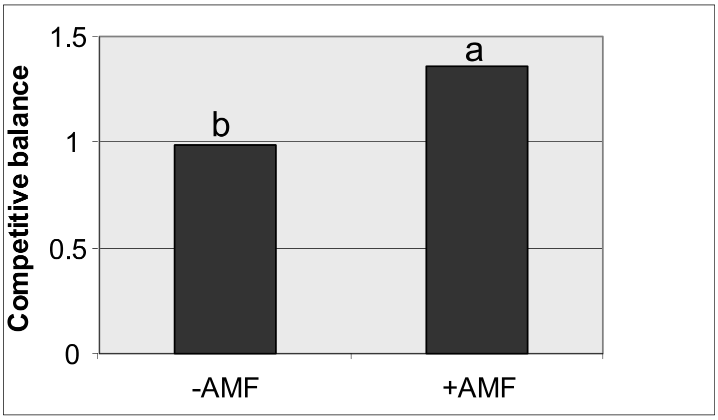

Figure 1: Competitive balance between sunflower and weeds in microcosms with AM fungi (+AMF) or without AM fungi (-AMF). A higher competitive balance indicates a higher competitive ability of sunflower. A competitive balance of > 0 indicates that sunflower is more competitive than weeds.

Conclusions

Our results show that mycorrhizal fungi can contribute to weed control because they suppress the competitive ability of weeds relative to sunflower. Moreover, mycorrhizal fungi can directly and indirectly contribute to plant productivity in organic farming systems. Mycorrhizal effects include enhanced nutrient uptake, enhanced seedling establishment and stimulation of soil structure. Additional research is needed to develop farming systems that optimize the use of natural resources such as mycorrhizal fungi for sustainable agricultural production.

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National-scale modelling of N leaching in organic and conventional horticultural crop rotations - policy implications

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Key words: Nitrogen leaching, modelling, crop rotations, vegetables, water framework directive

Abstract

A method is presented to model N leaching in crop rotations on a national scale. Representative crop rotations for different regions and soil types are used in the cross-disciplinary, plant, soil, environment & economics model EU-Rotate_N. By comparing contrasting farming systems (organic and conventional) in the UK, their strengths and weaknesses in delivering environmental and economic sustainability can be assessed. Modelling results show that the annual leaching in different horticultural rotations and UK regions, using median weather, is within the range of 13 - 88 kg N/ha/year for organic and 54 - 130 kg N /ha/year for conventional. The weighted annual average figures are 39 kg N/ha/year for organic and 81 kg N/ha/year for conventional, respectively. It is concluded that organic horticultural rotations, with a current share of 6.1% already contribute to lower overall N losses from agriculture. However, on a UK national scale, only a large share of organic land use (e.g. > 50%) has a large effect on reducing N losses. Similar reductions are also predicted by substantial cuts in conventional N inputs, giving a policy choice if pollution from agriculture steps up further on the political agenda.

Introduction

Many arable and vegetable crops across Europe are produced in intensive rotations, with large nitrogen (N) fertiliser inputs. Arable crops and especially field-scale vegetable crops use nitrogen often inefficiently and leave N residues in the soil after harvest. This can cause pollution to soil, water and aerial environments, economic losses and unnecessary recourse use. For policy planning, it is necessary to quantify these effects not only on a crop or farm rotation level but also on a national or county level with all its variations in soil type, climate, rotational design, management practise and marketing specifications. With the given constrains in computer power and data availability it is obviously currently not possible to model all rotations of a country and its differing farming systems. Therefore, the two main contrasting farming systems, conventional and organic production, in the United Kingdom were used. To simplify model inputs, statistic data were used to source representative rotations for each farming type.

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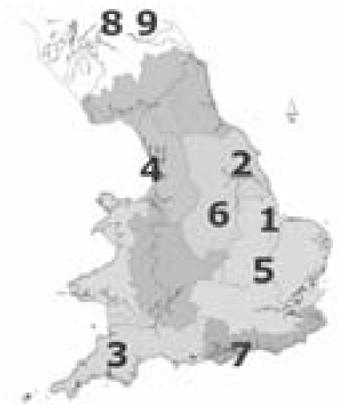
Materials and methods

The data were modelled using EU-Rotate_N a computer model developed over the last five years by a consortium of European researchers. It is a decision support system for soil-plant interactions based on N use in crop rotations. Up to 30 years of cropping can be simulated on a daily step in organic or conventional rotations. The model is written in Fortran and allows the experienced researcher great flexibility since all inputs can be modified to suit local conditions. The model includes routines for water use, water stress, mineralisation, snow and frost (Riley and Bonesmo 2005), root growth and distribution (Kristensen & Thorup-Kristensen 2006), N release from fertility building crops (Rayns et al. 2006) and economics including market channels, marketable yields, crop spacing and variable costs (Schmutz and Firth 2005). The model is available at www.warwick.ac.uk/go/eurotaten (Because of space constrains no further basic details about the model can be given here and reference may be consulted). The data and methods used to source representative 3 - 8 year crop rotations on a national scale are described elsewhere (Schmutz et al. 2006).

Based on these data, the following model runs have been selected (UK regions representing less then 5% of the national vegetable production e.g. Wales, North East England, Northern Ireland were excluded). The first five areas were also run with organic rotations. They represent main UK production areas for conventional and organic and are also scattered in the main river basins according to the water framework directive (WFD) as shown the England and Wales map Table 1.

Tab. 1: Represenative areas, regions, soil types and main crops used in the model runs. The first five areas are also done for organic rotations (run 1o-5o).

Run Nr	Area	Region	Soil Type	Main crops
1	South Lincolnshire	East Midlands	Heavy Silt	Brassicas
2	North Lincolnshire	East Midlands	Sandy Loam	Brassicas
3	Cornwall	South West	Sandy Loam	Brassicas
4	Lancashire	North West	Silt Loam	Brassicas
5	Bedfordshire	Eastern England	Light	Mixed vegetables
6	Nottinghamshire	East Midlands	Light sand	Onion, Carrot, Potatoes
7	Sussex	South East	Sandy Loam	Lettuces
8	Fife	Scotland	Sand	Root Crops
9	Fife	Scotland	Sandy Loam	Brassicas



Organic rotations were run with management data (not shown) representing current organic practices as defined by the Compendium of UK Organic Standards (Defra, 2006). Conventional rotations were run with management data (not shown) representing good agricultural practice (GAP) and N fertiliser inputs as defined by the Defra publication RB209. An example for current practice organic rotation is 2-year grass/clover, potatoes, broccoli, leeks, while the conventional has spring wheat, potatoes, broccoli leeks. In order to compare the land use patterns of organic and conventional rotations in a UK scenario they were statistically weighted according to their importance within UK vegetable regions (e.g. the current high representation of organic production in the high rainfall area of the South West (27.8% weight organic versus 5.8% weight conventional) is taken in account. The current dataset and method represents 86% of the UK conventional and 68% of the UK organic vegetable production. Because of limitations in statistically available data, potatoes and leguminous vegetable crops were excluded (Schmutz et al. 2006). The effects on N leaching, rotational gross margins and other parameters are shown for the current UK organic vegetable land use share of 6.1% and for scenarios with 0%, 2%, 20%, 50% and 100% organic management of the UK vegetable area.

Results

Given space constrains, the inputs and results of individual rotations and model runs are not discussed. Results are only presented on an aggregated level showing the weighted national UK average including all regions, rotations soil types and weather conditions. Data show (Table 2) that current good practice (GAP) horticultural land use has predicted looses of 39 kg N/ha/year under organic and 81 kg N/ha/year under conventional management, respectively.

Tab. 2: Average %-cropping in rotation, modelled N-fluxes and rotational gross margins of weighted organic and conventional horticultural rotations. Data are shown per ha and year, and for the UK horticultural sector assuming different land use percentages of horticultural crops.

Data per ha and year	Organic	Conventional	org%conv
% vegetables	56%	65%	
% cereals	4%	32%	
% fertility crops	40%	3%	
Modelled rotational N fluxes			
N input Mineral Fert (kg/ha/yr)	0	158	
N input Organic Fert (kg/ha/yr)	18	0	
N leach below 90cm (kg/ha/yr)	42	85	
N uptake below 90cm (kg/ha/yr)	3	3	
N system loss water (kg/ha/yr)	**39.2**	**81.4**	**48%**
N gaseous loss (kg/ha/yr)	54	28	191%
N fixed (kg/ha/yr)	30	0	
N system loss air (kg/ha/yr)	**24**	**28**	**86%**
N total loss (kg/ha/yr)	64	110	58%
Rotational gross margin (€/ha/yr)	**€ 3,466**	**€ 2,515**	**138%**
Data for UK horticultural sector			Combined
UK vegetable area (ha)	4720	72866	77586
N system loss water (kg/ha/yr)	39.2	81.4	78.8
Total UK kg N leached (t/year)	185	5929	6114
% organic land use	6.1%	93.9%	100%
Scenario with different % organic	% org	N (kg/ha/yr)	N (t/year)
	0%	81.4	6313
	2%	80.5	6247
current % organic land use	**6.1%**	**78.8**	**6114**
	20%	72.9	5658
	50%	60.3	4676

Gaseous losses of organic production are predicted to be higher than for conventional farming (54 kg versus 28 kg N/ha/year), however when N fixing by legumes is included, the system loss to air is slightly lower (24 kg versus 28 kg N/ha/year). With the current organic land use of 6.1%, the overall system loss for the horticultural sector of field scale vegetables (excluding potatoes and leguminous vegetables) is 79 kg N/kg/ha. Without organic land use (0%-scenario), the losses are predicted to be 81 kg N ha/yr or 6114 tonnes N per year for this sector. With 20% organic land use, the next realistic milestone in organic expansion of UK horticultural land use, the sector's losses are predicted to be 5658 tonnes N per year.

Conclusions and Discussion

For the organic rotations, it can be concluded that the annual leaching predicted for different UK regions and rotations, using median weather, is within the range of 13 - 88 kg N/ha/year. The weighted annual average figure for the UK with median weather is 39 kg N/ha/yr. The 25- and 75- rainfall percentiles give a range of the weighted average of 24 - 45 kg N/ha/year. Overall leaching losses in organic are predicted 48% of conventional. If individual rotations, not weighted, are compared a Student's t-test is possible showing significantly lower (5% error level) leaching losses in organic. For the conventional rotations it can be concluded that the annual leaching is within the range of 54 - 130 kg N /ha/year, with a weighted annual average of 81 kg N/ha/year. The 25- and 75- rainfall percentiles give a range of 50 - 93 kg N/ha/year. On a policy level, it can be concluded that organic production can play an important roll in reducing N losses from horticultural land use. However, on a UK national scale, only a large share of organic land use (e.g. > 50%) has a large effect on reducing N losses by 36% to 60 kg/ha/year. Similar reductions are also predicted by substantial cuts in conventional N inputs. Model runs where the current conventional average N input (based on GAP recommendations) was reduced from 158 kg/N/year to 111 kg/N/year resulted in leaching losses of 50 kg/ha/year on a national scale. However, these are only projections from today's land use and management practices, it is difficult if not impossible to predict the complex interactions of scale effects when organic production increases its critical mass, moves into more favourable low-rainfall areas and simultaneously conventional production becomes "greener". The conclusion is certainly different on a catchment scale, where 100% organic land use can be achieved or enforced by restricting management practices and reductions more specifically modelled.

Aknowledgments

Research was funded by EU Quality of Life Programme (QLK5-2002-01100)

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Beneficial System Outcomes in Organic Fields at the Long-Term Agroecological Research (LTAR) Site, Greenfield, Iowa, USA

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Key words: Crop rotations, soil quality, corn, soybean, economics

Abstract

In 1997, Iowa State University established the first U.S. Land Grant University permanent faculty position in organic agriculture to assist farmers in the rapid expansion of organic production in that state. Research agendas, developed in consultation with organic farmers and processors, led to the establishment of the Neely-Kinyon Long-Term Agroecological Research (LTAR) site in Greenfield, Iowa, in 1998 to study the long-term effects of organic production in terms of yield and economic performance, in addition to other system effects. Over nine years of comparison, there was no significant difference in corn or soybean yields in the organic and conventional systems. Organic corn yields in the longest rotation (C-S-O/A-A) over a 9–yr period were 9914 kg/ha compared to 10113 kg/ha in the conventional system and organic soybeans in the same rotation yielded 3043 kg/ha while conventional yields averaged 2906 kg/ha. Soil quality remains high in the organic system, with soil organic carbon and mineralizable nitrogen greater in the organic rotations relative to conventional, demonstrating greater C sequestration potential and N-use efficiency in the organic system. Over nine years, revenues generated from organic corn crops increased average revenues by a factor of 1.67 over conventional corn, while organic soybean revenues were 2.32 times greater than conventional soybean revenues.

Introduction

Because the state of Iowa advanced quite rapidly in organic production from 1992 to 1996 (USDA-ERS, 2007), Iowa State University (ISU) established the first U.S. Land Grant University permanent faculty position in organic agriculture in 1997. Research agendas were developed in consultation with organic farmers and processors in order to address the needs of the organic community. The Iowa State University Neely-Kinyon Long-Term Agroecological Research (LTAR) site was established in 1998 to study the long-term effects of organic production in Iowa, U.S. In the LTAR, we have involved organic farmers in the design and analysis, and in complementary on–farm trials examining soil processes in the organic transition and beyond certification. The State of Iowa Department of Agriculture organic division, which is accredited by the USDA–National Organic Program, certifies the LTAR organic plots on an annual basis.

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Materials and methods

Treatments at the LTAR site, replicated four times in a completely randomized design, include the following rotations: conventional Corn-Soybean (C-S), organic Corn-Soybean-Oats/Alfalfa (C-S-O/A), organic Corn-Soybean-Oats/Alfalfa-Alfalfa (C-S-O/A-A), and Soybean-Wheat with a frost-seeding of red clover (S-W/RC). For purposes of this paper, we will discuss the first three rotations. A 9.1–m buffer separates the certified organic and conventional plots within the forty-four plots, measuring 42 by 21 m each, that constitutes the experiment. Crop variety selections vary annually, according to recommendations from the farmer association affiliated with the LTAR site. Sowing dates and seeding rates follow local organic practices (Table 1). Following harvest of the organic corn plots in all years, winter rye is no-till drilled at a rate of 78 kg/ha into plots going to soybean to provide allelopathic control of future weed populations. Compost, made from a mixture of manure and corn stover that is removed from deep-bedded swine 'hoop-house' structures, is composted for one year and averages 7.8, 9.6, and 13.7 g/kg N, P, and K, respectively. The compost is applied to organic plots at rates intended to apply 134 kg N/ha during the corn phase of the rotation. Organic oat plots receive compost at a rate to apply 78 kg N/ha. Conventionally managed corn is fertilized at planting with 28% urea ammonium nitrate at a rate of 134 kg N/ha. Herbicides and insecticides are applied in conventional plots according to ISU recommended rates; no pesticides were applied in organic plots over the nine years of the experiment. Weed management in the organic plots included an average of four mechanical cultivations (two rotary-hoeings and two row cultivations) per season in the corn and soybean plots; no weed management was needed in the oat, wheat and alfalfa plots. Crops were mechanically harvested with combines and hay rakes/balers per local organic farm practices in the nine years of the experiment.

Tab. 1: Sowing and harvesting data for all crops in the rotations at the LTAR, 1998–2006.

Crop	Sowing Dates	Seeding Rate	Harvest Dates
Corn	17–27 May	79,040 seeds/ha	9 October–1 November
Soybean	15–28 May	407,550 seeds/ha	9–27 October
Oats	29 March–18 April	108 kg/ha	14 July–3 August
Alfalfa	29 March–18 April (seeded with oats)	18 kg/ha	26 May–25 August (green manure)
Wheat	15–24 October	101 kg/ha	8–25 July
Red Clover	1–9 March	28 kg/ha	Retained for green manure

Soils were sampled in the fall of each year from five randomly located 3.3-cm diameter soil cores collected to a depth of 15 cm from each plot, one from each of four quadrants and one core from the plot center. The five cores were combined into one composite sample, stored in plastic zip-lock bags, and kept cool during transport to the laboratory. A 10-g sub-sample of field moist 8-mm-sieved soil was extracted with 50-mL of 2M KCl, and inorganic N (NO_2 + NO_3) in the filtrate was quantified using flow injection technology (Lachat Instruments, Milwaukee, WI). Five grams of the sub-sample was ground pass a 250-μm diameter sieve and used to determine total organic C and total N (TN). Total organic C (after removal of carbonates with 1 M H_2SO_4) and TN were quantified by dry combustion using a Carlo-Erba NA 1500 NCS elemental analyzer (Haake Buchler Instruments, Paterson, NJ). Potentially mineralizable N was measured using an aerobic 28-day incubation method described by Drinkwater et al. (1996). All analyses were conducted at the USDA-ARS National Soil Tilth Laboratory, and the Iowa State University Agronomy Soil Analysis Laboratory, Ames, Iowa. Because farmers converting to organic production were particularly interested in the revenue generated from organic crops, we maintained records on all crops sold into commercial organic and conventional markets over the course of the experiment. Revenue was determined by multiplying the price received in the market by the yields from each crop in each rotation (Delate et al., 2006).

Results and Discussion

In each of the nine years of production (1998 to 2006), organic corn and soybean yields in the LTAR have equaled or exceeded conventional crop yields, with no statistical difference between conventional and organic crops over the combined 9-year period (Table 2).

Tab. 2: Average 9-yr yields in organic and conventional rotations at the LTAR, 1998–2006.

Rotation	9-Yr Corn Yield (kg/ha)	9-Yr Soybean Yield (kg/ha)	9-Yr Oat Yield (kg/ha)	9-Yr Alfalfa Yield (t/ha)
Conventional C-S[1]	10113a	2906a	N/A	N/A
Org. C-S-O/A-A	9914a	3043a	3260a	8.6
Organic C-S-O/A	8387a	2959a	3309a	N/A (green manure)
Significance (0.05 level)	NS[2]	NS	NS	—

[1] C = corn, S = soybean, O = oat, A = alfalfa, [2] not significant (LSD test $p \leq 0.05$)

Despite the lower external N input in the organic system, the organic crop rotations appeared to maintain adequate N levels throughout the season, as demonstrated by high organic corn yields, especially following two years of alfalfa. Soybean, not relying on external N, produced yields in both systems that were equivalent throughout the experiment. Organic corn yields in the longest rotation (C-S-O/A-A) over a 9–yr period were 9914 kg/ha compared to 10113 kg/ha in the conventional system; organic soybeans yielded 3043 kg/ha while conventional yielded 2906 kg/ha. Oat yields did not vary between the three- and four-year rotations. Soil data, when combined across all crops in each system, indicated that organic soils have the potential to cycle and store plant nutrients more efficiently and sequester more C than conventional soils (Table 3). After nine years of organic management, the organic soils had more total soil organic carbon and higher mineralizable N than the conventional soils. This result was particularly important in light of the four tillage operations in each of the corn and soybean years. The inclusion of the small grain crop and alfalfa in the rotation, in addition to the compost applications in the corn and oat years, led to significantly greater carbon and nitrogen pools in the organic system.

Tab. 3: Soil quality at the LTAR site after the first and ninth year of the experiment.

System	1998		2006	
	SOC[1] (Mg C/ha)	Mineralizable N (kg N/ha)	SOC (Mg C/ha)	Mineralizable N (kg N/ha)
Conventional	40.9a[2]	72a	44.4b[2]	95b
Organic	40.9a	65a	45.4a	114a
Signif. (0.05)	NS	NS	*	*

[1] Soil organic carbon, sampling depth 15 cm, [2] ,significant (LSD test $p \leq 0.05$).

Economic returns were a critical metric for farmers following the results of this experiment. The revenue received for the organic crops (during the two transition years and the seven certified years) was highest in the organic corn and soybean crops, followed by the alfalfa and oat crops (not shown). While income generated from the small grain crop produced the least revenue, the inclusion of the small grain/legume intercrop in the rotation is essential for soil building and pest management.

Conclusions

Over nine years of comparison, there was no significant difference in corn or soybean yields in the organic and conventional systems (Table 1). In a related study, costs of production were found to be lower in the organic system (Delate et al., 2006) while prices received for the organic crops increased significantly over conventional prices after certification in the third year. Organic corn increased average revenues by a factor of 1.67 over conventional corn, while organic soybean revenues were 2.32 times greater than conventional soybean revenues. Soil quality remained high in the organic system, with soil organic carbon and mineralizable nitrogen greater in the organic rotations. The critical issue of communicating results from this research is enabled through field days, workshops, internet broadcasts, and lectures in Iowa and across the U.S. (Delate et al., 2006).

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Experiences with intercropping design – a survey about pulse cereal-combinations in Europe

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Key words: Intercropping, cereal grain legume combinations, survey, European countries, EU project

Abstract

A survey was carried out within five European countries with regard to the practice of cereal grain legume intercropping. The mostly given combination was spring barley-spring pea beside 27 other combinations between pulses and cereals. 72 % of all examples consisted of spring varieties, the rest of winter varieties, mainly a special case of the French South West with mild winter climate. Intercrops were mainly used for feeding purposes. Best experiences were named as better yield stability, effective weed suppression, and good quality of feed. Of the negative experiences complicated mechanical weed regulation, unequal maturation and additional costs for separation were mostly named. The interviewed farmers showed predominantly positive prospects for the development of intercropping on their farms, problems with sowing techniques were only of minor importance.

Introduction

Intercropping per se corresponds to a very high extent to the concept of increased biodiversity within organic crop husbandry. It is mostly realised in multi-species mixtures of perennial pastures, partly in green manuring or undersowing approaches, much less in cultivation of main crops (Gliessman 2000). The latter aspects was focus of one workpackage of a European project <*Intercropping of cereals and grain legumes for increased production, weed control, improved product quality and prevention of N-losses in European organic farming systems (QLK5-CT-2002-02352)*> in order to record the daily practice, the experiences and the prospects of that cropping design within the farming community of organic farmers in Denmark, France, Italy, United Kingdom, and Germany.

Materials and methods

The survey was carried out in each country of the project partners by personal farm visits. A common questionnaire consisted mainly of questions concerning

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intercropping, farm structure and personal estimations, experiences and demands. All data of 65 interviews were collected through an online php-based input mask, stored in a mysql database and finally statistically evaluated by SPSS.

Results

The use of intercropping design in the organic farms was mainly initiated from 1981 on (table 1), approximately 90 % of all counts could be referred to that period. Between 1981 and 1990 it was mainly implemented on German farms, followed by French and Danish farms. Ten years later most of the Danish (and French) farmers integrated intercropping into crop husbandry. After 2000 another 11 % followed into the same direction (DK > FR > UK). That also reflects the different periods of conversion. Among the German group there was a longer experience of organic farming practice compared to the colleagues of the other countries.

Tab. 1: Since when intercropping was used? (*% of all counts*)

Year	(N)	(%)	DE	UK	FR	IT	DK
– 1970	2	3.1	*3.1*				
1971 – 1980	5	7.7	*3.1*		*3.1*		*1.5*
1981 – 1990	19	29.2	*15.4*		*9.2*		*4.6*
1991 – 2000	32	49.2	*7.7*	*1.5*	*13.8*	*7.7*	*18.5*
> 2000	7	10.8		*1.5*	*3.1*		*6.2*
Counts [N]	65		19	2	19	5	20

As reasons for intercropping six criteriae were named out of which intercrops for the production of feed was most prominent, especially in DE, DK and FR (table 2). Production for the market was the second criterium although the marketing due to necessary separation can only be realized with additional efforts and costs (table 5). Soil conservation was specified as third reason for working with intercropping, but on a distinctly lower level. The other criteria can be assessed as negligible with regard to number and relevance for the daily practice.

Tab. 2: Reasons for the use of intercrops (*% of all counts*)

Year	(N)	(%)	DE	UK	FR	IT	DK
Feed	39	60.0	*23.1*	*1.5*	*16.9*		*18.5*
Market	18	27.7			*12.3*	*4.6*	*10.8*
Soil conservation	5	7.7	*4.6*			*3.1*	
Demonstration	1	1.5					*1.5*
Research	1	1.5		*1.5*			
Seed production	1	1.5	*1.5*				
Counts [N]	65		19	2	19	5	20

Although intercropping in most cases and countries relied on 2 component mixtures (table 3), 3- and more component mixtures were also appointed, mainly in DE, DK and FR. Most of the specified examples for intercrops were build up with spring pea (22 %), spring barley (22 %), oats (13 %), winter pea (9 %) and winter triticale (9 %).

Tab. 3: Number of components per mixture (% per country)

No components	DE	UK	FR	IT	DK
2	52	100	72	100	80
3	39		10		15
4	6		14		5
5	3		3		
Counts [N]	31	1	29	5	41

Tab. 4: Frequency of spring and winter types (% per country)

Variety	DE	UK	FR	IT	DK
Spring	96	100	24	60	95
Winter	4		76	40	5
Counts [N]	27	1	29	5	40

Of 28 different combinations for used intercrops three examples covered >50 % of all combinations: (A) spring barley-spring pea (24 %), (B) spring barley-spring oats-spring pea (15 %) and (C) winter pea-winter triticale (15 %). The latter example is a special situation of the mild winter climate in the South West of France. Example (A) was grown on 513 ha, example (C) on 200 ha. (table 4). There was a clear distinction between the mixtures of Danish farmers on the one hand (prevalence of pulses), and French and German farmers on the other hand (prevalence of cereals). Farmers were asked about positve and negative experiences and estimations of intercrops (table 5). Of the 13 arguments emphasizing the benefit of mixed cropping systems yield stability, effective weed suppression, good quality of feed, easier harvest, good precrop effect, and less pests and diseases covered > 60 % of all answers. The opposite perspective was seen with regard to more complicated mechanical weed control (15 %), unequal maturation (11 %), problems due to lodging and additional costs for separation (7 %).

Tab. 5: Advantages and disadvantages of intercropping?

Positive	(%)	Negative	(%)
Yield stability	15	Mechanical weeding more complicated	15
Effective weed suppression	12	Unequal maturation	11
Good feed	11	Problems due to lodging	7
Easier harvest	9	Additional costs for separation	7
Good precrop effect	9	IC mixture at harvest unpredictable	6
Less pests & diseases	7	Marketing of mixed seeds	4
Less lodging risk for peas	4	Problems to preserve	4
Less labour	2	Grain losses at harvest	4
Better use of resources	2	Undersowing difficult in IC	2
More flexibility in rotational management	2		
Higher yield	2		
Higher diversity	2		
Compensation	2		

Among the group of interviewed farmers at least 40 % of the answers indicated maintenance and expansion of the area of intercropping in the next future of crop husbandry (not shown). Changes of the composition of mixtures were named as other aspects of wanted improvements of the intercrops. Aspects i.e. change of sowing technique or reduction of growing area were appointed less common.

Discussion

The results of the survey reflect the findings of Rauber & Hof (2003) to a high extent. The positive experiences about better weed suppression are in accordance with findings of Hauggard et al. (2006), Jensen (2006) and Trenbath (1993). Technical problems such as adequate mechanical tools for sowing and weeding were not so much emphasized by the farmers as done by interviewed advisors within the study of Rauber & Hof (2003), but belonged to the mentioned obstacles towards the use of intercropping. There is a distinct tendency for simple combinations, most of the appointed examples consisted of 2 or 3 components. Thus the claim for increased biodiversity by cultivation of intercropped pulses and cereals is of limited value and should be supported by further genom intercrops i.e. mixtures of cultivars within the species (Finckh 2001). The longest experiences were found on organic farms in Denmark, France and Germany, whereas very limited numbers of farmers with intercrop experiences could be found in United Kingdom and Italy. Therefore most of the conclusions are related to the Danish, French and German data.

Conclusions

Intercropping provides distinct benefits for organic farming systems. That is also true for the combination of pulses and cereals. It is desirable that scientific work is more concerned with related questions in order to convince advisors of these systems and to encourage practitioners to implement more of such cropping designs into their cultivation plans.

Acknowledgments

This work was financed out of funds of the EU 5th framework.

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Growing rapeseed in mixed cropping with cereals

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Key words: seed density, rapeseed, barley, rye wheat, LER

Abstract

Yields of mixed cropping systems of winter rapeseed (Brassica napus) with winter rye, winter wheat and winter barley in organic farming are reported by the example of a one year field trial in Trenthorst, North Germany. The trial was established as perpetuation of trials in the years before with different seed densities and row distances due to very low yields of both components to increase the overall yield of the mixtures. Winter rapeseed was heavily suppressed by the cereals when grown in mixture with rye. The winter rapeseed yields were more adequate in relation to the chosen seed reduction in combination with wheat. In systems with delayed drilling of the cereals between rows of rapeseed, wheat and barley had problems in field establishment and rapeseed yields were over-proportional in relation to the chosen seed reduction. Land equivalent ratios (LER) were around 1 in all systems. The use of those mixtures as practicable yield buffer in organic farms needs further evaluation.

Introduction

Rapeseed in organic farms is prone to pest and insect infestations. Additionally it has a high nitrogen demand. Its use as component of organic crop rotations therefore is very risky. Mixed cropping systems of rapeseed with cereals could be a possible tool to compensate for unstable rapeseed yields in organic farming and to keep a small scale rapeseed production upright. Effects on weed suppression and yields of those systems in Canada have been reported by Szumigalski and van Acker 2005 and 2006. The first experiences with rapeseed-cereal mixtures in organic farming are reported by Paulsen and Schochow (2007). These trials showed a very high variability in rapeseed yields due to difficult post winter establishment of the rapeseed and to heavy yield losses by *melingethes aeneus.* When cereals established well rapeseed biomass and seed yield at harvest were strictly reduced by the cereal partners and cereal yields were small. To increase overall yields of the mixtures row distances, row distribution and seeding dates were varied. The results of this trial are reported below.

Materials and methods

The actual field results given here are from field trials in 2005/2006 in Trenthorst in the South-East of Schleswig-Holstein in Germany at a loamy site with good water conditions and sufficient soil nutrient supply (available nutrient contents in spring [mg 100 g^{1}]: P_{CAL} 7.7, K_{CAL} 14.3, Mg_{CaCl2} 12.5, pH 6.4, C_{org} 1.1%, N_{min} 60 kg ha^{-1}). Preceding crop in the crop rotation was clover grass. The rapeseed cereal mixtures were established with different seeding times (table 1) and row densities. The following varieties were used: Rapeseed: Express, Barley: Lomerit, Wheat: Capo, Rye: Boresto. Sole cropped rapeseed and cereals were grown with 25 cm and 12.5 cm row distance, respectively. At end of August in mixtures alternating rows with 12.5

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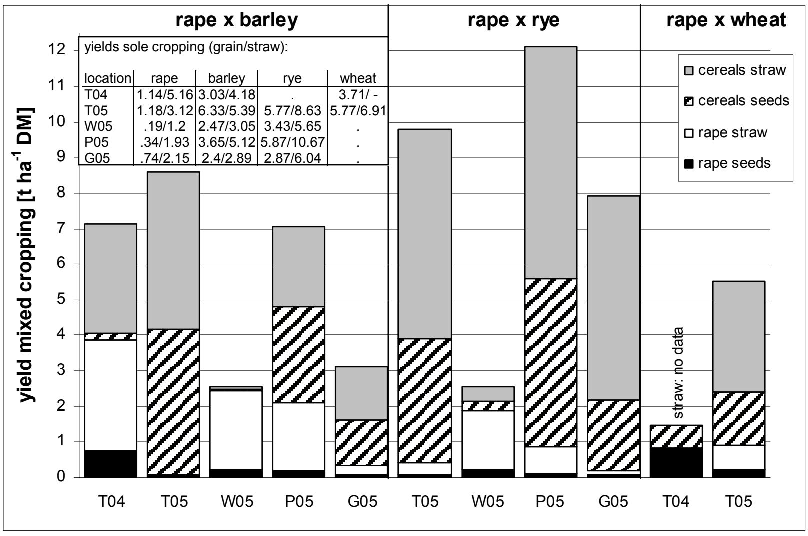
cm row distance were drilled simultaneously. Wheat and rye between the rapeseed rows were drilled in September in the rough soil after hoeing. For these treatments cereals were sown in double rows, 12.5 cm spaced, between two rapeseed rows with 37.5 cm row distance. Seed densities for the reduced row number, comparable to the seed densities in the rows of the sole cropped cereals were chosen. In the treatments with simultaneous drilling of the components in August the seed densities in the rows were kept constant or reduced to 50 % due to the untimely seeding date (table 1). Rapeseed densities were reduced so far that an overall seed density of 100 % compared to the sole cropped cultures was reached. Plot size at harvest was 27.5 m^{-2}. Four repetitions were used. Only the sole cropped plots were mechanically weeded with hoe or harrow. In the preceding trials in the years 2004 and 2005 in Trenthorst and additionally at tree other sites in 2005 single alternating rows of the crop components with 12.5-14 cm row distance, same plant varieties and clover grass as pre-crop were chosen.

Results

Seed and straw yields of mixtures of rapeseed with barley, rye (Paulsen and Schochow 2007) or wheat from the years 2004 and 2005 are shown in Figure 1.



T=Trenthorst, W=Wilmersdorf, P=Pfaffenhofen, G=Guelzow , shifted seeding only in T04

Figure 1: Seed and straw yields of mixed cropping of winter rapeseed with winter cereals (bars) and their components in sole cropping (table) (2004, 2005)

In 2005 barley was dominated by rapeseed in Wilmersdorf, whereas in Trenthorst, Pfaffenhofen and Guelzow grain and straw yields of barley reached more than 50 % in the mixtures compared to the sole cropping. Shifted seeding led to heavily decreased grain yield of barley in Trenthorst 2004. Except for Wilmersdorf the rye in mixture with rapeseed established very well and reached more than 50 % of straw and grain yield compared to the sole cropping variants. Wheat reached seed yield values between 17 and 25 % in mixture with rapeseed compared to its sole cropping. LER values higher than 1 where only reached in rape x barley in Wilmersdorf where the rapeseed yield in the mixtures were higher than sole cropped rape and in Pfaffenhofen at a low yield level of both components in sole and mixed cropping. In the trial of 2006 in Trenthorst reported in the following, insect pressure was moderate and rapeseed yields of 1.4 t ha-1 were possible. High barley yields (6.2 t ha-1) and medium rye (4.9 t ha-1) and wheat yields (4.4 t ha) were gained in sole cropping (table 1). The early drilling of wheat at end of August with halved seed density led to yield losses in seeds of 22 % compared to the normal seeding time.

Tab. 1: Seed and straw yields of mixed cropping of winter rapeseed with different winter cereals [t ha-1 dry matter], Trenthorst 2006

Variants	Seed density	Seeding date	Seeds Rape	Seeds Cereals	Straw total	Seeds total	Seeds + straw total
Barley 1/1	300	27 Sept		6.14	5.4	6.14	11.5
Wheat 1/1	350	27 Sept		4.46	7.6	4.46	12.1
Wheat 1/2	175	23 Aug		3.49	6.8	3.49	10.3
Rye 1/2	110	23 Aug		4.90	6.5	4.90	11.4
Rape 1/1	100	23 Aug	1.39a		4.7bc	1.39e	6.1d
Rape 2/3 Barley 2/3	65/225	23 Aug 27 Sep	1.20ab	0.73c	3.9d	1.93d	5.9d
Rape 2/3 Wheat 2/3	65/260	23 Aug 27 Sep	1.28a	0.69c	4.1d	1.96d	6.1d
Rape 1/2 Rye 1/2	50/110	23 Aug 23 Aug	0.31d	4.05a	5.6a	4.36a	9.9a
Rape 3/4 Rye 1/4	75/55	23 Aug 23 Aug	0.44d	3.23b	5.2ab	3.66b	8.8b
Rape 1/2 Wheat1/2	50/175	23 Aug 23 Aug	0.65cd	2.47b	4.7bc	3.11c	7.8c
Rape 3/4 Wheat 1/4	75/88	23 Aug 23 Aug	0.94bc	1.35c	4.6bc	2.28d	6.8cd

Comparison of rape and rape-cereal mixtures: Tukey-HSD, p=5%, after significant ANOVA

Later drilling of cereals between rapeseed rows led to high yield decreases for barley (-90 %) and wheat (-85 %) compared to their sole cropped treatments. Simultaneous drilling of rapeseed and cereals together showed a more proportional yield development. When seed numbers in the rows of rye or wheat were reduced to 50 % compared to the treatments with sole cropping (indicated in the table by 1/4), -34 % and -62 % lower cereal seed yields were found respectively. In the mixed variants 50 % of the seed rows of the sole cropped cereals were replaced by rapeseed. So for rye the yield loss was lower than anticipated by the row replacement. Compared to the early sown cereals in sole cropping non reduced seed numbers (indicated in the table by 1/2) led to over-proportional yield reduction of wheat (-61 %), even when rape density was also reduced. Rapeseed yields were reduced significantly when sown together with cereals in August due to the lush pre winter development of the cereals. The bad cereal establishment in the cereals with delayed seeding led only to small but insignificant yield decreases in rape. Looking for the total seed yield of the systems rapeseed in combination with rye had the highest yield but with lower rapeseed production than in combination with wheat.

Discussion

Obviously rapeseed and cereal yields in mixed cropping systems can be influenced by seed density management. But establishment problems of both cultures and their inhomogeneous year and site specific development are making reliable conclusions and even a suitable pooled statistical interpretation of all data dissatisfying. The LER (land equivalent ratio) values (Mead and Willey 1980) of the seed yields in the examined mixed cropping systems of 2006 are close to one and show no real yield advantages (table 2). That is congruent to the findings of the years before where other seed densities and row distances were chosen. Another open point of the cropping system is the probable risk of fungal pre-winter infections in the early sown cereals.

Tab. 2: Relative yields and LER values of different mixed cropping systems with rapeseed an winter cereals

	Relative yield compared to sole cropping		LER
	Rapeseed	Cereals	
Rape 2/3 Barley 2/3	0.86	0.12	0.98
Rape 2/3 Wheat 2/3	0.92	0.15	1.07
Rape 1/2 Rye 1/2	0.22	0.83*	1.05*
Rape 3/4 Rye 1/4	0.31	0.66*	0.97*
Rape 1/2 Wheat1/2	0.46	0.71/0.55**	1.17/1.01**
Rape 3/4 Wheat 1/4	0.67	0.39/0.30**	1.06/0.97**

*relative to rye 1/2, **first value is relative to wheat 1/2 Aug, second to wheat 1/1 Sept

Conclusions

With different seeding times cereals in rapeseed-cereal mixtures were difficult to establish due to inadequate possibilities for seed bed preparation between the rapeseed rows. Simultaneous drilling at end of August with non reduced seed distances led to luxurious growth of the cereals and suppression of the rapeseed. Rye showed the highest yield potential in the mixtures, independent of row distances and seed densities. Ongoing trials will give more experiences on yields and practicability of the systems.

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Evaluation of Crop Rotation on Organic Farms in Northern Serbia

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Key words: crop rotation, organic agriculture, crop management

Abstract

The objective of this paper was to analyze six organic farms in northern Serbia in order to evaluate crop rotation composition and identify its role in cropping technology of the organic production. The major agronomic indicators of organic crop rotation were analyzed: number of crops and their ratio, number of different crop schemes and fields in rotation, land coverage with crops, crops structure, etc. Information was acquired by visiting and surveying farmers during the 2005/06 as well as reading their documentation required for certification. The obtained results showed that the farmers carried out production on a 3-4-year rotation basis. The cropping plan was strongly driven by market demands. Deficiencies in structure of the rotation were compensated with crop management or organic fertilizers. The potential for the development of good farming management based on efficient crop rotation has not been fully achieved.

Introduction

Increasing demands for safe food in Serbia had resulted in conversion from conventional to organic farming which contributes significantly to the sustainability of the agricultural production. The fully converted organic area in Serbia now covers 591 ha of the total agricultural area (Willer and Yussefi, 2007), with potential for permanent growth. Crop rotation plays a central role in the basic design of an organic farm (Wijnands, 1999), maintenance and improvement of soil quality (Lampkin, 1994). In the organic production systems designing and planning of crop sequence is necessary for establishing the appropriate ratio between crop groups (i.e. legumes, cereals or row crops). In addition to that, the preferred order of crops and arrangement of plots can develop the desired agro-ecological layout of the farm and strongly contribute to the sustainability of the agro-ecosystem. For designing and evaluating multifunctional crop rotations there are several methods and approaches (Vereijken, 1997; Dogliotti *et al.,* 2003). The inappropriate selection of crops and design of rotation can create many problems with weeds (Barbieri, 2002), pests and diseases, which may lead to lower yields (Porter *et al.,* 2003). Possible weaknesses of designed crop rotation, especially at the beginning of the organic farming, could be the number of plots and their area, the number of species grown, and decrease of soil fertility (Seremesic and Milosev, 2006; Cuvardic *et al.,* 2006). In addition to that there is a relatively long period before rotations can be assessed in terms of their true effects on crop production and nutrient cycling on farm (Watson *et al.,* 1996).The aim of this study was to evaluate crop rotation composition at six organic farms in order to improve utilization of farm resources and management practice.

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Materials and methods

The following farms were analyzed: Kelebija, Tavankut, Ljutovo, Bajmok, Kisac and Orom. Selected farms were recommended for study after discussion with certification organisation in Serbia and therefore we consider them eligible according to national organic standard. Among them there were no common treatments. The information about cropping practice was obtained from questionnaires, farm documents (prepared for the certification), and by interviewing the farmers in investigation conducted 2005/06. Numerical data were presented as average values for two production year after statistical analyses, whereas indicators of crop rotation were expressed by proper mark. Soil chemical analyses indicated that the certified organic sites were either as fertile as the adjacent conventional fields or marginally less fertile but not significantly so (Cuvardic et al., 2006). Soil fertility was maintained, primarily, with different amounts of an organic fertilizer (i.e. manure, compost) applied at four-year intervals on each field and microbiological fertilizers (i.e. Bactofil A and B, Humisin, Bioactive etc.). Selected farmers utilized on-farms resources for additional nutrient input such as N-fixing crops (i.e. soybean, pea) and green manures (*Trifolium* sp., *Medicago sativa*, *Phacelia tanacetifolia* etc.). Primary tillage was conducted with shallow mouldboard ploughing or disc harrowing in autumn, and seedbed preparation was carried out with harrow, disk harrow and field cultivators.

Results

Organic farming at the observed sites was combined crop-livestock production fitted to specific agro-ecological condition. However, animal husbandry is not as important as arable production. We found that each farm is an independent production unit, strongly subjected to the dominant constraint of the production area. The number of the species grown at the organic farms was significantly different (Tab. 1, Tab. 2). As good preceding crops, cereals shared 21.4-25.8% of the total arable area of examined farms (except for Tavankut). The high proportion of cereals and legumes, necessary for the composition of a balanced crop rotation, was found on Ljutovo and Orom. Different from this, organic producers at Kelebija and Bajmok grew > 50% row crops and may have difficulties in achieving optimal rotation design. The Kisac farm was vegetable-oriented with more than 30 different varieties of vegetables and >60% of arable land covered with vegetables indicating that this production is orientated to fresh markets with labour intensive management and high production costs.

Tab. 1: Crop structure on the examined organic farms

	ORGANIC FARMS											
	Kelebija		Tavankut		Ljutovo		Bajmok		Kisac		Orom	
Total Arable area (ha)	**11.7**		**5**		**15,5**		**11.9**		**14**		**6.5**	
CROP STRUCTURE	*Crops (%)*	*Area (ha)*	*Crops (%)*	*Area (ha)*	*Crops (%)*	*Area (ha)*	*Crops (%)*	*Area (ha)*	*Crops (%)*	*Area (ha)*	*Crops (%)*	*Area (ha)*
Legumes (annual/perennial)	11.1	1.3	40	2	37.4	5.8	13.4	1.6	7.1	1	53.8	3.5
Cereals (winter/spring)	24.8	2.9	-	-	25.8	4	25.2	3	21.4	3	23.1	1.5
Roots and tuber plant	1.7	0.2	-	-	1.9	0.3	-	-	14.2	2	-	-
Vegetable	11.1	1.3	-	-	15.5	2,4	-	-	64.3	9	-	-
Row crops	51.3	6.0	60	3	19.4	3	61.4	7.3	-	-	23.1	1.5

On the Tavankut farm, there were only two fields in the certified production (alfalfa (third year) and oil pumpkin), established at the beginning of the certified production after soybean and wheat as preceding crops.

Tab. 2: Crop structure on the examined organic farms

CROP GROUPS	ORGANIC FARMS					
	Kelebija	Tavankut	Ljutovo	Bajmok	Kisac	Orom
Legumes	2	1	3	2	1	1
Cereals (winter/spring)	2	-	4	2	1	1
Roots and tuber plant	1	-	2	-	1	-
Vegetable	5	-	1	-	11	-
Row crops	3	1	3	2	-	1
Total number of crops	13	2	13	6	14	3

Discussion

After conversion from conventional agriculture organic producers continue growing same crops. Arable organic systems at the organic farms showed a tendency toward development in two directions, one being the improvement of soil quality with more N_2-fixing crops and lower economic value and the other more N demanding cash crops. As for the number of grown crops (except for Tavankut) and field allocation (Tab. 1) there were many possibilities for different rotations, especially mixed ones with row crops, cereals, vegetables and forage crops. Organic production on the examined farms was based generally on a 3-4 crops in rotation with a tendency for proper alternation of different crop groups (legumes/cereals/row crops/vegetables). However selection of appropriate crop (among desired crop group) was limited only to one year ahead, compatible with rotation design, proportion of crop groups, and agro-ecosystem resources (Tab. 2). Consequently, this approach generally resulted in "loose" rotation, where specific, apparently important crops for farmers can be overrepresented in the rotation and grown too intensively (Wijnands, 1999). The desired level for soil cover index (SCI) is to have crops covering the soil for more than 80% of the year (Helander and Delin, 2004). In our study soil cover index varies (55-90%). We found that SCI for the observed period averages at 70% (8 ½ months), which should be improved. Only two out of six farmers regularly included winter cover crops and planted second crop into a main crop to improve efficiency of the system.

Tab. 3: Agronomic evaluation of crop rotations

INDICATORS	ORGANIC FARMS					
	Kelebija	Tavankut	Ljutovo	Bajmok	Kisac	Orom
Type of rotation[1]	V/FCV	L	FCV	FCV	V	FCV
Intercropping	Yes	No	Yes	No	No	No
Winter cover crops	No	No	Yes	No	Yes	No
Number of crops in	4-5	3	3-4	4	4	3-4
SCI[2](%)	70%	75%	65%	65%	90%	55%
Rotation planning[3]	1	1	2	1	1	1

[1]Types of crops that were the subject of planned rotation (other crops were grown in other fields on the farm); **V**- vegetable crops, **FC**- field crops, **L**-legumes; [2]**S**oil **C**over **I**ndex-period of year during which the soil is covered with plants (% of 12 month) - estimated by farmers; [3]Number of years of planned crop rotation in the future.

Based on the observed crop rotation indicators and farm resources crop rotations should be more efficient in resources utilization and less dependant on market conditions. With clear goals of the organic production farmer will consider diversification of crop rotation which will provide an economical buffer against price fluctuations for crops and production inputs as well as unpredictable changes of pest infection and weather conditions.

Conclusions

The investigated farms in Northern Serbia were different in organic management and cropping technology. At the observed farms crop rotation was strongly driven by market demand. The obtained results show that the cropping strategy was based on a 3-4 year rotation, with the potential for the proper alternation of different crops. Design of the rotations can be improved with: introduction of winter cover crops; inclusion of N_2 fixing legumes; stubble crops and application of higher doses of organic fertilizers.

Acknowledgments

We would like to thank the farmers who helped us in our research. This work was funded by the Ministry of Science of the Republic of Serbia, Project number TR 6906.

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Effect of two Oat–legumes intercrop systems on weed flora under Mediterranean conditions

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Key words: intercropping, maize- legumes, LAI, weeds, PAR

Abstract

The experiments were conducted in Greece in 2002 and 2003. The objective of this research was to investigate i) the effect of intercrop system on weeds and ii) if each intercrop system (oat-pea or cereal legume) is going to affect the weed control differently. The light penetration within the canopy measured during the first experiment (2002), was decreased up to 90%, due to the increase of the companion crops' leaf area. In both years the decrease of the available light to the weeds, has led to the reduction of the weed dry matter, in comparison to the pure stands. Finally the oat-bean intercrop system gave better results than oat-peas system. As a result we can say that the intercrop system constitutes a new approach to weed control for low input agriculture under Mediterranean conditions.

Introduction

Intercropping, through more effective use of water, nutrients and solar energy, can significantly enhance crop productivity compared to the growth of pure stands (Bilalis 2005). The light plays a critical role in weed-plant growth and development; quantity and quality, as well as direction of the light, are perceived by photosensory systems which collectively regulate plant development, presumably to maintain photosynthetic efficiency (Hangarter, 1997). The amount of light intercepted by the component crops in an intercrop system depends on the crops geometry and foliage architecture. Intercrop systems are reported to use resources more efficiently and be able to remove more resources than monocrop systems, thus decreasing the amount available for weed production. Liebman and Dyck (1993) noted a decrease in weed biomass in intercrop as compared with monocrop systems in 47 studies, a higher level of weed biomass in four studies and variable results in three other cases. Our two year experiment was designed to investigate the effects of intercropping winter oat *(Aneva sativa)* with pea (*Pisum sativum*) and broad beans (*Vicia faba*) on the weed control. The question of this research is "what are the effects of different intercrop systems on weed growth?"

Materials and methods

This two years experiment was conducted at the organic field at Mavrica area (Lat: 38°36´, Long: 21°21´, alt: 24m) located at West Greece (2003). The soil type was Clay Loam (24.9% clay, 61.2% silt and 13.9% sand) with pH (1:1 H_20) 7.56, 3.21% organic matter, 13% $CaCO_3$, 0.152% total nitrogen and a sufficient supply of both phosphorus

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(P-Olsen 92ppm) and potassium (632ppm). Annual temperature and precipitation were 17.2°C and 955mm. The site was managed according to the Organic Agriculture (OA) guidelines (EN 2092/91) and no fertilization was applied. The experiment had a randomized plot design with eight replications. The main-plot treatments were solo cropped and intercropped spring crops (oat, broad bean and pea). The crops were seeded in rows with a distance of 30cm between the rows. Each plot was $50m^2$ and each replication $250m^2$ with a total coverage area of $2000m^2$. Intercrops seeding were 1:1 ratio oat/bean and 1:1 oat/pea. Legumes and cereal seeds were sown manually on 1 and 3 December of 2002 and 2003 respectively. Furthermore the components of mixtures were mixed within each row.

Plants were destructively sampled and the leaf area was measured using an automatic leaf area meter (Delta–T Devices Ltd, Burwell, Cambridge, UK). The sampling dates, for all parameters in the first year, were 40, 80 and 140 days after sowing (d.a.s.) and in the second were 40, 80 and 120 d.a.s. respectively. The difference of the third sampling day, between the two years (140 d.a.s. for the first and 120 d.a.s. for the second), was due to the climate conditions, which slowed down the Relative Grow Rate (RGR) of the plants. The results, on a plant basis, were converted into Leaf Area Index (LAI) by multiplying the average crop density of each plot. At each sampling date, weeds were sampled from five $0.25m^2$ quadrates per plot, dried at 70°C during 72 hours and dry matter (WDM) was weighted. All weeds were collected from the measured area then dried at 70°C during 72h and finally weighted, measuring their dry matter (WDM). The fraction of Photosynthetic Activate Radiation (PAR) intercepted was calculated by taking ten readings in rapid succession above the canopy and ten readings below the canopy at the soil surface using a 60cm light sensor (Sunfleck Ceptometer by Decagon devices, Pullman, Washington State, USA). The fraction of the incident PAR intercepted by the canopy (F_{int} PAR) was calculated with the following equation:

$$\%\ F_{int}\ PAR = \left(1 - \frac{PAR\_belowcanopy}{PAR\_abovecanopy}\right) \times 100$$

Results

The values of the LAI are presented in Table 1. At 40 days after soil (d.a.s.) in both years, the two systems (inter and solo crop) did not appear to have any statistically significant differentiation. At intercrop system plots the LAI was significant lower than the correlative solo crop plots at 120d.a.s. The highest values were observed at 140d.a.s. at the oat- broad beans intercropping plots.

The fraction of the incident PAR intercepted by the canopy (Fint PAR) is presented in Table 2. These results were similar to the aforementioned LAI results. The highest values were observed for the oat-broad beans (90% for both years at 140d.a.s.) and then at the oat-pea system. The observed differences between the two treatments of the intercrop were not statistically significant. The highest fraction of PAR intercepted for pure stands were observed at broad beans (78% in 2002 and 67% in 2003 at 140d.a.s.) and the lowest values at the solo oat crop (52% and 48% respectively).

The dry matter of weeds is presented in Table 3. From, 80d.a.s. up to 140d.a.s. in both years the least weed dry matter was observed at the intercropping systems, while the most weed dry matter observed at the pure stands. In all cases, between the crop systems (inter and solo) there were statistically essential differences observed.

Furthermore, between the two intercrop types, for the significance level of 5%, there were no statistically important differences observed.

Tab. 6: Leaf area index for solo and inter-crops

	cultivation period 2002			cultivation period 2003		
	40 d.a.s.	80 d.a.s.	140 d.a.s.	40 d.a.s.	80 d.a.s.	120 d.a.s.
Oat+pea*	0.22	1.89	3.22	0.30	3.98	5.05
Oat+broad bean*	0.24	2.24	3.78	0.39	3.21	4.66
Oat	0.21	1.22	2.11	0.21	1.52	2.71
Pea	0.19	1.41	2.42	0.29	1.93	3.45
Broad bean	0.22	1.67	2.66	0.25	1.77	3.32
$LSD_{5\%}$	0.07	0.14	0.25	0.08	0.16	0.29

*Summary of LAI_{cerial} and LAI_{legume}

As presented in Table 3 a 140 d.a.s. the weed dry matter at intercrop was less than the half in relation to that of the solo. Comparing the two intercrops types with pure stands, we come to the conclusion that there was less weed dry matter observed at oats-broad beans type, but the differences, between them, were not regarded as statistically essential for the level of 5%. Similar results have been also mentioned by Baumann et al. (2001).

Tab. 7: The percentage fraction of PAR intercept (Fint %) as affected by solo and inter-crops

	cultivation period 2002			cultivation period 2003		
	40 d.a.s.	80 d.a.s.	140 d.a.s.	40 d.a.s.	80 d.a.s.	120 d.a.s.
Oat+pea*	10	40	82	14	55	76
Oat+broad bean*	12	55	91	19	65	89
Oat	8	29	52	11	34	48
Pea	9	32	66	12	39	61
Broad bean	10	37	78	13	48	67
$LSD_{5\%}$	3	17	19	4	13	16

*Summary of LAI_{cerial} and LAI_{legume}

Tab. 8: Weed dry matter ($g.m^{-2}$) by solo and inter-crops

	cultivation period 2002			cultivation period 2003		
	40 d.a.s.	80 d.a.s.	140 d.a.s.	40 d.a.s.	80 d.a.s.	120 d.a.s.
Oat+pea*	1.32	6.31	16.71	3.24	7.12	14.56
Oat+broad bean*	1.23	4.78	12.32	2.11	4.32	12.21
Oat	4.42	15.11	28.45	8.12	16.76	27.45
Pea	3.20	12.22	24.17	6.21	13.42	22.32
Broad bean	2.79	9.37	22.11	5.31	10.07	18.94
$LSD_{5\%}$	1.39	3.12	4.92	5.98	3.22	9.99

*Summary of LAI_{cerial} and LAI_{legume}

Conclusions

The intercrops indicated higher soil canopy cover in comparison with the pure stands. This resulted in the increase of light interception by canopy. This fact is proved by the factor of cross-correlation between LAI and %F (light fraction) during both periods (r=0.935, p<0.001, Table 4). Shade was clearly a key factor in weed suppression for weed dry matter and weed density. The correlations coefficient between, %F (light fraction), and WDM were higher than -0.587 (p<0.001, Table 4). Concluding, the intercrop system can reduce the weed density and weed biomass, in OA, under Mediterranean condition.

Tab. 9: Correlation matrix between L.A.I., light interception (%F) and Weed dry Matter (WDM)-(r and p level)

	LAI	%F (light fraction)
WDM	-0.527(p=0.003)	-0.587(p=0.001)
LAI	--	0.935 (p=0.001)

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Intercropping of oilseeds and faba beans

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Key words: row distance, plant available nitrogen (PAN), resource use efficiency, land equivalent ratio (LER)

Abstract

Intercrops are considered as less susceptible to pests and diseases and may inhibit weeds more efficiently resulting in enhanced yields and profitability. N_2 fixation of legumes is an important nitrogen (N) input factor of Organic Farming systems and results in partly unused plant available soil N (PAN) in sole cropped faba beans. Simultaneously cultivated oilseeds may function as sinks for PAN and enhance biodiversity with all positive aspects. In this respect we investigated several oilseeds intercropped with faba beans at different row distances. Depending on row distance we analysed e.g. the use of soil nutrients and land equivalent ratio (LER). Intercropped oilseeds depleted PAN between FB rows significantly in early development. In 2007 yield performance was impaired by the extreme weather conditions. Under these circumstances LER > 1 in intercrops at wider row distance suggests facilitative interactions and some kind of compensation.

Introduction

In earlier studies accumulation of soil nitrate under faba beans (FB) (*Vicia faba* L.) was observed even during growth – especially between rows and in deeper soil layers (Justus 1996, Justus and Köpke 1995). This nutrient source is unused by FB and vulnerable to leaching but may be used by an intercropped oilseed (OS) which explores soil more efficiently. Hauggaard-Nielsen et al. (2008) found that the proportion of plant N derived from N_2 fixation by grain legumes was higher when intercropped with barley compared with grain legume sole crop (SC). Thus, a non-legume intercrop (IC) component competes for soil nitrate and may enhance N_2 fixation by legume. Besides more efficient use of nutrients, e.g. N, less susceptibility to pests and diseases as well as less weed infestation were reported for intercrops (Hauggaard-Nielsen et al. 2008, Paulsen et al. 2007). We cultivated safflower (*Carthamus tinctorius* L.), mustard (*Sinapis alba* L.) and linseed (*Linum usitatissimum* L.) as SC as well as IC with FB. Depending on row distance, we analysed the use of plant available nitrogen (PAN), yield performance and grain quality. The aim of the study was to determine the most suitable OS for intercropping with FB at optimized row distance, for optimized use of growth factors resulting in a land equivalent ratio (LER) > 1.

Materials and methods

The field experiments were carried out at Wiesengut experimental farm for Organic Agriculture in Hennef (Germany) on a clayey-silty to sandy-silty floodplain sediment. A preliminary field trial was performed in 2006; the first main experiment followed in 2007. Weather conditions were very different in the two years during growing season

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June to harvest in August: very hot and dry in 2006 (20.3°C, 135 mm $pcpn_{total}$, 695 sun $hours_{total}$) compared to high amounts of rainfall and relatively low temperatures in 2007 (18,4°C, 339 mm $pcpn_{total}$, 566 sun $hours_{total}$). FB cv. Limbo was grown in a two-species intercropping with safflower (cv. Sabina), mustard (cv. Martigena) or linseed (cv. Juliet), resp. (as well as false flax - *Camelina sativa* L. cv. Ligena in 2006, resp.) and as control without OS but with the same sowing density. In all intercropping treatments FB rows were 56.5 cm apart with two OS rows in between. Row distances between OS and FB rows were 5 cm and 18.5 cm resp. In 2007 all oilseeds (row distance: 17.0 cm) and FB (row distance: 28.0 cm) were also grown as SC. A completely randomized block design with four repetitions was used. Results of preliminary investigations in 2006 lead to an optimized sowing density and exclusion of false flax in the main experiment in 2007. Intercrops were drilled with the half sowing density of the corresponding SC, except for intercropped linseed which was drilled with 67% of linseed SC. Crops were cultivated according to organic management practice and hand harvested at flowering stage (2 x 0.5 m^2 /plot in 2006 and 2007) and at maturity (3 x 0.5 m^2 /plot in 2006 and 3 m^2 /plot in 2007 resp.). Harvested plant material was separated into fractions: shoots of FB and OS as well as weeds, grain and straw. 105°C dried and milled plant material was analysed for total N (elemental analyzer). LER_{Grain} was calculated by the sum of relative grain yields in IC referring to the corresponding SC: LER_{Grain}= [IC grain yield FB * (SC grain yield FB)$^{-1}$] + [IC grain yield OS * (SC grain yield OS)$^{-1}$]. Soil samples (0-90 cm) were taken in and between FB rows at FB´s juvenile and flowering stage as well as after harvest and analysed for PAN. Data analysis was conducted by ANOVA and post hoc test (Scheffé's test). Normal distribution and homogeneity of variance were assumed. In 2007 the assessed hail damage was correlated with the investigated parameters. Data sets with significant correlations were excluded from ANOVA.

Results and brief discussion

Preliminary investigations in 2006: The aim was to test the feasibility and to get some experience to design the main experiment in 2007. FB yield was diminished in all IC treatments compared to control (pure FB), but this could nearly be compensated for by the OS yield (Tab. 10). Mustard was the strongest competitor to FB resulting in lowest FB yield not compensated by mustard yield. In contrast, intercropping with safflower at narrow row distance achieved the highest combined grain yield despite significantly diminishing FB grain yield. This result was regarded as an effect of extremely high temperatures and water deficiency during July and August 2006. It is known that FB is very susceptible to drought which was increased in IC because of OS´s competition for water. Safflower prefers warm temperatures and tolerates dry weather conditions resulting in a compensation of decreased FB yield when grown intercropped. False flax achieved a very low grain and oil yield and was thus excluded in 2007. Oil content and fatty acid composition indicated a high grain quality of intercropped OS. N content of harvested FB grain was about 5.20% in all treatments. Analysis of soil samples showed that intercropped OS reduced soil nitrate between FB rows considerably (not significant). Since these results confirm to earlier results, the following data should be considered as a tendency: as soon as six weeks after sowing soil nitrate was curbed to 42% in wide row treatments compared with control. Afterwards at flowering stage, soil nitrate between FB rows was further diminished; now seen in both intercrop treatments. The soil nitrate was most efficiently depleted by intercropped mustard and safflower.

Depletion of soil N and yield performance in 2007: 53 days later sowing PAN between FB rows was significantly diminished by intercropped OS at wider row distance compared with sole cropped FB (56.5 cm). At FB´s flowering stage both IC treatments depleted soil N significantly (Figure 1). Mustard was the strongest sink for soil N (data not shown). Shoot biomass of FB harvested at flowering stage was not diminished by intercropped OS when compared with FB control (56.5 cm) but significantly lower than in FB SC with a row distance of 28 cm and twice as much the sowing density. The diminished FB shoot biomass in intercrops was nearly compensated for by OS`s shoot biomass resulting in no significant difference in combined shoot biomass between intercrops and sole cropped faba beans in that developmental stage. However, shoot biomass in FB SC (28 cm) was significantly higher than in FB SC (56.5 cm), caused by twice as much of the sowing density. Afterwards FB development was interfered with by hail damage. Damaged FB plants showed reduced pod insertion, grains per pod and thousand-seed weight (TSW), resulting in reduced grain yield compared with undamaged plants: in FB control, e.g., yield per individual plant was diminished by 67%. Since up to 73% of FB plants were damaged, a relative disadvantage for FB solecrops was given. In IC the reduced FB yield could not be compensated for by the OS yield and no significant difference was found in combined biomass between intercrops and FB sole crop treatments. Grain yields of mustard and linseed were impaired by pollen beetle (*Meligethes aeneus*) and birds resp., resulting in decreased grain yields (Tab. 10). The chilly, wet climate in July and August lead to the reduced grain yield of safflower compared with 2006. Enhanced LER_{Grain} values of 1.22 and 1.15 of intercropping with safflower and mustard resp. at wider row distance compared with sole cropping were determined under these circumstances and suggest facilitative interactions in mixed crops. On the contrary, LER_{Grain} values around 1 for intercropping at narrow row distance indicate competition between intercrops (Tab. 10).

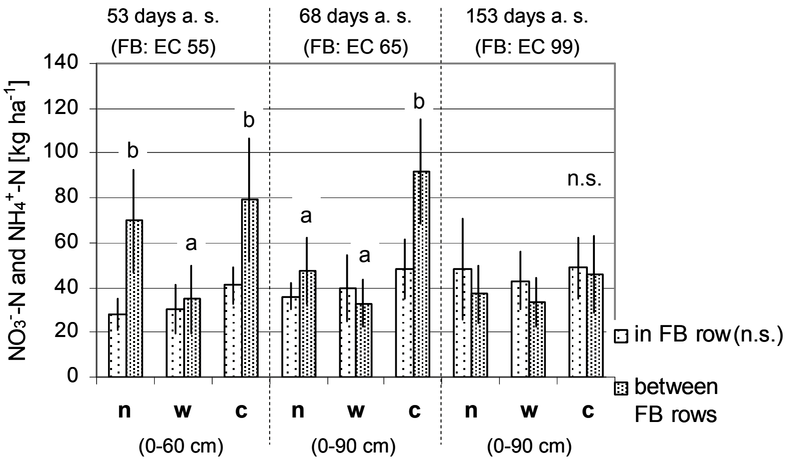

Figure 1: Plant available soil nitrogen under intercropped faba beans (FB) and oilseeds (OS) in 2007 depending on distance between FB and OS rows: n (narrow, 5 cm), w (wide, 18.5 cm), c (control without OS, 56.5 cm) – Data analysis conducted by ANOVA and Scheffé´s Test individual for the times of sampling; error bar: standard deviation

Tab. 10: Yields of intercrops (IC) and sole crops (SC) in 2006 and 2007

		2006			2007				
Oilseed	Row distance	FB-grain [tons ha^{-1}]	OS-grain [tons ha^{-1}]	Grain yield com [tons ha^{-1}]	FB-grain [tons ha^{-1}]	OS-grain [tons ha^{-1}]	Grain yield com [tons ha^{-1}]	Biomass com [tons ha^{-1}]	LER grain
Control	56.5 cm	1.85 c		1.85	1.50		1.50	5.16 ab	
Safflower-IC	narrow	1.29 ab	1.04	2.33	1.02	0.56	1.58	6.56 bc	1.01
	wide	1.07	0.91	1.99	1.30	0.64	1.94	7.48	1.22
Mustard-IC	narrow	0.88 a	0.64	1.52	1.14	0.26	1.40	5.83 abc	0.94
	wide	0.99	0.52	1.51	1.18	0.41	1.59	6.27	1.15
Linseed-IC	narrow	1.22 a	0.32	1.54	1.05	0.01	1.05	4.69 ab	
	wide	1.09	0.39	1.47	1.34	0.01	1.35	5.40	
False flax-IC	narrow	1.44 bc	0.13 *	1.57					
	wide	1.59	0.26	1.85					
FB-SC	28 cm				1.84		1.84	6.15 bc	
Safflower-SC	17.0 cm					1.24	1.24	7.68 c	
Mustard-SC	17.0 cm					0.82	0.82	5.47 abc	
Linseed-SC	17.0 cm					0.01	0.01	3.68 a	

FB: faba bean, OS: oilseed, IC: intercrops, SC: sole crops, com: combined; Different letters indicate a significant difference between intercropped OS (Scheffé's Test: $p<0.05$); * significant difference for $p<0.05$ between spacing; yields based on 100% dry matter

Conclusions

Intercropped OS and FB may have the potential for a more efficient use of resources compared to SC only. Under the extreme weather conditions in 2007 LER values > 1 were determined for IC treatments. However, this result was at least partly caused by the high percentage of hail-damaged FB plants and needs further investigation. Nutrient analysis indicated high quality of harvested grain and oil in 2006 (Data for 2007 are not available yet). But, there should be some limiting factors mentioned as well: in contrast to our hypothesis, the system is relatively susceptible to weed infestation, especially on fertile soil. Pollen beetles are difficult to control in Organic Farming and may cause total loss of brassica oilseeds. Extreme weather conditions affected crop maturity and lead to problems at IC harvest. Nevertheless, intercropped FB and OS have the potential to resist extreme conditions when facilitative interactions dominate.

Acknowledgments

Analysis of oilseeds for oil content and fatty acid composition has been carried out by B. Matthäus at Federal Research Centre for Nutrition and Food, Institute for Lipid Research in Münster, North Rhine-Westphalia, Germany.

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Comparison of cropping systems

Comparative analysis of conventional and organic farming systems: Nitrogen surpluses and nitrogen losses

Kelm, M.[1], Loges, R.[1] & Taube, F.[1]

Key words: Nitrogen, nitrate, leaching, farming systems, nitrogen fixation

Abstract

Nutrient management is a key factor for both economic viability and environmental performance of farming systems. On 32 representative conventional and organic farms in Northern Germany, nutrient management was analyzed in the interdisciplinary monitoring project "COMPASS". Organic farms had significantly lower nitrogen (N) surpluses compared with conventional farms. The majority of organic farms had very low or even negative N surpluses, indicating insufficient N supply in the cropping system. Nitrogen leaching, however, was too high in many cases on both conventional and organic farms. Strategies for a more targeted nutrient supply in organic farming need to be developed and implemented.

Introduction

Nutrient-efficient farming is characterized by the minimization of nutrient losses to the environment while ensuring the necessary nutrient supply to crops and livestock. Organic farming is generally associated with sustainable nutrient management. Representative data from typical farms is scarce, however. Symbiotic N_2 fixation of legumes represents the most significant N input in organic farming. Even though both own and purchased organic fertilizers are applied on most organic farms, a sufficient N supply to crops cannot always be realized. On the other hand, N losses to the environment, e.g. through leaching, should be minimized.

In the present study, N fluxes and N leaching on 32 commercial farms in Northern Germany were analyzed in a 3-year monitoring project that allowed for a direct comparison of conventional and organic faming systems.

Materials and methods

The project "COMPASS" was carried out over the period 2004-2006 on commercial farms in Northern Germany. 16 pairs of farms were selected by two main criteria:

a. Farm type: Specialized arable farms, specialized dairy farms.

b. Intensity: Conventional farms, organic farms.

Within a pair of farms, a conventional farm and a comparable organic farm were located at the same site. This project set-up allowed for a direct comparison of conventional and organic farms under similar soil and environmental conditions. We analyzed 8 pairs of arable farms and 8 pairs of dairy farms. The comparability of farms within a pair was assured by comparable farm size, and similar specialization under the prevailing soil conditions. In dairy farming, the stocking rate was generally lower on organic farms (mean: 0.86 LSU ha-1 vs. 1.46 LSU ha-1 on conventional dairy farms).

Farm management was documented accurately, covering all aspects of crop and animal production. Additionally, we sampled forage yields, forage quality, botanical diversity of grassland, and symbiotic N2 fixation of legumes on representative fields. Symbiotic N2 fixation was determined according to Høgh-Jensen et al. (2004). N balances were calculated for all 32 farms. N input included purchased fertilizers, feedstuffs and livestock, and N_2 fixation. N output was the sum of sold crops, animals, milk, and manure. From the difference between N input and N output at the farm scale, NH_3 emissions during manure storage and application were subtracted.

N leaching was determined on 8 selected farms. We used suction cups during the leaching periods (November-April) of 2004-2005 and 2005-2006 in representative fields of selected crops (see Table 1).

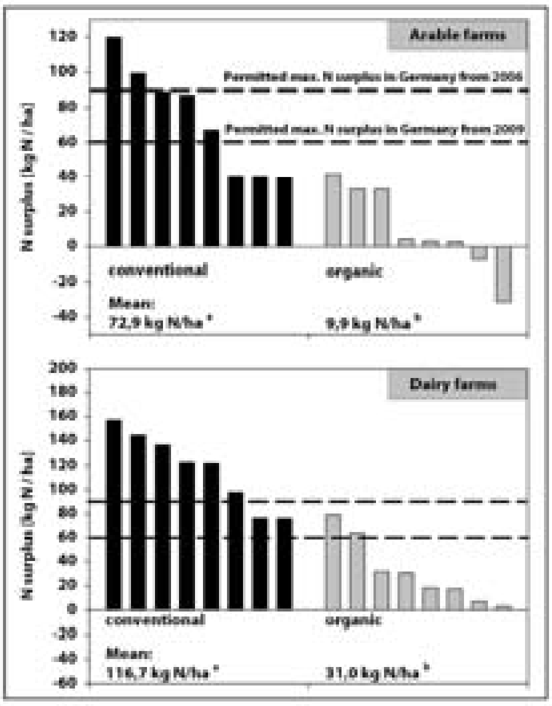
18 (arable crops) or 24 (permanent grassland) suction cups were installed per field. N concentrations (NO3-N + NH4-N + Norganic) in the leaching water (sampled at weekly intervals) were measured photometrically with an autoanalyzer. Total N leaching per winter [kg N/ha] was calculated as the sum-product of N concentrations and amounts of leaching water over the sampling period. In a separate experiment (split-plot with four replicates, large plots of >600 m²), N turnover and N leaching were measured after the renewal of an organically managed permanent grassland sward on a sandy soil (ploughed in spring or autumn).

Results and discussion

Farm-gate N surpluses (indicating the total potential N loss to the environment) were significantly higher in conventional farming compared with organic farming, with generally higher N surpluses on dairy farms compared wiith arable farms (Figure 1). This is in line with some former studies (e.g., Dalgaard et al., 1998). Other investigations, however, did not find systematic differences in N surpluses between conventional and organic farms (e.g., Hansen et al., 2000). The majority of analyzed conventional farms – both arable and dairy farms – need to improve their N management in order to fulfil future requirements. The large variation among individual farms clearly shows the potential for improvement. Some conventional farms already show that efficient nutrient management is possible without yield losses. Amongst conventional farms, there was no significant correlation between N surpluses and crop yields or milk yields, respectively. Weak points in conventional agriculture were mainly associated with N fertilization. In many cases, mineral N application to crops was far too high, or nutrients in slurry were not accounted for. Replacement rates frequently exceeded 35%, and the feeding ration was not always well adjusted.

In contrast, the majority of organic farms suffered from low or even negative N surpluses at the farm scale, which indicates a lack of nitrogen (Figure 1). The main reasons for variation in N surpluses were the proportion of legumes in the crop rotation and N_2 fixation rates of legume crops. For instance, the proportion of grass/clover in the crop rotation of organic arable farms varied from 0% to 53% (mean: 19%). N_2 fixation rates ranged between 45 kg N/ha (Persian clover *[Trifolium resupinatum],* mulched) and 339 kg N/ha (red clover *[Trifolium pratense]*, mixed cutting/mulching). N_2 fixation rates of red clover/perennial ryegrass (*Lolium perenne*) swards were in the range 150-250 kg N/ha, depending on the proportion of red clover, soil type, and cutting, mulching or grazing treatment. Some organic arable farms tried to maximize cash crop production by eliminating grass/clover from the crop rotation. N input was realized only through N_2-fixing cover crops, undersown clover in cereals, or purchased organic fertilizers. Even though this strategy could be opportune from an economic point of view, declining soil fertility and increasing weed levels might limit cash crop yields of these systems in the long run. Another weak point on organic farms was the adjustment of feeding rations to lactating cows. Both milk yields and animal health could be improved significantly by constantly providing a well-adjusted ration.

Figure 1: Net N surplus of conventional and organic farms, mean of 2004-2006.



[a, b] significantly different for $P<0.05$

Significant N leaching losses were observed in both conventional and organic farming (Table 1). In organic farming, the ‘critical N load’, which corresponds to a mean concentration of 50 mg/l nitrate in leaching water, was exceeded if grass/clover was ploughed in autumn (followed by winter wheat), a finding supported by a number of other authors (e.g., Dreymann, 2005). The same occurred after silage maize harvest on sandy soils. Organic silage maize was grown after grass/clover ploughed in spring. Additionally, high amounts of slurry and manure were applied, which is not necessary, since the N supply to silage maize is already ensured by the mineralization of grass/clover residues. Neither conventional nor organic maize fields had a winter cover crop. On grassland and in cash crop production, N leaching losses were significantly affected by N input (mainly N fertilizer, slurry, and excrements) and N surpluses at the field scale. In silage maize production, however, this relationship was absent. Mineralization of soil organic matter seemed to have a much stronger effect on N leaching since these fields have been fertilized with manure and slurry for many years, which accumulated a large pool of soil nitrogen. Extremely high N leaching losses of 115-125 kg N/ha were observed in the first winter after the renewal of organically managed permanent grassland (data not shown). It made no significant difference if the grass sward was ploughed in spring or autumn. Mineralization of organic matter from the grass sward released very high amounts of N that could hardly be utilized until the following leaching period. As a consequence, grassland should be maintained in good condition as long as possible in order to postpone the renewal of grassland swards.

Tab. 1: N leaching (kg N ha^{-1} yr^{-1}; sum of NO_3-N + NH_4-N + organic N) in representative crops on conventional and organic farms. Mean of 18-24 suction cups per field, averaged over leaching periods 2004-2005 and 2005-2006.

Farm	**Winter wheat** *after oilseed rape (c) or grass/clover (o)*		**Oilseed rape (c) or grass/ clover (o)** *after cereals*		*After* **silage maize**		**Permanent grassland** *(1 cutting + grazing)*	
	Arable farms		**Arable farms**		**Dairy farms**		**Dairy farms**	
conventional	32.1	L	28.7	L	22.1	L	40.1	L
organic	45.4	L	13.2	L	27.8	L	26.2	L
conventional	45.5	L	42.2	L	52.4	S	38.2	S
organic	37.5	L	15.2	L	65.5	S	19.5	S

L: loamy soils, S: sandy soils

Conclusions

Organic farms were characterized by lower N surpluses and - in most cases - lower N leaching losses compared with conventional farms. N leaching on organic farms, however, still exceeded a 'critical N load' in most crops. Options for improved N management in organic farming include the layout of rotations, grass/clover management, more efficient utilization of manure, and better adjustment of feeding.

Acknowledgments

The project "COMPASS" was supported by the Ministry of Agriculture, Environment and Rural Areas (MLUR) of Schleswig-Holstein, the Rentenbank Frankfurt/Main, and the foundation Schleswig-Holsteinische Landschaft.

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Nitrogen use efficiency of cereals in arable organic farming

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Key words: crop rotation, spring barley, winter wheat, winter rye, nitrogen supply.

Abstract

The effect of nitrogen (N) supply and weeds on grain yield of spring barley, winter wheat and winter rye was investigated from 1997 to 2004 in an organic farming crop rotation experiment in Denmark on three soil types varying from coarse sand to sandy loam. Two experimental factors were included in the experiment in a factorial design: 1) catch crop (with and without), and 2) manure (with and without). The apparent recovery efficiency of N in grains (nitrogen use efficiency, NUE) from NH_4-N in applied manure varied from 29 to 38% in spring barley and from 23 to 44% in winter cereals. The NUE of above-ground N in catch crops sampled in November prior to the spring barley varied from 16 to 52%, with the highest value on the coarse sandy soil and the lowest value on the sandy loam soil. The NUE of N accumulated in grass-clover cuttings varied from 14 to 39%, with the lowest value on the coarse sandy soil, most likely because of high rates of N leaching. The NUE declined with increasing amounts of N accumulated in the grass-clover cuttings. This indicates that grain yields can be improved by removing the grass-clover cuttings and applying the N contained in the cuttings in spring to the cereal crops, possibly after fermentation in a biogas reactor.

Introduction

The productivity of arable crops in organic farming is restricted by the supply of nitrogen (N) (Olesen et al., 2007), and there is a need for sources of N in addition to manure to meet the N demand of cereals crops. Biological N fixation (BNF) is one of the primary sources of N in organic farming (Berry et al., 2002). The N supply through BNF will directly affect yields of legume crops. However, other crops will need to benefit from BNF through N recycled in manure or through crop residues returned to the soil. In systems with grass-clover for grazing or as green manures, a major input of N from BNF is returned to the soil by incorporating the grass-clover pasture. Similar inputs are obtained from crop residues of grain legumes and from catch crops.

In the analysis of experiments with application of fertiliser N, the apparent recovery efficiency of applied N is typically taken as a measure of the N use efficiency (NUE) (Cassman et al., 1998). NUE is usually calculated as the difference in N uptake between fertilised plots and an unfertilised control. However, it may also be calculated as the slope of a regression on crop N uptake (either N in total above-ground biomass or in grain yield) versus applied fertiliser N. In this paper we analyse the effects of N input through green manures, crop residues, catch crops and animal manure on grain yield and N uptake in spring barley and winter cereals.

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Materials and methods

A crop rotation experiment was initiated in 1996/97 at three sites in Denmark (Olesen et al., 2000). The sites represented different soil types and climate regions (Jyndevad: coarse sand; Foulum: loamy sand; and Flakkebjerg: sandy loam) in Denmark. In this paper we present results for cereals in a 4-course rotation with a pulse crop, spring barley, grass-clover and winter cereal. The pulse crop was a mixture of pea and barley in 1997 to 2000, lupin in 2001, a mixture of lupin and barley at Foulum and Flakkebjerg in 2002 to 2004, and a mixture of field bean, lupin, and barley at Jyndevad in 2002 to 2004. The cereal and pulse crops were grown for grain harvest. The grass-clover was undersown in the spring barley in spring, and it was subsequently managed as a green manure crop with mulching of the cuttings. The grass-clover was followed by winter wheat, except for Jyndevad in 2001 to 2004, where it was followed by winter rye. All straw was left in the field. Weed harrowing was used where possible to control weeds in cereals and legumes. The experiment was irrigated at Jyndevad.

The experimental factors were 1) catch crop (with and without catch crop) and 2) manure (with and without animal manure applied as slurry). All crops in all rotations were represented every year in two replicates (blocks) in a two-factorial randomised design with plot sizes varying from 169 to 378 m^2. The plots receiving manure were supplied with anaerobically stored slurry at rates such that the amount of NH_4-N corresponded to 40% of the N demand of the specific rotation based on a Danish national standard (Plantedirektoratet, 1997). In the catch crop treatment, a mixture of perennial ryegrass, chicory and various legume species were used.

Grain yields were measured at maturity using a combine harvester. Samples of total above-ground biomass were taken in each plot at growth stage 59 in spring barley and winter cereals. Each sample was separated into barley, grass-clover, and weeds for assessing weed pressure. To determine the amount of crop residues returned to the soil, samples of total above-ground biomass were taken at growth stage 85, 1-2 weeks before yellow maturity in the pulse and cereal crops. Similar samples were taken about 1 November to measure the above-ground biomass of catch crops and weeds. Samples of total above-ground biomass in the grass-clover were taken at each cut. The dry matter content of grains and plant samples were determined after oven drying at 80 C for 24 hours. Total N in the grains and plant samples were determined on finely milled samples from each plot by the Dumas method. Total N was not determined in the plant samples taken at GS 59. The amount of straw and other residues left on the soil after harvest of the previous crops was estimated from the samples of above-ground plant material taken at growth stage 85 by subtracting the grain dry matter yield.

The grain yield and grain N uptake in spring barley and winter cereals were related to inputs of N in various forms and to the weed pressure using linear regression. The following regression equation was used for spring barley:

$$Y = a_y + a_1 N_{man} + a_2 N_{res} + a_3 N_{Nov} + a_4 R_{wgc} \quad (1)$$

The following equation was used for winter cereals:

$$Y = b_y + b_1 N_{man} + b_2 N_{gc} + b_3 N_{gc}^{\ 2} + b_4 R_{wgc} \quad (2)$$

where a_y *and* b_y are effects of year, and a_1-a_4 and b_1-b_4 are regression coefficients. N_{man} is ammoniacal N in the applied manure (kg N/ha), N_{res} is N in the above-ground residues from the previous crop (kg N/ha), N_{Nov} is N in the above-ground plant parts on 1 November (kg N/ha) prior to spring barley, N_{gc} is accumulated N in the above-ground biomass of the previous grass-clover (kg N/ha), and R_{wgc} is weed and grass-clover biomass as per cent of total above-ground dry weight at growth stage 59.

Results

There were generally consistent yield benefits from N in manure, with average grain yield increases of approximately 20 kg DM/ha per kg NH_4-N in manure, with slightly lower values at Flakkebjerg for both spring barley and winter wheat (Tables 1 and 2). The apparent N recovery efficiency (NUE), taken as the slope of N uptake in grain versus the N input in manure was highest at Foulum and similar at Jyndevad and Flakkebjerg for both crops (see coefficients of N_{man} under grain N uptake, which is the recovery efficiency (NUE)).

N in above-ground residues of pulses insignificantly affected grain yield and N uptake in spring barley (Table 1). Grain yields of winter wheat responded strongly to accumulated N in the mulched grass-clover cuttings, especially at Flakkebjerg (Table 2). However, this response was non-linear, as seen by the negative coefficient for N_{gc}^2, which results in a saturation response. This means that the NUE is reduced with increasing N input, resulting in NUE values of only 9, 14 and 16% at Jyndevad, Foulum and Flakkebjerg, respectively, for an N input in grass-clover of 300 kg N/ha.

The grain yield response of spring barley to N in the catch crop samples in November showed large site differences, with considerably higher responses at Jyndevad compared with Flakkebjerg (Table 1). The associated NUE showed similar site differences, but the NUE for spring barley from N in the catch crop was always higher than the NUE for winter cereals from N in grass-clover (compare Tables 1 and 2).

There were negative effects of weeds and an undersown catch crop or grass-clover on cereal yields. The effects of weeds on NUE were considerably more pronounced for winter cereals compared with spring barley (compare Tables 1 and 2).

Discussion

The results demonstrate that the yield benefits and the NUE from manure application are considerably more consistent across sites than the effects of various types of N in green manure or crop residues. The lower yield benefits from manure application at Flakkebjerg compared with the other sites can probably be explained by higher ammonia volatilisation due to reduced infiltration of the slurry on this soil type.

A large part of the site differences in grain yield response to inputs of N in grass-clover and catch crops can probably be explained by differences in N leaching during winter. The combination of a sandy soil and relatively high rainfall gives a high risk of N leaching at Jyndevad compared with the other sites. The soil at Flakkebjerg has the highest N retention and the lowest rainfall. The benefits of using catch crops in terms of retaining N in the system are therefore highest at Jyndevad and lowest at Flakkebjerg. The risk of losing N from the autumn-ploughed grass-clover is similarly highest at Jyndevad and lowest at Flakkebjerg, resulting in large differences in the NUE of N in grass-clover.

The low NUE of N in grass-clover at Jyndevad and the non-linear response of yield to increasing N input in grass-clover suggests that the N supply to the cereal crops may be improved by harvesting the grass-clover cuttings and applying them to the crops in spring in the form of manure, possibly after anaerobic digestion in a biogas reactor.

Tab. 1: Regression coefficients from regression of grain yield and N uptake of spring barley, 1998-2004, on ammoniacal N in manure (Nman), N in the above-ground residues of the previous crop (Nres), N in above-ground weeds and catch crop in November prior to spring barley (NNov), and weeds and undersown grass-clover as percentages of total above-ground dry weight at growth stage 59 in spring barley (Rwgc).

Variable	Location	N_{man}	N_{res}	N_{Nov}	R_{wgc}
Grain DM yield	Jyndevad	23.0	2.3	32.1	-29
(kg DM/ha/yr)	Foulum	20.9	-0.1	15.4	-44
	Flakkebjerg	16.9	3.3	9.6	-23
Grain N uptake	Jyndevad	0.29	0.04	0.52	-0.49
(kg N/ha/yr)	Foulum	0.38	0.03	0.33	0.67
(NUE)	Flakkebjerg	0.30	0.05	0.16	0.07

Tab. 2: Regression coefficients from regression of grain yield and N uptake of winter cereals, 1998-2004, on ammoniacal N in manure (Nman), N in above-ground biomass at time of cutting in the previous grass-clover (Ngc) and weeds and undersown grass-clover as percentage of total above-ground dry weight at growth stage 59 in winter cereals (Rwgc).

Variable	Location	N_{man}	N_{gc}	N_{gc}^2	R_{wgc}
Grain DM yield	Jyndevad	17.2	4.4	-0.004	-32
(kg DM/ha/yr)	Foulum	22.4	9.9	-0.011	-18
	Flakkebjerg	12.0	14.6	-0.016	-92
Grain N uptake	Jyndevad	0.23	0.09	-0.00006	-0.6
(kg N/ha/yr)	Foulum	0.44	0.21	-0.00022	-0.5
(NUE)	Flakkebjerg	0.23	0.27	-0.00030	-1.7

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Performance of Organic Grain Cropping Systems in Long-Term Experiments

Teasdale, J.R.[1] & Cavigelli, M.A.[1]

Key words: organic farming, no-tillage, crop rotation, soil carbon, weed control

Abstract

Organic farming and conventional no-tillage farming systems share many of the same benefits from protecting and improving soils. A review of recent results from two long-term systems experiments in the mid-Atlantic region of the U.S.A. demonstrates that organic cropping systems with organic amendments can increase soil carbon, nitrogen, and yield potential more than conventional no-tillage, despite the use of tillage in organic systems. However, reduced-tillage organic systems present challenges for weed control, particularly with simple rotations typical of conventional grain cropping systems. Organic systems that employ more complex rotations including a hay crop have demonstrated greater potential for improved weed control, increased nitrogen availability, and increased yields.

Introduction

Conventional grain production in the mid-Atlantic region of the U.S. is characterized by short rotations [primarily maize (*Zea mays* L.), soybean (*Glycine max* L. Merr.), and wheat (*Triticum aestivum* L.)] and reduced- or no-tillage planting practices on soils that are relatively low in organic matter and drought-prone. No-tillage systems have been particularly successful in this region for soil conservation, building soil organic matter, capturing and retaining soil moisture, and reducing runoff as well as nutrient and pesticide losses into the Chesapeake Bay watershed. There has been increasing interest in organic grain production in recent years because of premium prices and potential environmental benefits to the Chesapeake Bay region. However, there are challenges in adapting organic approaches to the conventional model of short-rotation, no-tillage grain production because longer rotations are usually recommended for organic farming and tillage is usually required for seedbed preparation and weed control. Two long-term experiments were established at the USDA-ARS Beltsville Agricultural Research Center in Beltsville, Maryland, to compare the performance of conventional and organic grain production systems. The Sustainable Agriculture Demonstration Project (SADP) was initiated in 1994 to compare the sustainability of four reduced-tillage cropping systems. The Farming Systems Project (FSP) was established in 1996 to compare three rotation lengths of organic cropping systems with two conventional systems.

Materials and methods

SADP. The SADP was conducted on a droughty, sloping site in a randomized complete block with four replicates. Four cropping systems were included in this long-term experiment, but only two will be discussed here: 1) a standard Mid-Atlantic no-

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tillage system (NT) with recommended herbicide and nitrogen inputs; and 2) a chisel plow-based organic system (OR) with cover crops and manure for nutrients and post-planting cultivation for weed control. The NT system followed a two-year maize-wheat/double-crop soybean rotation, while OR followed a three-year maize-soybean-wheat rotation. This systems comparison was conducted from 1994 to 2002, followed by a uniformity trial in which all plots were planted to maize according to the NT system from 2003 to 2005. Further details of the experimental methods are described in Teasdale et al. (2007).

FSP. This long-term experiment was conducted on relatively level Coastal Plain soils in a randomized complete block design with four replicates. The five cropping systems included: 1) a conventional no-till maize-soybean-wheat/soybean rotation (NT); 2) a conventional chisel-till maize-soybean-wheat/soybean rotation (CT); 3) a two-year organic maize-soybean rotation (Org2); 4) a three-year organic maize-soybean-wheat rotation (Org3); and 5) a four- to six-year organic maize-soybean-wheat-hay rotation (Org4+). Hairy vetch and manure were the nutrient sources for Org2 and Org3, while hay and manure provided nutrients for Org4+. Each phase of each rotation was included as a split plot in each year. Further details of the experimental methods and analyses are described in Cavigelli et al. (2008).

Results

FSP. Maize yields at FSP were similar in NT and CT but were lower in the three organic systems (Figure 1). Among the organic systems, maize yield increased as the length of rotation increased. Nitrogen availability and weed control exhibited a similar pattern of response as did maize yield (Figure 1), suggesting that these variables were important determinants of maize yield (Cavigelli et al. 2008).

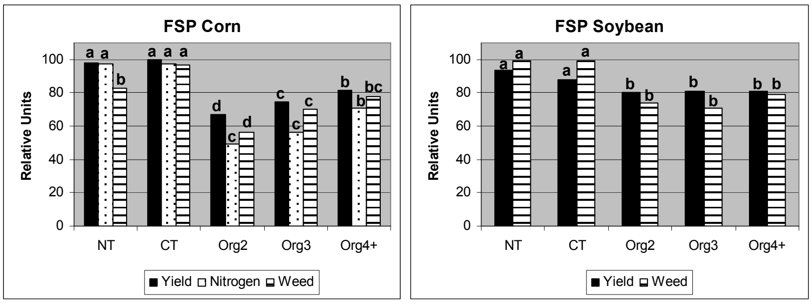

Figure 1: Average crop yield, nitrogen availability (based on fertilizer rates or estimated mineralization from organic sources), and weed control at the FSP. Relative unit of 100 = 10 Mg ha^{-1} maize grain, 5 Mg ha^{-1} soybean grain, 170 kg ha^{-1} nitrogen, and 100 % weed control. Bars within variables with the same letter are not significantly different (P<0.05).

Generally the legumes preceding maize provided insufficient nitrogen and supplemental manure was limited because manure application rates were phosphorus-based and this site was high in soil phosphorus. Weed control improved as organic rotation length increased because there were fewer niches for weed adaptation in the longer, more phenologically diverse rotations (Teasdale et al. 2004). An analysis of covariance demonstrated that nitrogen availability accounted for 70-

75% of the yield differences between organic and conventional systems, while weed control accounted for 21-25% and maize population for 3-5% (Cavigelli et al. 2008).

FSP full-season soybean grain yields were similar in the two conventional systems and similar among the three organic systems but higher in the conventional than the organic systems (Figure 1). Differences in soybean yield were accounted for exclusively by differences in weed control among systems.

SADP. Maize grain yield averaged over nine years, 1994 to 2002, was 28% lower in OR than in NT (Teasdale et al. 2007). Reduced yields in OR were accounted for primarily by competition with weeds. A reduced-tillage approach to weed control was used for OR whereby a winter annual cover crop (crimson clover before maize) was flail mowed with the expectation that surface residue would suppress early-season weeds and that escaped weeds would be controlled by between-row cultivation with a high-residue cultivator. This approach did not successfully control annual weeds and a substantial seedbank of broadleaf and grass weeds built up in the soil.

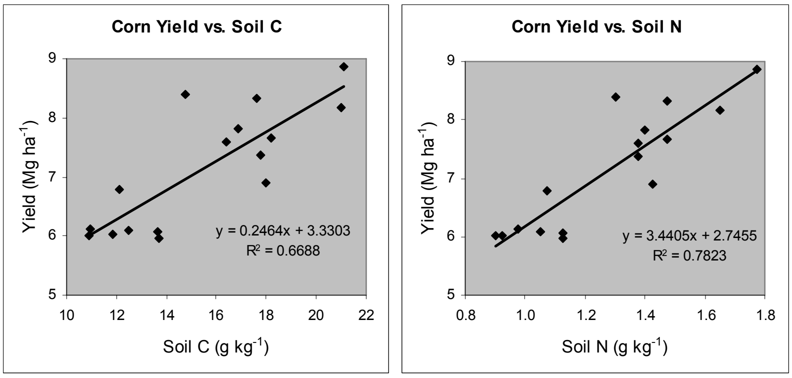

Figure 2: Uniformity trial maize yield (2003 to 2005) as a function of combustible soil carbon and nitrogen at 0 to 15 cm depth at the conclusion of the SADP systems comparison (1994 to 2002).

At the conclusion of the SADP systems comparison in 2002, soil carbon and soil nitrogen were significantly increased in the OR compared to the NT system (Teasdale et al. 2007). The OR system had supplemental carbon inputs of manure in addition to plant residue inputs that accounted for higher carbon inputs in this system than in NT. All plots were planted to maize grown according to NT system operations during a uniformity trial from 2003 to 2005. Maize grown on plots with a history of OR yielded 18% higher than those with a history of NT during this uniformity trial (Teasdale et al. 2007). Yields in OR and NT during this uniformity trial were highly correlated with 0-15 cm soil carbon and nitrogen at the conclusion of the experiment (Figure 2). Soil carbon and nitrogen at 6-12 cm were less correlated with yield (R^2 = 0.37 and 0.33, respectively). Thus, it is likely that yields were higher in plots with a history of OR rather than NT because of improved soil conditions and nitrogen availability as a result of increased soil carbon and nitrogen, primarily in the surface 0 to 15 cm of soil. Higher maize ear leaf nitrogen and higher soil nitrate levels at the maize six-leaf stage in OR than NT confirmed that there was higher nitrogen availability in the OR system.

Discussion

Organic farming has many of the same goals and benefits for soil improvement as conventional no-tillage systems. A simulation study of SADP where all systems had either no or reduced tillage predicted similar annual soil erosion losses among the four systems (Watkins et al. 2002), while a simulation of FSP based on soil aggregate distribution showed erosion potential of CT > Org3 > NT (Green et al. 2005). Results of SADP research showed that soil carbon and nitrogen concentration and maize yield potential were increased in OR compared to NT, and preliminary data from FSP shows similar results (Cavigelli, personal communication). This suggests that organic farming systems with organic amendments can provide greater long-term soil improvement than conventional no-tillage systems, despite the use of tillage in organic systems. Manure- and legume-based organic farming systems from nine long-term experiments across the U.S. also increased soil organic carbon and nitrogen compared with conventional systems (Marriott and Wander 2006).

This research also demonstrates that the soil-building benefits of organic farming may not be realized because of the difficulty of controlling weeds in organic systems, particularly, reduced-tillage organic systems. Additional research is needed to develop reliable weed management for reduced-tillage organic farming. Advances in equipment design (The Rodale Institute 2008) have led to improved control of annual weeds by rolling cover crops to form a dense, tight mat of residue in no-tillage organic systems. In addition, FSP research (Teasdale et al. 2004) has shown that more diversified organic systems with perennial hay crops in the rotation maintain a lower weed seedbank and lower weed abundance than those following simpler grain crop rotations such as those used in the SADP research. Utilizing rotations with perennial hay crops would benefit organic systems not only by reducing weed populations but also by eliminating tillage during a significant portion of the rotation. Therefore, with inclusion of a perennial crop, the soil-building benefits of no-tillage could be obtained during the perennial phase of the rotation and the negative consequences of tillage during the grain crop phase would be minimized.

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Effects of an organic and a conventional cropping system on soil fertility

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Key words: crop rotation, nitrogen, phosphorus, potassium, carbon

Abstract

An experiment was started in 1998 in Central Italy to evaluate changes in soil fertility and the risk of N loss in an organic (ORG) and a conventional low input (CONV) cropping system. At the end of a 6-year rotation, ORG caused a higher plant biomass incorporation into the soil and thus a higher soil soluble organic carbon. The N surplus in ORG was 32% higher than in CONV, while no differences were recorded on N content in the top soil, so that ORG implicated a higher N loss from that soil layer. In ORG we recorded a higher phosphatase activity but a lower available soil P (due to application of rock phosphate in sub-alkaline soil) and a lower exchangeable K.

Introduction

Nutrient management in organic systems is based on atmospheric nitrogen (N) fixation, combined with recycling of nutrients via bulky organic materials, such as farmyard manure and crop residues, with only inputs of permitted fertilizers. Organic systems are expected to improve soil quality parameters and reduce N leaching (Haas et al., 2002), but this is not always confirmed. Actually, these systems have been criticized for relying on reserves of soil phosphorus (P) and potassium (K) built up by fertilizer additions prior to organic management (Heathwaite, 1997; Løes and Øgaard, 2001), and for increasing residual N exposed to leaching (Kirchmann and Bergström, 2001, Torstensson et al., 2006). This research is aimed to evaluate changes on soil quality indicators in an organic and a conventional low input cropping system over a long term rotation.

Materials and methods

An experiment was started in 1998 in Central Italy (43°N, 165 m a.s.l.) to compare an organic (ORG) and a conventional low input (CONV) system in two contiguous fields, both clay loam, pH 7.8 and with same initial contents of SOM, total N, available P and exchangeable K. The conversion to organic of the ORG field had been started in 1996. Both fields were divided in six sectors (A1, A2, B1, B2, C1, C2) to reproduce the steady-state running of a 6-year rotation in a farm and test several food crops concurrently. In each cropping system a randomized block design with 3 or 4 replicates (depending on year and crop) was adopted. The same sequence of cash crops over the 6 years was adopted in both systems (Table 1). The nutrient supply was assured by green manures, pelleted poultry manure (4% N, 4% P_2O_5, 3% K_2O), rock phosphate (P_2O_5 17% soluble in formic acid 2% concentrated) and potassium sulfate (50% K_2O) in ORG; by green manure (only until 2000) and mineral fertilizers in CONV.

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Tab. 1: Six-year crop rotations in the six field sectors in organic (ORG) and conventional low input (CONV) cropping systems. Green manure crops (GM) were adopted in ORG and CONV until 2000, only in ORG afterwards. The N supply (kg ha^{-1}) from fertilizers in ORG/CONV system is reported in brackets.

Sector	Years					
	1999	2000	2001	2002	2003	2004
A1	bean (40/0)	spelt (40/40)	GM1+ maize (40/150)	GM4+ soybean (0/0)	GM1+ pepper (0/200)	wheat (0/80)
A2	bean (40/0)	wheat (80/80)	GM1+ pepper (40/175)	GM4+ maize (40/40)	GM1+ tomato (0/200)	wheat (0/80)
B1	field bean (0/0)	GM3+ pepper (100/100)	pea (40/0)	wheat (80/80)	GM2+ maize (0/150)	GM3+ tomato (60/160)
B2	field bean (0/0)	GM3+ maize (100/100)	field bean (40/0)	wheat (80/80)	pea (0/0)	GM3+ pepper (60/200)
C1	GM1+ pepper (0/70)	bean (40/0)	spelt (80/80)	GM1+ tomato (60/200)	wheat (40/80)	field bean (0/0)
C2	GM1+ millet (20/135)	bean (40/0)	wheat (80/80)	GM1+ pepper (60/200)	wheat (40/80)	GM1+ maize (40/150)

GM1: field bean; GM2: field bean+rapesed; GM3: hairy vetch; GM4: barley.

Above-ground biomass and N accumulation (Kjeldahl method) and partitioning between marketable yield and residues were determined at the end of each crop. The biomass incorporated into the soil was calculated as the sum of crop residues and green manures. Apparent residual N in the soil (ΔN, kg ha^{-1}) (i.e. the soil-crop component of the soil surface budget) (Aarts et al., 2000) was calculated at the end of each crop cycle as: N input with fertilizers plus legume Ndfa (i.e derived from atmosphere via symbiotic fixation, estimated as in Boldrini et al., 2007) minus N off-take with marketable yield removal. At the end of the 6-year rotation four 0-0.40 m soil cores per sector were taken to determine: total organic carbon (TOC); water extractable organic carbon (WEOC); total soil N content, as mineral N (i.e. either $N0_2$-N + NO_3-N or NH_4-N) (Bremner and Keeney, 1966) plus organic-N (i.e. reduced-N obtained by Kjeldahl minus NH_4-N); available P (Olsen method); phosphodiesterase activity; exchangeable K (ammonium acetate method). Data were submitted to analysis of variance according to a hierarchical design (crops within systems).

Results

As an average over the 6 years and the six field sectors, both the total biomass yield and biomass incorporated into the soil were higher in ORG than in CONV (+13% and +26%, respectively) while marketable yield was 12% lower in ORG (Table 2). Actually, incorporated biomass was the 74% of the total in ORG and the 66% in CONV. The ΔN (Table 2) was 32% higher in ORG than in CONV.

Tab. 2: Average values over 6-year and 6-sectors of total biomass, biomass incorporated into the soil, marketable yield and N surplus (∆N) per year for an organic (ORG) and a conventional low input (CONV) cropping system.

Systems	Total biomass (t ha^{-1} d.m.)	Incorporated biomass (t ha^{-1} d.m.)	Marketable yield (t ha^{-1} d.m.)	∆N (kg ha^{-1})
ORG	12.9	9.5	3.4	41
CONV	11.4	7.5	3.9	31
Pooled SD	*1.34*	*1.21*	*0.46*	*2.3*

At the end of the 6-year rotation, no significant differences were observed between the two systems for TOC in the 0-0.40 m top soil, while WEOC was 13% higher in ORG than in CONV (Table 3). In that soil layer, total N content was not significantly different in the two systems, available P was 21% lower and phosphatase activity 14% higher in ORG than in CONV, exchangeable K was significantly but slightly higher in CONV.

Tab. 3: Total organic carbon (TOC), water extractable organic carbon (WEOC) total N, available P, P-diesterase activity, and exchangeable K in the 0-0.40 m soil layer for an organic (ORG) and a conventional low input (CONV) farming system at the end of a 6-year crop rotation.

Systems	TOC (g kg^{-1})	WEOC (mg kg^{-1})	Total N **(g kg^{-1})**	Avail. P **(mg kg^{-1})**	P-diesterase (µmol p-NP g^{-1} h^{-1})	Exch. K (mg kg^{-1})
ORG	9.84	52.9	0.80	18.7	55.7	180.4
CONV	9.30	47.0	0.82	23.6	48.9	192.9
Pooled SD	*0.050*	*9.04*	*0.110*	*3.85*	*4.78*	*15.57*

Discussion

The higher total biomass yield in ORG is the consequence of the regular use of green manure crops before summer cereals and vegetables (Table 2). On the contrary, the lower total and marketable biomass yield of cash crops in ORG, especially in spring-summer crops, was due to either a lower nutrient availability from green manures and organic fertilizers or to a higher competition of weeds in ORG (particularly for summer grain legumes). As well, the higher ∆N in ORG with respect to CONV (Table 2) was determined by both a 17% lower cash crop N off-take (data not shown) and the imprecise N availability (as total amount and timing of release) from green manuring and organic fertilisers, that caused a lower N fertilisation efficiency. On the contrary the total N input (i.e. N from fertilizers + legume Ndfa) was similar in the two systems (100 kg ha^{-1} per year on average) even though with a 3.5 times higher estimated legume Ndfa in ORG than in CONV, as already reported for this trial by Boldrini et al. (2007). The lack of difference for TOC between systems and the higher WEOC in ORG (Table 3) are probably consequent to no use of amendments and incorporation of greater plant biomass in ORG. In fact, plant tissues contain a high quantity of simple organic molecules that increase WEOC. The not statistically different total N content in the 0-0.40 m top soil layer in the two systems suggests that the higher ∆N recorded in ORG should have implicated a higher N loss from that soil layer. However, the invariance for total N and TOC between systems need to be further checked in the future, since changes might need more time to be detectable. The lower available P in

ORG, was likely due to the fertiliser-P form applied in this experimentation; in fact the main amount of phosphate in ORG was added as Ca triphosphate that, in a soil with a sub-alkaline pH value, tends to transform to very insoluble forms as apatites. Indeed, organic P fertilisers will be preferred for our soils in the future. The phosphatase activity, instead, was higher in ORG, where the final product of reaction (available P) was less concentrated and where the substrate for enzyme activity (organic P) was higher. The significant but slight difference on exchangeable K cannot be traced back to the fertiliser form, that was the same in both systems, and need to be further confirmed in the future to advance any hypothesis on why it originates.

Conclusions

As compared to the conventional low input cropping system, the organic system increased biomass supply to the soil and thus soil soluble organic carbon. Moreover, the organic system increased N surplus, but the total N content in the top 0.40 m soil at the end of the 6-year rotation did not vary, so that the surplus of N was necessarily lost from that soil layer. The organic system also increased phosphatase activity but the use of rock phosphate in our sub-alkaline soil reduced available soil P. Finally, the organic soil showed a slightly lower exchangeable K. A longer time-interval will allow to better evaluate effects on those soil fertility indicators. In any case, our experiment already confirms that the supposed benefits of organic systems on soil fertility and environment are not to be taken for granted, but depend on the adoption of suitable cultivation strategies such as those that may increase N use efficiency and reduce N loss from the soil (Kirchmann and Bergström, 2001; Torstensson et al., 2006).

Acknowledgments

Research funded by the FISR SIMBIO-VEG Project (2005-2008).

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A comparison of organically and conventionally grown vegetable crops: results from a 4-year field experiment

Tabaglio, V.[1], Gavazzi, C.[2] & Nervo, G.[3]

Key words: organic farming, conventional farming, vegetable crops

Abstract

A four-year field trial (2004-2007) was carried out to compare performances of organic and conventional farming systems in the Po Valley (Northern Italy). Four vegetable crops were grown in the sequence: 2004 – processing tomato; 2005 – bean followed by savoy cabbage; 2006 – processing tomato; and 2007 – zucchini. The experimental design was a split-plot with four replicates, the management system being the main factor (OF, organic farming vs. CF, conventional farming) with the rate of nitrogen fertilisation as the secondary factor. N efficiency of the organic fertilizers was assumed as being 50-75%). In all four of the years studied, the two farming systems did not show significant differences in marketable yields for any vegetable crops. The reduction in OF compared with CF was 17% for tomato-2004 and 2% for zucchini; in contrast, for cabbage and tomato-2006 the yields in OF were 10% and 3% higher respectively.

Introduction

Conventional vegetable growers who want to convert to organic farming systems have to pass through a 3-year transition period before their farms can be qualified for organic certification. Most of the research indicates that in the first transition year, yields of several conventionally grown vegetables are higher than those of organically grown vegetables (Gregori and Prestamburgo, 1996). However, in the following years yields of tomato (*Lycopersicon lycopersicum* L.) (Steffen *et al.*, 1995) and bean (*Phaseolus vulgaris* L.) (Temple *et al.*, 1994) were not statistically different between the two farming systems. In contrast, Sellen *et al.* (1995) report that in the second and third transition years, yields and net income from organically grown vegetables were still lower than those for conventional crops. Since in Italy there is limited knowledge of both vegetable crop productivity during the transition phase and the evolution of soil fertility, a composite project was set up (ORTOFRUBIO, funded by Mi.P.A.A.F., Italian Ministry of Agriculture) to evaluate the quantitative and qualitative potential and the environmental aspects of organic farming, of which this research is only one part.

Materials and methods

The field experiment was set up in 2004 at Montanaso Lombardo (LO, Northern Italy) on a *fine loamy, mixed, superactive, mesic Ultic Haplustalf* (Soil Taxonomy) or a *Haplic Alisol* (FAO), moderately acid (pH = 5.6 in H_2O), low in total N (0.072%), organic matter (1.21%), and exchangeable K (57 mg kg^{-1}), but high in available P (35

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Tab. 1: Nitrogen fertilisation scheme during the experimental period

Year and crop	Organic Farming	Conventional Farming
2004: tomato	200 kg N ha^{-1} (*)	100 kg N ha^{-1} as NH_4NO_3 (26% N)
2005: bean (spring) savoy cabbage (autumn)	 no fertilisation 160 kg N ha^{-1} (*)	 no fertilisation 120 kg N ha^{-1} as NH_4NO_3 (26% N)
2006: tomato	200 kg N ha^{-1} (*)	100 kg N ha^{-1} as NH_4NO_3 (26% N)
2007: zucchini	60 kg N ha^{-1} (*)	60 kg N ha^{-1} as $Ca(NO_3)_2$ (15.5% N)

(*) as organic fertiliser (Fertorganico, Ilsa, granular, 11% N) at ploughing.
During the conversion period, N efficiency is lower in OF than in CF, so the comparison of organic N has been based on a value equal to 50-75% of inorganic N.

mg kg^{-1}). The field was previously cropped conventionally for two years under corn and two under wheat. The experimental design used was a split-plot with four replicates; the main factor was the farming system (organic farming, *OF* vs. conventional farming, *CF*), with the rate of applied nitrogen as the secondary factor (*N0*, control plots; *N1*, fertilised plots; the annual rates applied are shown in table 1). The sub-plot was 5.4 m wide and 10 m long.

Four vegetable crops were grown in the sequence: 2004 – tomato (Podium F1); 2005 – bean (cv. Taylor) followed by savoy cabbage (***Brassica oleracea*** L. var. ***sabauda***, cv. Montalto Dora); 2006 – tomato (Podium F1); and 2007 – zucchini (***Cucurbita pepo*** L., Altea F1). Because of the low availability in the soil, 250 kg K_2O ha^{-1} as potassium sulphate (50% K) was applied annually at ploughing, to both the CF and the OF plots. In 2004, after the tomato harvest, 8000 kg ha^{-1} of lime (80% CaO) was used to adjust soil acidity in all the plots. As tomato and bean crops were watered by sprinkler, for the zucchini drip irrigation was adopted. Weed control was carried out using herbicides and cultivation in the CF plots, while a PP woven fabric film was used as mulch in the OF plots. Pest control, when necessary, was ensured by spraying with copper, sulphur, propolis, and biopesticides derived from plants (pyrethrum, rotenone, spinosad) in OF, whereas copper and chemical pesticides were used in CF. In 2004 and 2006, immediately after the tomato crop, a cover crop of Italian ryegrass (***Lolium multiflorum*** Lam. var. ***italicum***) was grown on the OF plots, then ploughed in before bean (2005) and zucchini (2007) were planted. Crop yields were determined for sample areas of 3.90-15 m^2 depending on the crop; marketable and discarded fruit weight, total biomass weight, and some important morphological and qualitative features were measured. ANOVA was performed for statistical analysis of all data (MSTAT-C Software); the LSDs were calculated for $P<0.05$ and $P<0.01$ levels.

Results and Discussion

Year 2004 – Processing tomato (figure 1). In the first year of the trial, marketable yields were not statistically different between the farming systems, according to Mazzoncini *et al.* (2000), although CF yielded about 13 Mg ha^{-1} more than OF. As regards the effect of fertilisation, only one case of statistical significance ($P \le 0.05$) was obtained: the fertilised plots yielded 163% more non-ripening fruits than N0 plots (24 vs. 9 Mg ha^{-1}). No significant interaction was found. The main qualitative traits of the marketable fruits were quite similar between the two farming systems (Nervo *et al.*, 2007).

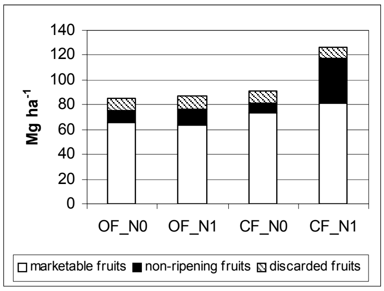

Figure 1: Processing tomato yields in 2004

Year 2005 – Bean (figure 2). No statistical differences in yields were obtained, although total biomass and bean seeds were higher in CF than in OF (7.6 vs. 4.9 and 1.78 vs. 1.21 Mg ha^{-1}, respectively); neither fertilisation, nor interaction with the farming system, had any effect. The absence of significant effects for bean may in part be due to increased soil variability caused by the liming.

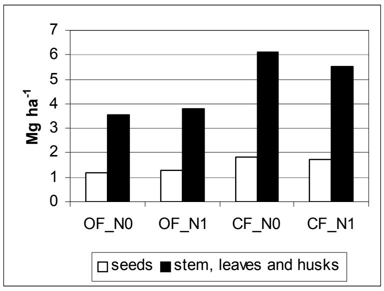

Figure 2: Bean yields in 2005

Year 2005 – Savoy cabbage (figure 3). Yields were not statistically different between farming methods, although the OF marketable yield was about 3 Mg ha^{-1} higher than CF. Nitrogen fertilisation and its interaction with the farming method was not statistically different, but the average weight of the marketable head in the fertilised organic sub-plots (OF-N1) was over 500 g higher than in the corresponding CF-N1 sub-plots (3 086 vs. 2 527 g).

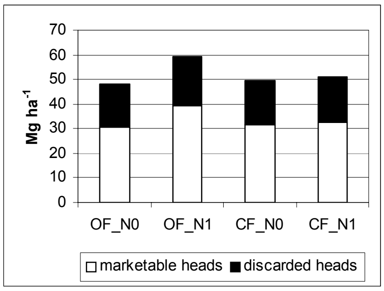

Figure 3: Savoy cabbage yields in 2005

Year 2006 – Processing tomato (figure 4). For the second tomato crop the marketable yields were not significantly different between the two farming systems. However, in the third year of the conversion period, OF yielded a higher percentage of marketable fruits (82%) than CF (68%). As in 2004, the non-ripening fruit yield of the fertilised plots (N1) was significantly higher than for control plots (N0), by more than 14 Mg ha^{-1}.The qualitative parameters of the marketable fruits, all included in values ranging from satisfactory to optimal, showed no significant differences; nitrogen fertilisation also had no effect on fruit quality, except for the acidity (Nervo *et al.*, *2007*). By the third conversion year, yield and quality of organically grown marketable tomato were competitive compared to those conventionally grown, partly because of the choice of the well-adapted and productive genotype Podium F1 (Dadomo *et al.*, 2002).

Year 2007 – Zucchini (figure 5). The two farming systems did not show any significant differences in marketable yield and fruit number. However, fertilisation was

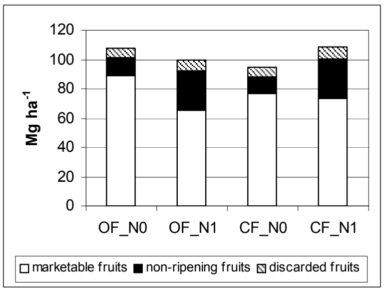

Figure 4: Processing tomato yields in 2006

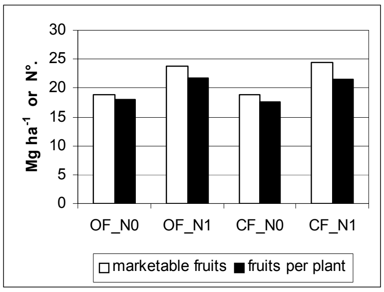

Figure 5: Zucchini yields in 2007

statistically significant for both parameters (P□0.001). N1 yielded 28% more marketable fruits than N0 (24.1 vs. 18.8 Mg ha^{-1}) with 22 vs. 18 fruits per plant. The use of the highly adaptable genotype Altea F1 (Azzimonti *et al.*, 2007) permitted optimal yields under both farming systems.

Conclusions

The yield performance during the 4-year period of the trial was quite good for all the vegetable crops, except bean. The changes which occurred in the soil did not significantly reduce the yields of organically grown compared with conventionally grown vegetable crops. The decrease in marketable yield in OF was 17% for tomato-2004 and 2% for zucchini; in contrast, for cabbage and tomato-2006 yields were 10% and 3% higher respectively.

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Comparative dynamics of tea (*Camellia sinensis* L.) roots under organic and conventional management systems with special reference to water use.

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Key words: organic, tea, roots, water use

Abstract

Comparative measurements were carried out in the on-going, long-term organic and conventional comparison "TRI OR-CON" trial at the Tea Research Institute of Sri Lanka. The tea was grown organically using tea waste (TW), neem oil cake (NOC), compost (COM) as soil amendments using IFOAM guidelines, which were compared with tea grown conventionally (CONV) with recommended synthetic inputs. Responses of the tea yield, root system and mass volume sap flow were studied.

The tea bushes showed comparable responses between all the treatments, the differences of which were not statistically significant: They exhibited similar yield, root distribution, growth, extension rates, mortality, mass volume flow of water and water use efficiency (WUE). The organically grown (ORG) tea bushes invested more roots in deeper soil layers than the CONV bushes.

The results showed that in terms of plant growth, managing tea organically is as equally feasible as managing tea in the conventional manner.

Introduction

Sri Lanka is the pioneer in organic tea production. However, organic systems provide more management challenges than conventional systems. Organic cultivation is often blamed for higher cost of production and low productivity, mainly owing to limited technology available (Peck, 2004). The comparative responses of the tea (*Camellia sinensis* L.) shoots in organic and conventional systems have been previously reported (Mohotti et al., 2001). However, there is very scarce information on the comparative responses of the tea root system in organic and conventional systems of tea, with even little information on the comparative studies on water relations.

Therefore, this study was carried out to examine and compare the behaviour of the root system and study the sap flow of field grown mature tea, grown under organic and conventional management systems.

Materials and methods

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This study was carried out in the on-going, long-term, organic and conventional comparison "TRI OR-CON" trial, established at St Coombs estate, Tea Research Institute, Talawakelle, Sri Lanka (latitude 6°55', longitude 80°40', altitude 1382 m amsl) during January 2004 to September 2006. The long-term average annual rainfall in this region is 2250mm and maximum and minimum temperature 22.8^{0}C and 14.2^{0}C.

The experiment consisted of approximately ten year-old tea bushes of the cultivar DT1, in a land area of approximately 1.6 ha, consisting about 20,000 bushes. Three treatments were managed organically according to IFOAM guidelines viz. TW, NOC and COM (TW and COM were given at 2kg per bush and NOC at 500g per bush, twice a year, which contained N%:P%:K% 2.4:0.4:1.7, 2.8:0.5:1.1 and 1.6:3.7:0.3 respectively). These were compared with tea grown conventionally (CONV), using recommended inorganic fertilizer and other recommended management practices by the Tea Research Institute (N:P:K at 270:123:200 kg ha^{-1} year^{-1}). The treatments were arranged in a randomised complete block design with four replicates. Two sub-plots each consisting approximately 25 bushes were separately maintained in each plot for monitoring yield. The bushes were plucked weekly and a representative sample was oven dried at 95 °C for extrapolation of yield per ha.

Three experiments were carried out in order to study the root dynamics and water relations: In the first experiment (January 2004), the distribution of the tea root system was studied. Soil was sampled in fixed volumes of (3375 cm^2) using a soil core sampler, at different distances from the base of the tea bush and at different depths. The roots were hand-separated and measurements on the root length and weights were taken. Soil N, P, K, organic C (OC) and soil moisture (MC) contents were analyzed using standard methods. Data were statistically analyzed using GLM procedure in SAS statistical package and the means were separated using Duncan's Multiple Range Test.

In the second experiment, root windows that were constructed in 10 bushes in each treatment, using a plane glass fixed to a metal frame, were used. Root maps were drawn in two-week intervals, during December 2005 to September 2006. Root growth rate, extension rate, regeneration and mortality were measured using the root maps. Data were statistically analyzed using GLM procedure.

In the third experiment, sap flow was monitored using sap flow sensors (Thermal Logic, USA) using the heat-pulse technique, which was fixed to a data logger, in November and December 2005. An average rainfall of 114 mm was received during this period (long-term average is 112mm). Only TW and CONV treatments were included in the experiment due to practical limitations. Water use efficiency (WUE) was calculated as the ratio between dry matter accumulation and mass flow per day. Soil moisture content was measured weekly by drying soil samples at 105°C. Data were statistically analyzed using GLM procedure.

Results

The yield and soil nutrient contents were not statistically significant at P=0.05 (data not shown). Differences were significant with soil OC (at P>0.0013) and probably resultantly in soil MC (at P>0.0027) during a relatively dry period (in experiment 1, 25.8%, 23.4%, 25.9% and 22.7% in TW, NOC, COM and CONV respectively).

The root distribution parameters (i.e. root weight, total root length) did not significantly differ (at P=0.05) between the treatments. The total root (young and mature) fresh weights were not significant at P=0.05, but when expressed as a percentage of roots in different depths (Figure 1b), showed that in organic treatments, more roots were concentrated in the deeper layers of soil (i.e. 37% and 35% in 15-30cm and 30-45cm depths respectively in overall ORG treatments vs 31% and 31% respectively in CONV) while in CONV, more roots were concentrated in the topmost layer of soil (38% as against 29% in overall ORG treatments) (Figure 1b).

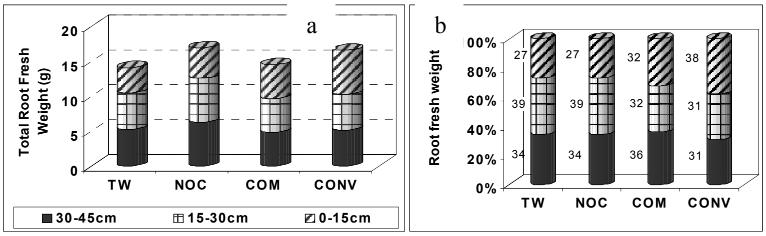

Figure 1a: Distribution of tea roots in different soil depths and figure 1b: root fresh weight as a percentage of the total, in each soil depth.

Feeder root growth rate (Figure 2a), length, mortality and extension rate (data not shown) did not significantly differ between the treatments. However, root regeneration rate (Figure 2b) as measured by the number of root tips at each measurement, was significantly higher in ORG plants compared with the CONV.

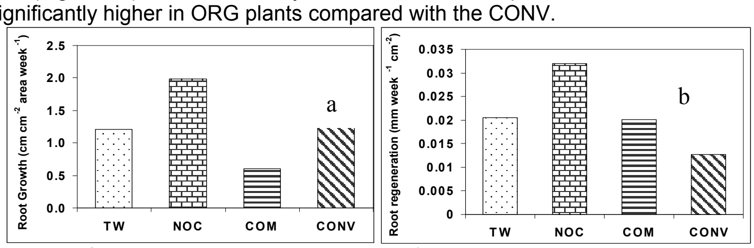

Figure 2: Growth and regeneration rates of tea roots.

Sap flow studies showed that the volume flow was slightly higher (not significant at P=0.05) in the CONV treatment (Figure 3a). However, TW showed higher water use efficiency (WUE) compared to CONV (Figure 3b). During this study, the soil moisture content did not differ significantly (34.78% and 34.81% in TW and CONV respectively).

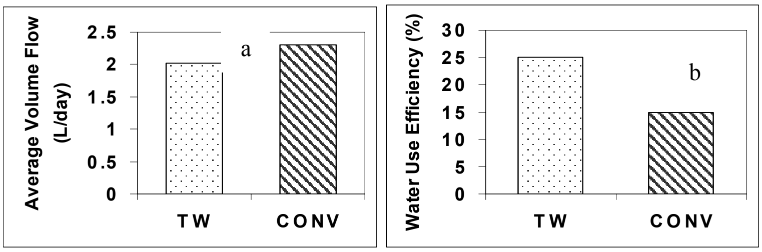

Figure 3a: Average volume sap flow and b. water use efficiency.

Discussion

The tea bushes grown organically and conventionally showed similar performances in terms of root growth and yield. These results agree with earlier observations made on comparisons between organic and conventional systems of young tea (Mohotti et al., 2001) and some other crops such as apple (Reganold et al., 2000), corn (Lang, 2005), tomatoes (Mitchell et al., 2007) and soybean(Lang, 2005; Prasad, 2005).

Organically grown tea also seemed to invest on a deeper root system compared to the conventionally grown tea, as reported earlier by Mohotti et al. (2001) in young tea and similarly in other crops such as soybean (Prasad, 2005). These differences could also be seen in the WUE, as the TW exhibited higher WUE than CONV. The volume sap flow was comparable in both CONV and TW. The results also show that the plants in organic systems use the resources more usefully than the CONV systems. Repeating the sap flow studies during a dry season can be suggested. In this study, organic cultivation did not change the soil nutrient content, but improved the organic carbon content in soil. Resultantly, during dry periods organically managed soils held more moisture.

Conclusions

The study emphasizes that organically and conventionally grown tea exhibit similar growth performances, in terms of the responses of the root and shoot systems. This shows the feasibility of growing tea organically, without affecting the yield or plant performance.

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Effects of arbuscular mycorrhizal fungi and free-living nitrogen-fixing bacteria on growth characteristics of corn (*Zea mays* L.) under organic and conventional cropping systems

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Keywords: Organic and low input cropping systems, mycorrhiza, free-living nitrogen-fixing bacteria.

Abstract

In recent years, biological fertilizers have received special attention in sustainable agriculture. Inoculation with arbuscular mycorrhizal fungi and free-living nitrogen-fixing bacteria had significant effects on corn photosynthesis and yield; the highest photosynthesis rate and yield were obtained with dual inoculation with fungus plus bacteria. These outcomes were also affected by cropping systems, but to a lesser extent. Therefore in organic and low input cropping systems, a combination of mycorrhiza and free-living bacteria performed satisfactorily.

Introduction

Biological fertilizers are gaining importance in sustainable cropping systems. Application of mycorrhiza and nonsymbiotic nitrogen-fixing bacteria have been shown to enhance soil fertility and availability of nutrients for plants (Cardoso et al. 2006, Dodd, 2000), and to increase photosynthesis and water use efficiency (Estrada-Luna & Davies, 2003; Auge 2000; Gosling et al. 2006; Wu & Xia 2006), and also resistance to biotic and nonbiotic stresses (Jeffries et al. 2003).

Materials and Methods

An experiment based on a randomised complete block design with split plots and three replications was conducted in the Research Farm of Ferdowsi University of Mashhad in 2006 to evaluate the effects of biofertilizers on corn under four different cropping systems. The cropping systems, including high, medium and low input and also an organic system were allocated to the main plots, and four inoculation treatments including application of *Glomus intraradices* (mycorrhiza), *Azotobacter paspali* (bacteria), *Azospirillum brasilense* (bacteria), a combination of fungus plus two bacteria, plus a control (no inoculation) were allocated to the subplots. Specification of the cropping systems is shown in table 1. Nutrient contents of the manure used were 2.36, 0.59, and 2.08 % N, P and K respectively. Original nutrient contents of the soil were: 800, 37 and 400 ppm N, P and K respectively. Corn seeds inoculated with fungus and bacteria (except the control plots) were planted in rows 75 cm apart with 25 cm between plants in the row. During the growth period, photosynthesis rate (using LC*i*, ADC Ltd., UK), dry matter yield and finally seed yield (14% moisture content) were measured. The statistical method used was the analysis of variance (ANOVA). Data were analyzed with Minitab software Ver. 13, and means were compared with

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Duncan's multiple range test. The probability level for the determination of significance was 0.05.

Tab. 1: Amounts of input consumption and agronomic practices in different cropping systems.

Inputs	Cropping systems			
	High input	Medium input	Low input	Organic
1- Soil amendments (times)				
Tillage (Moldboard plow)	2	1	-	-
Disk	3	3	3	1
Leveler	3	3	2	1
2- N-P_2O_5-K_2O (kg ha^{-1})	220:150:100	170:100:50	120:50:0	-
3- Cattle manure (t ha^{-1})	-	-	-	60
4- chemical control of plant pests and disease (times)	2	1	-	-
5- Chemical control of weeds (times)	3	2	1	hand control

Results and Discussion

Inoculation with fungus and/or bacteria increased the photosynthesis rate (Fig. 1). This has also been found elsewhere (Panwar, 1991; Wu & Xia, 2006) and has been reported to be associated with higher stomatal conductance (Wu & Xia, 2006) and stimulation of photosynthesis by providing extra sink for the assimilates (Wright et al. 1998).

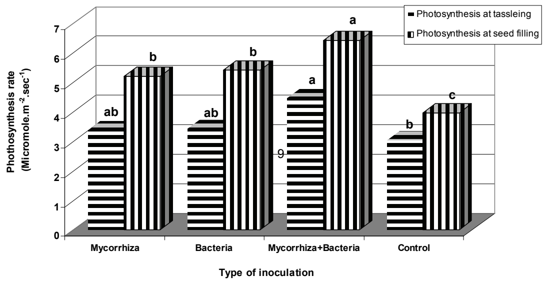

Figure 1: Rate of photosynthesis at two stages of plant growth due to the type of inoculation. In each stage, means that follow the same letters have no significant difference (p<0.05).

Application of a combination of a fungus and bacteria showed the highest dry matter yield (Fig. 2). Such results have also been reported by others (Panwar, 1991; Sanches-Blanco et al. 2004). However, there are cases with no effect reported (Wright et al. 1998).

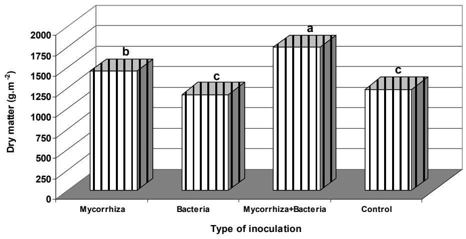

Figure 2: Corn dry matter yield with different type of inoculations.
Means that follow the same letters have no significant difference ($p<0.05$)

In Fig. 3 seed yield changes associated with cropping systems are shown. In general, there were no consistent differences between cropping systems. In other words, seed yield has not changed much by type of cropping systems; this could be an indication of similar performance of organic systems compared with even a high input cropping system. Pimentel et al. (2005) reported that energy efficiency and yield may increase in organic farming compared with conventional systems.

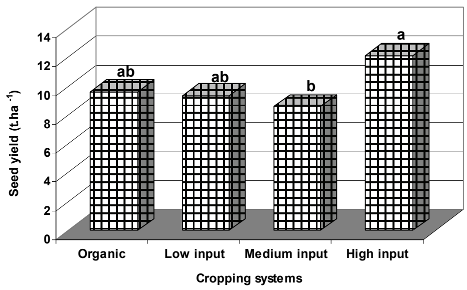

Figure 3: Corn seed yield with different cropping systems.
Means that follow the same letters have no significant difference ($p<0.05$)

Conclusion

It appears that in general, application of biofertilizers in promising and there are good reasons to believe that organic systems could perform satisfactorily in terms of yield compared with systems using other externally applied inputs. There were no significant interactions between two factors in the criteria measured. However, this experiment is being repeated for the second year to clarify the results.

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Cropping Intensity and Organic Amendments in Transitional Farming Systems: Effects on Soil Fertility, Weeds, Diseases and Insects

Wander, M[1]., Eastman, C., Zaborski, E., Eastburn, D., Masiunas, J., Engiseth, N. Ugarte, C., Marzano, S.-Y. & Rosa, I.

Key words: Organic transition strategies; farming systems; soil quality, plant quality,

Abstract

The Windsor Organic Research Trial (WORT) is a farming systems experiment initiated in 2003 to investigate alternative strategies for transitioning to certified organic vegetable production that compares the influence of transition schemes that differ in management intensity (cropping, tillage) and organic matter inputs on weeds; soil organic matter and nutrient availability; soil invertebrate communities; and the relationship between soil fertility, plant health and insect/disease pressure. Soil quality was improved during transition in all systems. Conventional soil tests were unable to document differences among systems that were reflected in biotic indicators. The pasture-based transition system was superior.

Introduction

The WORT study is an interdisciplinary project carried out in partnership between the Illinois Natural History Survey (INHS) and University of Illinois. The project was an outgrowth of efforts that began in 2001–02: with experienced organic growers who became our advisors. Six acres were planted to winter rye cover crop in 2002. The broad objectives were to: to compare the influence of transition schemes that differ in: management intensity (cropping, tillage) and organic matter inputs on: weed populations, soil organic matter and fertility, soil invertebrates, and the relationship between soil fertility, plant health and insect/disease pressure.

Materials and methods

Three farming systems (treatments) representing different cropping intensities: 1) high-intensity transition (intensive vegetable production), 2) intermediate-intensity transition (organic cash-grain), and 3) low-intensity transition (perennial ley system). Treatments are divided into sub-treatments representing different strategies for organic matter and fertility management: a) plant inputs (e.g., cover crops) providing all organic inputs and N fertility, b) plant inputs plus composts, or c) plant inputs plus fresh wastes or manure. These transition strategies are being evaluated using a systems research approach. Baseline data was collected for comparison with variables at the completion of transition (2006). The site is a randomized complete block with four replicates that include fertility treatments applied as a split plot within. Priorities established separately for each farming system-based transition scheme determined amendment applications. Sawdust-pack dairy manure and compost were applied to appropriate subplots in fall 2003 for the medium-intensity system and in spring 2004 for the other systems based on anticipated nutrient needs. Initial soil test

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values (pH, P, K) were in the high to very high range for all plots; thus, no separate additions of lime or mineral K sources were made. Manure and compost were added to appropriate subplots in all systems in fall 2005; winter rye was broadcast and incorporated in the high- and medium-intensity treatments only. Rotations are summarized in Table 1. The ley treatment plots were tilled under in spring 2006, and the rye in the other treatments was mowed and incorporated. For 2006, three varieties of tomatoes and peppers were grown across all systems. Plastic mulch and straw was used to control weeds in the vegetable crop system in 2003. In all years, weeds emerged were controlled in the vegetable- and row crop transition systems as time allowed using both mechanical and hand methods. Mowing and selected hoing of thistle were used in the ley system. Rotation and crop choice were the principal tools used to control diseases and pests. Scoting for pests was used to determine application need. Entrust (Spinosad) was applied in 2004 for control of cabbage caterpillar complex. Blue Ballet (a hubbard-type squash) was planted in 2005 as a perimeter trap crop for squash insects with Pyganic EC (Pyrethrum) applied if needed.

Soil-cores to 1 m were taken in 2003 & 2006 and work on biological attributes began in 2004. Variables considered include standard soil texts for pH, extractable P, K, base cations, total soil organic matter and particulate organic matter (POM) after Mariott and Wander (2006), nematode community information after Bongers and Ferris (1999), soil N mineralization potential (PMN & ISNT) (after and Khan et al. 2001). Disease ratings were taken each year in the field. Soil samples taken throughout the study were used in greenhouse-based bioassays to evaluate their disease suppression characteristics against: *Rhizoctonia* root and stem rot, *Phytophthora* root and stem rot, and sudden death syndrome. The influence of cropping intensity on predatory arthropods, such as spiders and ground beetles was evaluated during the transition phase of the study. Pitfall trapping was carried out each year to assess abundance/activity of ground beetles and other feeders on insect prey and/or weed seeds. Bait stations and quadrat sampling were carried out in 2003 and 2004. Emerged weed counts and seedbank estimations were carried out annually. Plant assays included measurement of yield with harvests in the vegetable crop system being carried out to estimate direct and whole sale markets. Tomato fruit quality (BRIX, pH) were evaluated in the Roma variety in 2003 and 2006. Ascorbic acid was determined in 2006.

Results

Transition strategies used did not differ in their ability to build soils. Standard tests indicate fertility was improved in all cases by conversion to organic management (Tab 2). The only difference among systems was their ability to change soil pH; pH was increased in the low input pasture-based scenario. The calcium-to-magnesium ratio, which was already above the 7.5 value recommended by many, increased under organic management. Nematode maturity Index determinations during transition indicated that the nematode community was dominated by bacterial and fungal feeding nematodes that influence N mineralization. This was consistent with high levels of plant available N. In 2006, regardless of amendment type, all three transition strategies maintained target POM-C concentrations and contained labile N concentrations (PMN, ISNT) that were high and possibly in excess. This is suggested by the nematode enrichment index (EI) which indicates the presence of bacterial and fungal feeding nematodes responsive to N-enrichment. High structure index (SI) values suggest the nematode community was diverse and complex at the start of the transition year. Values fell under intensive vegetable cultivation regardless of history.

Up until 2006, we saw no effect of cropping system or type of organic amendment on levels of disease severity or root system characteristics in the field. Diseases observed on tomatoes in 2006 included *Septoria* leaf and fruit spot, anthracnose, and some virus infections. Pepper diseases included bacterial spot and *Phytophthora* fruit rot. Levels of *Septoria* and anthracnose on tomatoes were significantly affected by previous cropping history and by type of organic amendment.

Tab. 1: Rotation and field management summary

Date		*Pasture (Ley)*		*Row crop*		**Vegetable crop**	
		Crop	_Mgt[¥]_	_Crop_	_Mgt_	_Crop_	_Mgt_
03	W			Winter rye		Winter rye	
	S	Alfalfa, Red	¥		T		2XT
	S	cover, Alsike	2Xt	Soybean	3Xt	Tomato	3Xt;Mul;LF
	F	clover,		Winter wheat			
04	W	Timothy,				Fallow	t
	S	Orchard				Winter pea	
	S	grass	M&C	Fallow		Broccoli	3XT;2Xt;M&C
	F			Hairy vetch	M&C		t
05	W					Wheat & Vetch	
	S			Field corn	T		T
	S				4Xt	Winter squash	
	F		M&C	Winter rye	M&C		2Xt; M&C
06	W					Winter rye	t
	S	Tomatoes	1X2	Tomato	1X2	Tomato	1X2
	S		2X3		2X3		2X3

[¥] Where T= disruptive tillage by aggressive means using moldboard plowing, spading or bed shaping; t= soil disturbances caused by field cultivation or disking. The number eg: (2X) indicates the frequency of the operation during the season. M&C indicates the times when manure and compost were added to appropriate subplots. “Mul” refers to the use of plastic and wheat straw mulch and ‘LF” identifies when ≈ 0.5 L of dilute liquid fish emulsion was applied to M & C plots.

The lowest levels of *Septoria* leaf spot were in the low-intensity (ley) and high-intensity (vegetable) system plots; highest levels occurred in the intermediate-intensity (grain crops) plots. *Septoria* severity also was higher in non-amended subplots than in subplots receiving compost or manure. Anthracnose levels were highest in the high-intensity system plots and in subplots not amended with compost or manure. For bacterial spot on peppers, incidence levels were highest in the intermediate-intensity plots and lowest in the high-intensity plots. Bacterial spot levels were not significantly affected by amendment treatments. Based on greenhouse bioassays, we see a general reduction in disease severity and an increase in root system length and volume over the four years of the study. The number of emerged weeds per plot in the different systems decreased between 2003 and 2006. In 2003, the ley-system had the most weeds, but in subsequent years it had fewer weeds than the other systems. Weed species composition changed depending on management intensity and year, while weed species diversity in the seed bank increased between 2003 and 2005. Fewer lambsquarters (*Chenopodium album*) emerged due to later plantings, but there were more pigweed and waterhemp (Amaranthus spp.). Common purslane (*Portulaca oleracea*) was first found in 2005. Increasing weed pressure was encountered during 2006 & 2007. There was little evidence that soil fertility management altered insect pest abundance during the course of the study. Investigations of abundance of carabid beetles (*Pterostichus melanarius*) conducted during the first two years of transition showed that the ley-system supported larger carabid beetle populations.

Tab. 2: Changes in soil properties (0-6”) during four year transition from conventional cash grain based system to organic vegetable crop production

Year		Bray P	K	Ca	Mg	SOC	C/N	pH
		ppm				(%)		
2003		53a	167a	2228a	245a	2.21a	11.9a	6.76
2006		61b	261b	3062b	321b	2.36b	12.7b	6.8
2003	ley□							6.7a
2006	ley							6.9b
		ppm						
		0.03	0.0001	0.0001	0.0001	0.1	0.006	.08

□Differences in pH were significant only in the pasture-based system

In 2006, when plots were eligible for organic certification, yields differed as a result of management with yields after the perennial-ley always exceeding those in the intermediate and high intensity annual cropping systems. Yields did not differ among the intermediate intensity grain and high intensity vegetable system for any of the tomato varieties but there was a significant increase in yield where fertilizers were applied within those treatments. Yields of ‘Roma’ tomatoes were higher in 2003 than in 2006. Water and weed management are likely contributing factors. Fruit quality differed among varieties but did not vary based on management past except for brix, which were significantly greater in ‘Classica’ tomatoes grown in vegetable transition plots than in ‘Classica ‘ tomatoes grown after ley-transition.

Conclusions

The three transition systems compared maintained different environmental conditions during transition that were apparent in beetle and nematode communities and disease suppression evaluated in the green house, appeared to increase in all instances. The ley system minimized increases in weed populations. Despite extremely different management pasts, soil quality was improved during transition in all systems. Conventional soil tests were unable to document differences that were apparent in nematode community structure, disease incidence in the field and yields achieved. These results indicate that the pasture-based transition system is superior

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Sustainable management

Residues in beeswax after conversion to organic beekeeping

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Key words: beekeeping / beeswax / acaricide/ residue / *Apis mellifera*

Abstract

Beekeepers interested in converting their honey farms to organic management must replace old combs with organic foundations. The experiment described in this paper compares two methods of replacement of old combs, "fast" (5 combs per year) and "slow" (2 combs per year), by measuring the levels of acaricide residues in the newly built combs. Considered acaricides were coumaphos (Perizin and Asuntol), fluvalinate (Apistan) and clorfenvinphos (Supona). Significant differences between the two replacement groups were observed only for the Apistan group in the third year, confirming high lipophilicity of fluvalinate. The residue levels in the newly built combs three years after beginning the conversion were significantly lower than initial levels for all products. Direct contamination of the combs was evaluated at the beginning of the trial and was found to be highest in Asuntol-treated hives and lowest in Perizin-treated hives. Residues in honey exceeding EU Maximum Residue Limit were found only in the case of Asuntol.

Introduction

Beekeeping is one of the Italian agricultural sectors in which the organic production method has registered a great proportion of adherents: the number of organic beehives rose from 48000 in 2001 to 72000 in 2005 (SINAB, 2006). According to the EU Reg.1804/99 the conversion of traditionally managed honey farms to organic production methods must be carried out by substituting all the combs in the hive with foundations obtained from organic beekeeping. The implementation Decree issued by the Italian Ministry of Forestry and Agriculture Policies on 29/03/2001, specifies that this substitution should take place within 3 years to limit contamination of new combs. It has in fact been shown that some acaricides, due to their lipophilic nature, can contaminate both the combs present in the hive during the chemical treatment (direct contamination) and the new combs built by the bees (indirect contamination) even 18 months after the treatment (van Buren, 1992). Experiments by Bogdanov et al. (1998) showed that acaricide residues in beehive products decreased according to the order: brood combs>honey combs>> honey. While acaricide levels in honey are found to be generally lower than the accepted MRL levels, in comb wax the residues tend to accumulate (Wallner, 1999) and, if the levels are high, residues can pass into honey (Kochansky, 2001).

The experiment described in this paper aimed at comparing two conversion methods in which substitution of old combs took place over two or more years. The experiment also gave us a chance to evaluate the differences in direct and indirect contamination of the selected acaricides, by analysing residue levels in old and newly built combs in the years following the interruption of traditional acaricide treatments.

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Materials and methods

The experiment was carried out in apiaries consisting of 15-20 hives each, in which the beehives had been treated with on of the following commercial products for at least 5 preceding years:

- Perizin® (Bayer), active ingredient: coumaphos. Registered for use on honeybees;
- Asuntol® (Bayer), active ingredient: coumaphos. registered for use on cattle, sheep and dogs. The beekeeper used 0.5 g of Asuntol 50 powder mixed with icing sugar to disperse over the combs;
- Apistan® (Vita Europe), active ingredient: fluvalinate. Registered for use on honeybees;
- Supona® (Cyanamid), active ingredient: chlorfenvinphos. Registered as a cattle dip. The beekeeper impregnated wooden strips with 1 ml of a.i. and placed them at the entrance of the hive.

The hives in each apiary were equally divided between the two replacement methods, which differed in the time scale of comb substitution with residue-free foundations: in one group of hives the conversion took place in 2 years, replacing 5 combs each year ("fast replacement"); in the other group 2 combs per year were replaced ("slow replacement"). During the experiment, *Varroa destructor* infestation was controlled according to organic beekeeping methods (thymol-based products in August and oxalic acid sucrose solution in November or December).

Initial levels of residues (and thus direct contamination of the wax by the applied acaricide) were determined in year 2000 by sampling combs which had been present in the hive for at least 4 years ("old combs"). Collection of new comb wax, honey cap and honey samples were carried out until 2003, when conversion was over for the fast replacement hives, and a single overall sample was collected. Samples from all combs described below were collected by cutting out portions measuring 15 cm x 15 cm, whereas honey caps and honey were collected after honey extraction. The residues in the newly built combs were also used to determine the indirect contamination caused by each product. The samples were analysed for presence of residues of the acaricide pertinent to each apiary by the laboratory of the Istituto Nazionale di Apicoltura (certified UNI CEI EN ISO/IEC 17025).

Comparisons between the mean wax residue levels of the two replacement techniques were carried out using one-way analysis of variance (ANOVA). To establish differences among different aged combs of a same group (same a.i.), Scheffé's multiple comparison procedure in GLM analysis was used at the P=0.05 significance level.

Results

The only difference in the kind of replacement occurred in the 2003 overall sampling in the hives that had been treated with Apistan (P=0.034), where the mean level of residues was lower in the fast replacement group. For the other products no significant differences were observed between the two kinds of replacement in any of the considered years (Tab. 1).

Tab.1: Mean residue levels (µg/kg ± SE, n= number of samples) in the brood comb wax in the two different replacement groups (fast and slow).

Product	Comb replacement	Old combs (2000)	New combs (2001)	New combs (2002)	New combs (overall 2003)
Perizin	FAST	272 ± 80, n=8	154 ± 69, n=8	N.D., n=9	21 ± 7, n=23
	SLOW	199 ± 63, n=7	329 ± 14, n=7	N.D., n=6	16 ± 3, n=18
Asuntol	FAST	4969 ± 590, n=12	973 ± 261, n=9	37 ± 14, n=12	183 ± 37, n=12
	SLOW	3588 ± 728, n=7	1260 ± 461, n=7	56 ± 20, n=7	213 ± 49, n=21
Apistan	FAST	3787 ± 1448, n=5	913 ± 247, n=6	139 ± 65, n=4	205 ± 44, n=10 [a]
	SLOW	3475 ± 886, n=8	1256 ± 303, n=5	316 ± 60, n=8	468 ± 87, n=16 [b]
Supona	FAST	673 ± 195, n=5	251 ± 76, n=7	76 ± 40, n=6	40 ± 11, n=16
	SLOW	793 ± 133, n=5	188 ± 50, n=5	34 ± 4, n=8	19 ± 3, n=17

The overall 2003 value refers to comb wax built in 2001 and 2002 for the “fast replacement” group and in 2001, 2002 and 2003 for the “slow replacement” group. Different letters in the Apistan (fluvalinate) row indicate significant differences (P=0,034). N.D.= not detectable.

Residue levels due to direct contamination were found to respect the following order: Asuntol > Apistan >> Supona > Perizin. To establish differences in the indirect contamination of newly built brood and super combs in hives treated with different products data from the replacement groups were pooled, as the differences between the 2 replacement theses were not statistically significant (with the exception of Apistan in the 2003 overall sampling, which has however been shown as a whole in figure 3). Results are shown in figures 1 to 4, where contamination is expressed as mean residue levels (± SE) of coumaphos in the brood-combs and honey-combs. Different letters over bars indicate significant differences (P < 0.01) calculated separately for brood combs and for honey combs. The year in brackets indicates time of sampling.

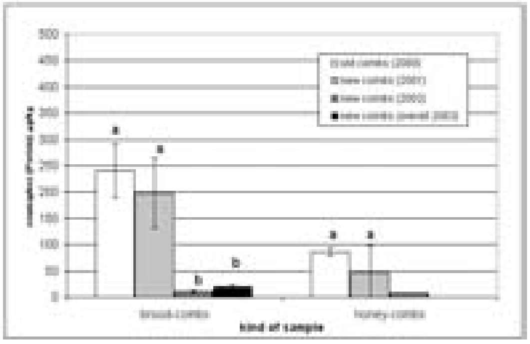

Figure 1: Wax contamination in hives treated with Perizin (coumaphos) until year 2000. Samples of honey-combs were collected from individual supers in 2000 and 2001 and as a single apiary sample in 2002.

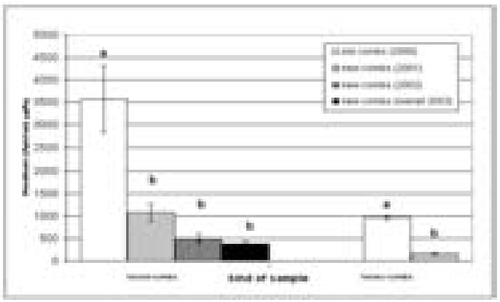

Figure 2: Wax contamination in hives treated with Apistan (fluvalinate) until year 2000. Samples of honey-combs were collected from individual supers in 2000 and 2001 (only new combs).

Discussion

Comb wax at the end of experiment contained residues of the previously used acaricides (compared to initial concentrations: 4% Supona, 5% Asuntol, 8% Perizin and 10% Apistan), independently from the speed of replacement. This confirms that a complete renewal of the brood combs in the hive over 2 or more years is not sufficient to guarantee complete absence of residues of some of the used products (not only for the unregistered Asuntol but even in the case of Apistan). The decision adopted by many Organic Farming Control Bodies in Italy, to accept certain levels of residues in brood comb wax in the initial years of organic management, therefore appears justified. The same allowance is also valid for the melted honey-cap wax used to be transformed in foundations by the converting beekeepers. The risks of using coumaphos in the unregistered product Asuntol, in terms of high levels of residues which may contaminate honey for human consumption, are confirmed by this study.

Acknowledgments

We wish to thank the beekeepers who contributed their time and hives to this project: Roberto Guidetti, Giovanni Scozzoli, Riccardo Durì.

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Sustainable management of foxtail meadows through hay making at seed maturity

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Key words: grassland management, meadow foxtail, *Alopecurus pratensis*, self-reseeding, botanical composition

Abstract

Harvesting meadows at early heading of the grasses yields large quantities of high quality forage but might in the long term cause the swards to deteriorate due to the lack of formation of mature seeds. We studied 4 cutting regimes on a foxtail meadow to define which would maintain the foxtail population naturally and is acceptable in terms of forage quality. The 1st cut of the different cutting regimes was done either at early shooting, shooting, early heading or seed maturity of Alopecurus pratensis *L.. The 2nd cut of the 3 first treatments was simultaneous to the 1st cut of the 4th treatment and was ground dried to allow the seeds to fall on the soil. When the meadow was harvested regularly at early heading of* A. pratensis*, its botanical composition deteriorated within 5 years and its yield decreased. With a 1st cut at seed maturity,* A. pratensis *produced the most seeds and its proportion in the sward increased, but the forage had the lowest quality. In the treatments with the 1st cut at early shooting or at shooting,* A. pratensis *produced significant quantities of seeds during the 2nd regrowth, maintained its population and forage of intermediate quality was produced. Sustainable production of quality forage on intensive foxtail meadows might be achieved by periodically having the 1st cut at shooting and using the second regrowth at seed maturity for ground dried hay.*

Introduction

In order to harvest large quantities of high quality forage, the first cut of intensively used meadows is usually carried out when the inflorescence of the main grass species is emerging. This cutting regime neither allows the grasses to produce seeds, nor triggers their tillering (Gillet, M., 1980), and therefore may cause a considerable decrease in the proportion of forage grasses in the sward in the long term. The disappearance of good forage grasses can be avoided by regular overseeding with commercial seeds, but organically produced seeds of adapted genotypes are not always available. This is especially true for species that are not very widely grown like meadow foxtail (*Alopecurus pratensis* L.). On the other hand, meadow foxtail is a very interesting grass species for growing conditions unfavourable to ryegrass species. This study aimed to define a sustainable intensive management of foxtail meadows allowing the grass to produce seeds with a minimum loss of forage quality.

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Materials and methods

Four cutting regimes were applied over 5 years to an intensive permanent meadow with about 40 % initial yield proportion of *A. pratensis*. The cutting regimes differed from each other by the date of the 1st cut, which was either at early shooting (ESh), shooting (Sh), early heading (EHe) or seed maturity (SMa) of *A. pratensis*. The 2nd cut of ESh, Sh and EHe was simultaneous to the 1st cut of SMa, allowing plants of *A. pratensis* to reach seed maturity in ESh and Sh. The 15 m^2 permanent plots were harvested 6 times per year in ESh, Sh and EHe and 5 times in SMa. At the 2nd cut (1st cut of SMa) the forage was ground dried on each plot and the number of seeds falling on the soil during hay making assessed by placing 4 Petri dishes 8.5 cm in diameter in the soil. The botanical composition of the plots was estimated yearly in May according to Dietl (1995), modified to 12 yield proportion classes. The energy value (MJ NEL kg^{-1} DM) of the forage (200 g subsamples) was evaluated based on the digestibility of organic matter according to Tilley and Terry (1963). The plots were arranged in a randomized complete block design with 4 replicates. Differences between treatments are shown as the results of the combined ANOVA over the years 1 to 5 for the number of seeds produced (after square-root transformation of the data) and as the results of ANOVAs on the year 1 or year 5 data for the yield and the proportion of *A. pratensis*.

Results

In SMa the average quantity of *A. pratensis* seeds that fell on the soil was 31 kg ha^{-1} yr^{-1} (Tab. 1), with large differences between the years (from 7 to 66 kg ha^{-1}). The quantity of matured seeds of *A. pratensis* produced in ESh and Sh reached 29 to 60 %, and 15 to 63 %, of the seed quantity produced in SMa respectively (Fig. 1A). Only very few seeds were produced in EHe. From the 1st to the 5th experimental year, the yield proportion of *A. pratensis* strongly increased in SMa, was maintained in ESh and Sh, and strongly decreased in EHe (Fig. 1B). In EHe, the decrease in *A. pratensis* was compensated by an increase in the proportion of *Poa trivialis* L. and *Taraxacum officinale* agg., which are low yielding species. Correspondingly, the annual dry matter yield of the EHe treatment was 12.8 t ha^{-1} in year 1 but decreased to only 10.2 t ha^{-1} in year 5 (Tab. 1). This trend of decreasing yield was not observed in the other cutting regimes. The annual yield in ESh and SMa was therefore lower than in EHe in year 1, but was higher in year 5 (Fig. 1C). The energy value of the forage harvested at the 1st cut was lower in EHe than in ESh and Sh (Fig. 1D). By the 2nd cut (1st cut in SMa), the energy value of the forage was lowest in SMa and highest in EHe. From the 3rd cut onwards, no difference in energy value was observed between the treatments.

Discussion

When harvested every year at early heading, the population of *A. pratensis* was not able to regenerate itself with seedlings and its proportion in the meadow strongly declined. *A. pratensis* can also propagate vegetatively by short stolons, but because apical dominance is strong at heading (Murphy & Briske, 1992), cutting at this stage is probably also unfavourable to stolon formation. Consequently, the botanical composition of the sward deteriorated within 5 years and the yield decreased. This cutting regime should therefore be modified to sustain the population of *A. pratensis* in order to avoid problems with undesired plant species, which once established, are very difficult to control in organic farming. The population of *A. pratensis* was promoted by a 1st cut at seed maturity, when the plants could produce the most seeds. This indicates that reproduction by seeds is an important process for *A. pratensis* populations. But this cutting regime yielded the forage with the lowest quality and lodging was a problem for the very late harvest of this nutrient-rich meadow. In the two cutting regimes with a very early 1st cut and a late 2nd cut (ESh and Sh), the lower seed production than in SMa shows that many of the apexes were removed at the 1st cut. Nevertheless, *A. pratensis* still produced significant quantities of matured seeds and was able to maintain its population in the meadow. Under these two cutting regimes, *P. trivialis* and *T. officinale* were not able to increase their population and the total yield of the sward was maintained.

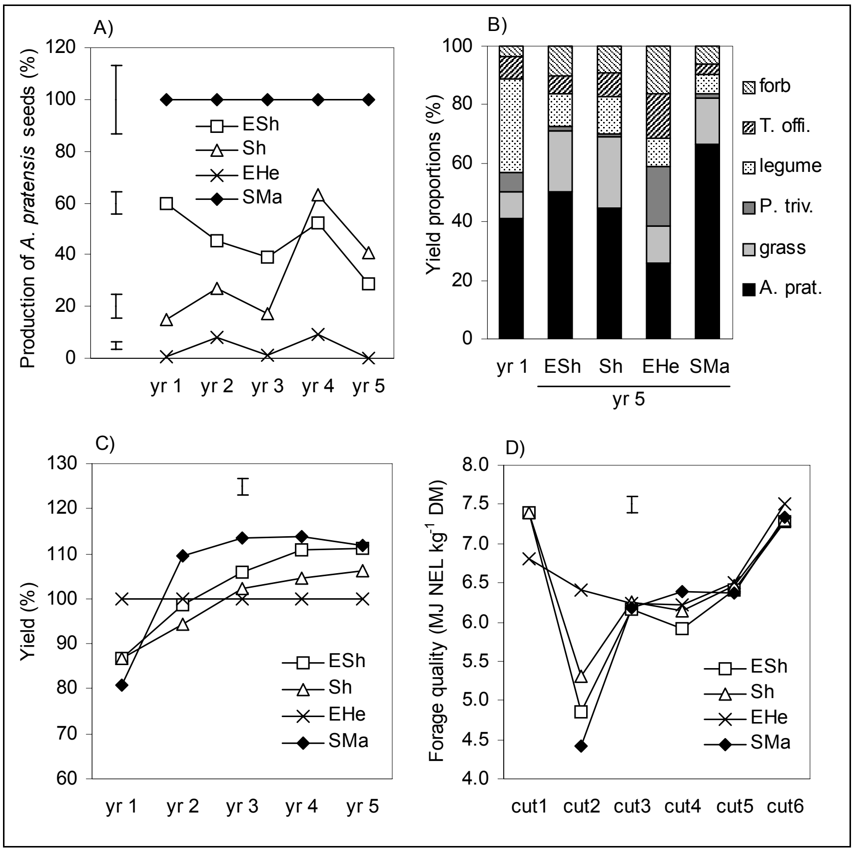

Figure 1: A) Production of *A. pratensis* seeds in the different cutting regimes from the 1st to the 5th experimental year (yr 1 to yr 5) given in percent of the seed quantity produced in SMa, B) Botanical composition of the sward in May, in yr 1 and after 5 years of differing cutting regime, C) Evolution of the annual yield from yr 1 to yr 5 given in percent of the yield in EHe, D) Energy value of the forage at each cut of yr 5 for the different cutting regimes. ESh = 1st cut at early shooting, Sh = 1st cut at shooting, EHe = 1st cut at early heading, SMa = 1st cut at seed maturity, A. prat. = *Alopecurus pratensis*, grass = other forage grass species, P. triv. =

Poa trivialis, legume = legume species, T. offi. = *Taraxacum officinale*, forb = other forb species. Error bars = averaged s.e.m (n = 4; in A) given in % of mean of SMa).

Tab. 1: Quantity of *Alopecurus pratensis* seeds produced, yield and proportion of *A. pratensis* (*A. prat.*) in the sward in the different cutting regimes. In a column, the means followed by a common letter are not significantly different at the 5% level by LSD.

	Seeds (kg ha^{-1} yr^{-1})	Yield (t DM ha^{-1} yr^{-1})		*A. prat.* (%)
Cutting regimes	Mean yr 1 to 5	yr 1	yr 5	yr 5
1st cut at early shooting (ESh)	16 b	11.1 a	11.3 b	50 b
1st cut at shooting (Sh)	10 b	11.1 a	10.8 ab	45 b
1st cut at early heading (EHe)	1 a	12.8 b	10.2 a	26 a
1st cut at seed maturity (SMa)	31 c	10.3 a	11.4 b	67 c

In ESh and Sh, energy rich forage was harvested at the 1st cut and the energy value of the forage harvested at seed maturity (2nd cut for ESh and Sh and 1st cut for SMa) was better than in SMa. ESh and Sh therefore allowed a considerable reduction in forage quality losses compared to SMa. Moreover, it reduced the problem of lodging. Because individual grass plants live for many years (Treshow M. & Harper K., 1974), yearly seed production is probably unnecessary. To periodically change from a 1st cut at early heading to a 1st utilisation at shooting followed by a 2nd cut at seed maturity might therefore be a good compromise in achieving a sustainable production of forage with satisfactory quality on foxtail meadows.

Conclusions

Harvesting foxtail meadows every year at early heading of *A. pratensis* leads to an increasing proportion of undesired plant species and a decreasing yield. Sustainable management of foxtail meadows can be achieved by allowing the formation of mature *A. pratensis* seeds. An early first utilisation at the shooting stage of *A. pratensis* followed by a second cut at seed maturity with ground drying of the forage can fulfil this requirement with a minimum loss in average forage quality.

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Plant genetic resources in mountain oases of northern Oman[1]

Gebauer, J.[2], Luedeling, E.[3], Hammer, K.[4] & Buerkert, A.[5]

Key words: crop diversity, genetic erosion, indigenous knowledge, multicropping systems

Abstract

In this study we assessed the genetic resources of three mountain oases in the al-Hajar range using a GIS-based field survey and farmer interviews. While arid conditions prevail throughout the mountain range, the different elevations of the oases in the Jabal al Akhdar mountains provide markedly differing agro-climatic conditions. Overall, 107 different crop species were identified belonging to 39 families. Species number was highest among fruits (33 spp.), followed by vegetables (24 spp.). Intensive irrigation allows cultivation of a broad range of species at all oases. However, the number of species varied significantly among sites. Fruit species diversity and homogeneity of the distribution of individual fruit species was highest at Balad Seet and lowest at Maqta, as indicated by respective Shannon indices of 1.00 and 0.39 and evenness values of 32% and 16%. Century plant, faba bean and lentil were identified as relict crops, supporting oral reports of past cultivation and providing evidence of genetic erosion. Overall greatest species similarity was found between Balad Seet and Al Jabal al Akhdar, as indicated by a Sørensen coefficient of similarity of 67%. Overall the study shows a location-specific but surprisingly diverse mosaic of crops in Omani mountain oases that merits further studies and conservation efforts.

Introduction

As in many other oil-producing countries in the Middle East, the economy and infrastructure of the Sultanate of Oman are developing at a rapid pace. Asphalt roads, housing and other amenities are being built to fulfil the needs of a fast-growing nation. In the mountain region of northern Oman, fascinating and sustainable agricultural systems have persisted for millennia in which agricultural and horticultural crops are intensively cultivated in traditional, mainly subsistence-oriented oasis systems (Nagieb et al. 2004, Buerkert et al. 2005). Fields consist of small man-made terrace systems, which are often squeezed between cliffs. Because of their green vegetation, pleasant microclimate, and availability of fresh water, the oases contrast strikingly with the dry

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[1] This contribution is an extract of the recently published paper: Gebauer J., Luedeling E., Hammer K., Nagieb M. and Buerkert A. (2007): Mountain oases in northern Oman: an environment for evolution and *in situ* conservation of plant genetic resources. Genet. Resour. Crop Evol. 54: 465-481.

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and rough hyperarid landscape of northern Oman, and in recent years have gained increasing interests from scientists and tourists alike.

Materials and methods

Our survey was conducted in the Al-Hajar Mountains in northern Oman and comprised three spring-fed oases that have existed in this area for centuries to millennia and whose characteristics are listed in Table 1. Balad Seet and Al Jabal al Akhdar are located in the western Al-Hajar Mountains (Al Gharbi), while Maqta is situated in the eastern Al-Hajar Mountains (Ash Sharqi). Geo-referenced digital maps of the oases were produced from satellite images and low altitude aerial photography. The field work was conducted during August and September 2005 and March and April 2006. In the three oases each individual terrace was visited, resulting in a total of 1907 survey plots. In addition, three extensive palm groves at Balad Seet (8.88 ha) and 17 palm groves at Maqta (3.6 ha) were also studied in detail. Different farmers in each oasis were interviewed about the local names and primary uses of each species.

Tab. 1: Characteristics of the three study oases in northern Oman.

Characteristics	Balad Seet	Maqta	Al Jabal al Akhdar
Type of oasis	Core oasis	Scattered oasis	Core oasis
Altitude (m a.s.l.)	950 – 1020	930 – 1180	1750 – 1930
Mean annual rainfall (mm)	100	148[a]	336
Rainfall range (mm)	30 – 240	42 – 255[a]	128 – 901
Mean Temperature (°C)	23	[b]	19
Temperature range (°C)	3 – 43	[b]	-4[c] – 32
Terraced land (ha)	13.48	4.40	13.92
Number of springs	12	22	2
Available water (m^3 d^{-1})	601	115	856
Water m^3 ha^{-1} d^{-1}	44.8	25.6	65.6
Number of houses	120	73	147
Number of inhabitants	650	200	330
Number of households	80	73	45
Number of survey plots	385 agricultural fields and 3 palm groves	130 agricultural fields and 17 palm groves	375 agricultural fields and 1017 orchard terraces

[a]Based on records from Ibra (2003 – 2005), 48 km west of Maqta,

[b]no data available,

[c]according to World Conservation Union (1987)

Results

In total, 107 different plant species belonging to 84 genera and 39 families were identified. Amongst the 39 families, Leguminosae (11 spp.), Gramineae (10 spp.), Rosaceae (7 spp.), Rutaceae (7 spp.) and Solanaceae (6 spp.) have the highest numbers of species. 91% of species are of exotic origin, while the remaining ones are indigenous to northern Oman. Of the 107 taxa found in the oases, 46 species are woody perennials and 61 are herbaceous crops. With a total of 85 cultivated species, Balad Seet was the oasis richest in species. The analysis of the species distribution among the three oases revealed that 27 species were common to Balad Seet, Maqta and Al Jabal al Akhdar (Figure 1). In general, fruits were the use category with the highest number of species (Figure 2). Fruit species diversity and homogeneity of the distribution of individual fruit species was highest at Balad Seet and lowest at Maqta as indicated by respective Shannon indices of 1.00 and 0.39 and evenness values of 32% and 16%. Century plant (*Agave americana* L.), faba bean (*Vicia faba* L. var. *minor* Peterm. em. Harz), and lentil (*Lens culinaris* Medik.) were identified as relict crops. Overall greatest species similarity was found between Balad Seet and Al Jabal al Akhdar, as indicated by a Sørensen coefficient of similarity of 67%.

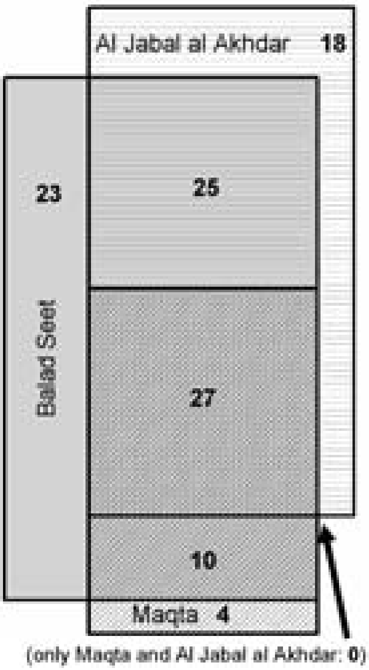

Figure 1: Species distribution among the three oases. The areas shown in the graph are proportional to the relative numbers of species.

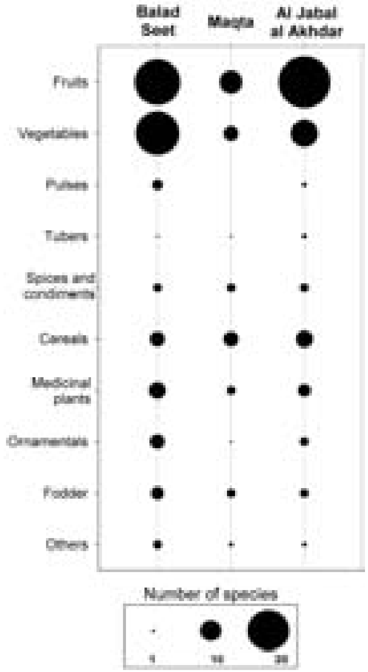

Figure 2: Abundance of plant species of different use categories in the three oases in northern Oman.

Discussion

With a total of 107 different plant species, the number of crops was very high in comparison to other small-scale cropping systems under arid or semi-arid conditions (Hammer and Perrino 1985, Ceccolini 2002, Gebauer 2005). Fruit species richness was highest at Al Jabal al Akhdar, comprising 25 species. However, the Shannon indices indicated that species diversity was slightly higher at Balad Seet compared with Al Jabal al Akhdar. This is reflected in the highly heterogeneous distribution of individual fruit species at Al Jabal al Akhdar compared with Balad Seet, which translates to evenness values of 30% (Al Jabal al Akhdar) and 32% (Balad Seet). The occurrence of some individual plants in the fields and field borders supports the local oral records that some decades ago landraces of these species were widely cultivated. The complete loss of a species is only a last step in a long way of disappearance that reduces agricultural and horticultural biodiversity. Relict crops can also be considered as indicators of past genetic erosion (Hammer et al. 1999). According to the different climatic situations of the study oases (Table 1), some species were exclusively found under cooler or hotter conditions. This was especially obvious in the fruit category and is reflected by the Sørensen coefficients of similarity that were calculated to compare the three oases. The similarity between hot Maqta and cool Al Jabal al Akhdar is only 39%.

Conclusions

Germplasm collection activities, *in situ* conservation programs and interdisciplinary analysis of socioeconomic aspects or rural communications are urgently needed to better understand and preserve the heritage of these ancient agro-ecosystems.

Acknowledgments

The authors are indebted to Dr. Maher Nagieb for part of the data collection, the Agricultural Extension Center of the Ministry of Agriculture and Fisheries at Sayh Qatanah for general information about the oases on Al Jabal al Akhdar, to Sultan Qaboos University at Muscat for infrastructural support and to the Deutsche Forschungsgemeinschaft, DFG (BU1308) for funding.

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A Model for Pre-Estimation of Production of Organic Cotton in Iran; Case study of Khorasan Province

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Keywords: organic product, organic cotton, farm size, economics, modeling.

Abstract

Organic farming and organic production methods have gained importance in agriculture from environmental point of view as well as economical and social stand points. The purpose of this study was to propose a model in order to estimate the cotton production in organic farms of Khorasan province, Iran. Production of organic cotton was obtained through surveys of 241 farms in 2007, partial elasticity of production of different inputs were derived from Cobb-Douglass production function. The results revealed that the cotton production decreased by 34.2 percent when the chemical factors were eliminated. The drop off yield of organic fields in large farms (more than 10 ha) is higher than small (less than 5 ha) and medium (5 to 10 ha) size farms due to over-use of chemicals and fertilizers. Also, the maximum yield in conventional system was derived from mild region (3.044 t/ha), while the minimum belonged to warm region (1.48 t/ha). If organic products are to develop, it is recommended that financial support (subsidy), extension education, and providing non-chemical inputs be provided to compensate the related production loss.

Introduction

The main concern of organic farmers and those who whish to shift to organic farming is that whether organic farming is profitable or not? Although some of organic farmers are motivated by economic objectives, most are inspired by more than economic intentions. Their main goal is to optimize land, animal, and plant interactions, preserve natural nutrient and energy flows, and enhance biodiversity, all of which contribute to sustainable agriculture (Eyhorn et al., 2007). There appears to be mixed results in studies related to change in yield through shifting from conventional agriculture to organic farming. Furthermore, while investments, research and development efforts are more focused on conventional agriculture rather than organic farming comparing these two systems from stand point of yield is not so sensible (Koocheki, 2004).

Khorasan province is one of the leading producers of cotton in Iran. With increasing importance of organic production systems due to high cost, it is not possible to examine different aspects of organic farming in greenhouse context. Therefore, an attempt was made to develop a model to estimate yield reduction in real farm situation due to shift from conventional agriculture to organic farming practices. As the estimation of parameters of this model is experimented under real farm situation, the results are more accurate than greenhouse experiments. Finally, we will compare organic and conventional cotton in three climate regions across three farm size.

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Material and Methods

In this study, a model is proposed to estimate the organic cotton productions. In fact the research emphasise is more on methodology than results. In order to estimate the organic production of cotton, there is a need to purge the chemical fertilizers, herbicides and pesticides effects from production function. For this propose, Cobb-Douglas production function (1) is estimated

$$Y_{cp} = A\sum_{i=1}^{8} X_i^{\alpha_i} e^u \qquad \textbf{(1)}$$

Where Y_{cp}, X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, A, u, α_i are cotton production, labor (person-day), acreage (hectare), seed (Kg), Water (number of irrigation rotation), chemical fertilizers (Kg), Pesticides (Liter), manure (ton), machinery (hour), coefficient of technology, random error term and parameters, respectively.

The factor elasticities (α_i) derived from estimation of production function. Value of factor elasticity revealed the amount of influence that specific factor has on production. Therefore, with purging the portion related to chemical factors from present production function (purifying the production), we can obtain cotton organic production of cotton.

$$Y_{op} = Y_{cp} - (E_{fe} \times Y_{cp} - E_{pe} \times Y_{cp}) = Y_{cp}\left[1 - \left(E_{fe} + E_{pe}\right)\right]$$

Where E_{fe}, E_{pe}, Y_{op} and Y_{cp} are the chemical fertilizers elasticity, pesticides elasticity, organic production and conventional production, respectively. In this way, the organic production can be calculated by using the developed model. Also, the percentage of production reduction (in organic situation) is computable via following formula:

$$\text{Production Reduction Percentage} = \frac{Y_{cp} - Y_{op}}{Y_{cp}} \times 100 \qquad (3)$$

Data were collected via a stratified random sampling. The cross-sectional data were gathered from 241 cotton producers of Khorasan (North, South and Razavi) provinces.

Results and Discussion

Equation 4 shows the results of Khorasan cotton production function. The variables X_1 (labor), X_5 (chemical fertilizers), X_6 (chemical pesticides and herbicides) and X_7 (manure) are statistically significant. The coefficient of determination (R^2) reveals that 35.6 percentage of variation in cotton production can be explained by labor, chemicals and manure factors. The factor elasticity for labor, acreage, seed, water, chemical fertilizers, pesticides, machinery and manure are 0.0718, 0.079, 0.079, 0.125, 0.152, 0.235, 0.107, 0.052 and 0.038, respectively. The estimated elasticities show that chemical fertilizer has maximum and the manure has minimum elasticity. Also, the farmers use labor, chemical fertilizers, pesticides and manure factors in second stage of production function.

$$Y_{cp} = -1.712(5.71^{*}) + 0.0718X_1(3.51^{*}) + 0.079X_2(1.4^{ns}) + 0.079X_3(1.24^{ns})$$
$$+ .0152X_4(1.56^{ns}) + 0.235X_5(4.88^{*}) + 0.107X_6(2.73^{*}) + 0.052X_7(1.86^{***})$$
$$+ 0.038X_8(1.27^{ns}) \qquad R^2 = 0.356 \qquad \bar{R}^2 = 0.333 \qquad F = 16.001^{*} \qquad \textbf{(4)}$$

$(^{*}\,significant\ \ in\ \ \%1\ \ level\ \ ^{***}\,significant\ \ in\ \ \%10\ \ level)$

After computation of equation (2) and (3), results show that the yield of organic and conventional cotton is 1.578 and 2.412 tons per hectare, respectively. Comparing these two figures indicate a 34.2 percent decline in production of organic cotton. This result is comparable with findings of many researchers reporting yield decease in organic products in transition period of about 16.7 to 50 percent period (Gunnarsson and Hansson, 2003; Sartori et al., 2005).

Tab. 1: The organic and conventional cotton yield in acreage levels

System	Acreage (ha)	Mean yield (t/ha)
Organic	Less than 5	1.588
	5 to 10	1.550
	More than 10	1.637
Conventional	Less than 5	2.410
	5 to 10	2.358
	More than 10	2.490
Decrease percentage	Less than 5	34.20
	5 to 10	34.17
	More than 10	34.27

The results in table (1) revealed that the maximum conventional cotton yield with 1.64 ton is for large scale (more than 10 ha). Also, the percentage reduction for the organic cotton yield in small (less than 5 ha), medium (5-10 ha) and large (more than 10 ha) scale is 34.20, 34.17 and 34.27, respectively. The maximum value is in large scale due to over-use of chemicals and fertilizers.

According to table (2), the maximum yield in conventional system is for mild region (3.044 t/ha), while the minimum is warm region (1.48 t/ha).

Tab. 2: The organic and conventional cotton yield in climatic regions

Climatic region	System	Mean yield (t/ha)
Cold	Organic	1.73
	Conventional	2.63
	Decrease percentage	34.18
Mild	Organic	2.00
	Conventional	3.04
	Decrease percentage	34.23
Warm	Organic	1.48
	Conventional	2.25
	Decrease percentage	34.22

In the next stage, the manure elasticity is increased as a scenario to determine how a unit of increase in cotton production causes an increase in manure share in production. Interestingly, table (4) revealed the simulation results due to increasing the manure share in cotton production to substitute with chemical fertilizers. On this basis, the manure significant affects on cotton production, but the average production won't be considerable by increasing in manure elasticity. As a result, the organic and conventional productions are the same whereas the manure elasticity increases by 0.53.

Tab. 4: Simulation an increase share of manure in cotton production

Elasticity	Production (t/ha)
0.052 (base)	1.587
0.07	1.616
0.09	1.648
0.11	1.680
0.13	1.713
0.15	1.747
0.17	1.781
0.19	1.816
0.53	2.420

Conclusion

As results indicates, supporting the farmers in primary stage for organic agriculture (transition phase); through credit facilities and extension services, and etc. will encourage farmers to shift to organic products and decrease imports. Therefore, we suggest planning for financial support. For example, subsidy payment for organic cotton in transition period is recommended. Moreover, training through extension education and providing non-chemical factors to compensate the related production loss is further suggested.

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Effects of reduced tillage on soil organic carbon and microbial activity in a clayey soil

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Key words: soil fertility; cultivation; soil organic matter; crop farming; reduced tillage

Abstract

In a long-term field trial recently launched (2002-2011), located in Frick (878 mm mean annual precipitation) near Basle, Switzerland, the effect of reduced tillage on soil fertility indicators and crop yield was studied in a heavy soil (45% clay) in a crop rotation under organic farming conditions. We present the results of soil analyses after three cropping years (2002-2005). Soil organic carbon (C_{org}) increased over that period by 7.4% (+1.5 g C_{org} kg^{-1} soil) in the 0-10 cm soil layer in the reduced tillage plots, while it remained constant in the ploughed plots. Soil microbial carbon (C_{mic}) and dehydrogenase activity (DHA, TTC-reduction) were 28% higher in reduced-tillage plots in this soil layer. Biological soil quality as calculated by C_{mic} to C_{org} was 15% enhanced under reduced tillage. In the 10-20 cm soil layer no significant C_{org}, C_{mic}, C_{mic} to C_{org} and DHA differences between the tillage schemes were found. It is suggested that reduced tillage improves important indicators of soil fertility during the conversion period. Long-term aspects of soil fertility, crop yield and weed infestation need investigation over a prolonged experimental period.

Introduction

Reduced tillage diminishes soil erosion and enhances soil fertility. In organic farming, problems remain to be solved with respect to weed competition, slug control and plant nutrition (Peigné et al., 2007). Long-term experiments have revealed that soil turning with a plough is necessary after several years in order to gain satisfactory yields (Hampl, 2005; Kainz et al., 2005; Pekrun et al., 2003). By turning the soil layers, however, the benefits of reduced tillage may vanish within a year (Stockfisch et al., 1999). The experiment on a clayey soil presented here seeks to broaden the available experience with reduced tillage under organic conditions. Tillage, fertilization and the use of biodynamic preparations were combined, mimicking different agricultural organic farming systems.

Materials and methods

In autumn 2002, we established in Frick, Switzerland, a field experiment comprising the following factors, each at two levels:

Soil tillage Ploughing system (mouldboard plough, 15 cm deep, followed by rotary harrow, 5 cm deep) *versus* reduced tillage system (chisel plough[2], 15 cm deep, followed by rotary harrow[3], 5 cm deep).

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[2] WeCo-Dyn-System of the EcoDyn company, Schwanau, Germany

[3] Rotary harrow of the Rau company, Weilheim, Germany.

Fertilization Slurry alone *versus* manure compost and slurry (both systems at a level of 1.4 livestock units).

Biodynamic preparations With *versus* without biodynamic compost and field preparations[1] (the latter applied three times a year).

The three factors – tillage, fertilization, preparations – were fully factorized. This resulted in eight treatments, each replicated four times. The 32 plots were arranged in a split-plot design. Plot size was 12 x 12 m, allowing the use of common-size farming equipment.

Soil cores were taken at the beginning in autumn 2002, and again in spring 2005 (n = 32). The clay soil at the experimental site initially contained mean levels of 2.2% organic carbon (C_{org}) and 45% clay, and had a pH of 7.1 (H_2O). C_{org} was analysed by wet oxidation, microbial biomass (C_{mic}, N_{mic}) by chloroform fumigation extraction and dehydrogenase activity by TTC reduction. The mean annual precipitation in the experimental period was 878 mm.

Before the experiment started, the field site was uniformly planted with silage maize in 2002. The crop rotation in the first three years (2002-2005), being the period to which the results presented here refer, was winter wheat, oat-clover intercropping, sunflower and spelt. Two years of grass-clover were planted in 2006-2007. Wheat grains and straw were harvested and removed from the field.

Data were analysed by three-way analysis of variance (ANOVA). In this paper, first results of the soil analyses from 2005 are presented.

Results

Within three years, C_{org} levels in the 0-10 cm soil layer rose in reduced-tillage soils by 7.4% (+1.5 g C_{org} kg^{-1} soil) as compared to the ploughed soils (Fig. 1a). Microbial biomass (C_{mic}, N_{mic}) and DHA were 26-28% higher in reduced tillage at the same soil depth (Fig. 1b). The C_{mic} to C_{org} ratio was increased by 15% under reduced tillage. For these parameters, we found no significant interactions between the factors of tillage, fertilization and biodynamic preparations. In the 10-20 cm soil layer no significant differences in soil properties were found.

The yields of the cereals wheat and spelt were 14% and 8% lower in reduced-tillage plots compared to ploughed plots. Sunflower yield was slightly higher in reduced-tillage plots. Application of slurry only delivered a 5% higher grain yield with wheat. The biodynamic preparations had no effects on yield.

Discussion

The increase of C_{org} under reduced tillage in our experiment can be explained by large amounts of carbon contained in the roots of the crops, and especially in the biomass of the sunflower residues which were incorporated into the soil. This matches the findings of Alvarez (2005), Ogle et al. (2005) and Teasdale et al. (2007). In other experiments, a reduction of C_{org} in deeper soil layers compensated the enhancement of C_{org} in the upper soil layers (Wright et al., 2005). Angers et al. (1993) reported that a sufficient amount of plant biomass incorporation is a prerequisite for enhanced C_{org}, including under reduced tillage as in the experiment described. The high plant

[1] see http://www.sciencemag.org/cgi/content/full/296/5573/1694/DC1

biomass input in our experiment resulted in increased microbial biomass in the 0-10 cm top soil layer. Weber and Emmerling (2005) studied soil microbial activity in a ten-year tillage experiment, finding soil microbial activity to be enhanced by 30% following layer cultivation with a chisel plough and by 21% following two-layer ploughing in the 0-15 cm surface layer.

Yield reduction in reduced tillage plots in our experiment was substantially lower than that found in various comparable studies, e.g. the results reported by Kainz et al. (2005) where crop yields dropped by up to 35%.

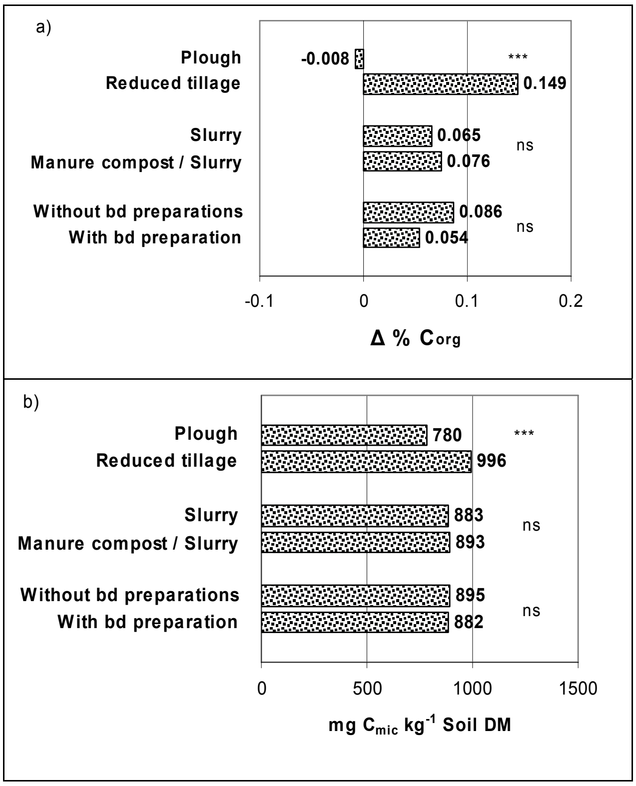

Figure 1: (a) Development in C_{org} between 2002-2005. Zero line means no change of C_{org} in the three experimental years. Note that 0.1 % C_{org} change corresponds to 1 mg C_{org} kg^{-1} soil. (b) Microbial biomass (C_{mic}) 2005 at 0-10 cm soil depth. A three-way ANOVA was calculated for C_{org} and C_{mic} for the three factors tillage, fertilization and biodynamic preparations at two levels each (n = 16).

Conclusions

Based on the results obtained, we can conclude that reduced tillage is viable under organic farming conditions in the conversion phase, even on a clay soil.

Furthermore, the results suggest that reduced tillage is feasible both with manure compost and slurry fertilization. Since there were no interactions between the three factors of tillage, fertilization and biodynamic preparations, neither for yields nor for soil fertility indicators, we are unable to suggest any combinations of these farming practices for optimal conversion to reduced tillage under organic farming conditions. The long-term effects of the reduced tillage system need to be assessed to elucidate their impact on soil fertility indicators and yield performance from the point of view of carbon sequestration and weed competition.

Acknowledgments

This work was funded by the Swiss Federal Office for Agriculture and the following institutions: Dutch BD-Vereniging, Stiftung zur Pflege von Mensch, Mitwelt und Erde, Sampo Verein für Anthroposophische Forschung und Kunst, Software AG Stiftung and Evidenzgesellschaft.

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A new approach to soil tillage for organic vegetable production: permanent beds

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Key words : organic vegetable production, soil tillage, permanent beds, soil fertility

Abstract

The effect of controlled traffic with permanent crop beds was compared to mouldboard ploughing in France for organic vegetable production. Four trials were carried out over a period of three to seven years at four sites with different pedo-climatic conditions. Variable results were obtained, depending on soil type (susceptibility to compaction), tillage machinery type, vegetable type (root or not, grown from seed or transplant) and weed development. However, permanent crop beds with controlled traffic generally improved biological activity and reduced labour demand.

Introduction

In vegetable production, rapid succession of several crops during the year leads to intensive vehicle traffic, sometimes on wet soils, and therefore to soil compaction. Reduced tillage technique developed for vegetable crops by Wenz and Mussler in Germany (Deveyer et al., 2001) offers a new type of tillage management with permanent beds: no mouldboard ploughing, permanent wheel tracks and preferential use of tine machines. A national network was created in France in 2005 to study new approaches of tillage in organic farming, associating several trials on arable farms (results reported in these proceedings by Peigné et al.) and four trials in vegetable production. We studied the feasibility of permanent crop beds under various soil, climate and crop rotation conditions. The aim was to answer the following questions: is it possible to avoid ploughing in vegetable crops ? What are the requirements for the successful adoption of a permanent bed system? What are the consequences on soil fertility, crop development and weed control?

Materials and methods

Four trial plots are included in this study with two soil tillage treatments on a randomised block design with 2 or 3 replicates : controlled traffic tillage with Permanent Beds ("PB") compared with Conventional tillage ("C"). Sites conditions are shown in table 1. Permanent Beds (PB) : wheel tracks were the same from the beginning of the trials, regardless of the cultural practice. The crop bed (1.2 m to 1.5 m wide depending on the site) was free from any compaction due to vehicle traffic. Tine machines were preferentially used for this treatment with "Actisol" and some specific equipment developed at each site (Berry D., Taulet A., 2006). Conventional tillage (C):

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wheel tracks were not controlled. Mouldboard ploughing was the reference at three sites, with use of rotary equipment. Same fertilisation as in PB.

Measurements and observations were the same for the four experimental sites: evolution of the physical (cultivated soil profile (Roger-Estrade J. et al., 2004)), chemical (organic matter, nitrogen, phosphorus, potassium, magnesium), and biological fertility (microbial biomass (Chaussod et al., 1988) and activity, earthworm activity); crop performance (yield and quality); weed pressure and labour times.

Tab. 1: main characteristics for the four experimental sites

Site	A Rhône-Alpes	B Nord	C Charentes	D Provence
Beginning	2001	2003	2005	2005
Soil texture (% clay/silt/sand)	26 / 47 / 27	27 / 49 / 24	28 / 42 / 30	22 / 62 / 16
Rainfall (mm/nb days)	1000 mm / 86 days	680 mm / 120 days	716 mm / 77 days	660 mm / 45 days
Crop rotation	2001 : leek + GM* 2002 : lettuce 2003 : carrot + GM 2004 : cabbage 2005 : GM + spinach 2006 : leek	2003 : turnip 2004 : carrot 2005 : pea + GM 2006 : onion 2007 : turnip	2005 : carrot 2006 : leek 2007 : potato	2005 : squash 2006 : melon + GM 2007 : onion & Japanese radish

** GM : Green Manure*

Results

Physical, chemical and biological fertility:

- The reduced tillage with permanent bed system tended to increase soil compaction, especially in the 10-30 cm layer. The proportion of non-compacted clods (with internal structural state □) was higher for PB in the surface layer (0-10cm) and lower underneath. This observation was very clear for the most recent sites (C and D), but not for the oldest one (site A), where PB had been used for seven years. Compaction under the PB can also affect the culture bed on the sides (lateral compaction); this effect seemed to decrease with time (sites A and B).

- Cultivation using permanent beds had little impact on organic matter, except for a slight increase of the labile organic carbon (diameter > 50 µm). On the contrary, it enhanced the microbial activity, which can be measured through potential mineralisations of carbon (C) and nitrogen (N) (Table 2). For site D, the different measurements were not in favour of PB compared to conventional tillage because of the soil compaction problems.

- After three to six years of cultivation using PB, macrofauna activity did not significantly increase (data not shown). Nevertheless, structure from biological activity is higher in less compacted cultivated soil profiles.

Crop performance: The permanent bed tillage system did not affect the yield of the main vegetable crops measured on crop bed, but the quality of root vegetables decreased. Carrot and Japanese radish roots harvested at three of the four trials were deformed, because of the more compacted soil. Weed control was a real problem for one site only (site B), where perennial weed (*Sonchus spp.*) development affected some crops yield such as peas.

Labour time: The implements used on the permanent beds that are not driven by the tractor's power take-off allow faster cultivation speeds and thus reduce the labour time for soil preparation. In the seven-year study at trial site A, the average cultivation time using a tractor was reduced by 30% (Table 3).

Tab. 2: Evolution of organic matter, microbial biomass and potential mineralisation (C: conventional tillage – PB: Permanent Beds)

Site	A (0-25 cm)		B (0-25 cm)		C (0-12 cm)		D (0-25 cm)	
Treatment	C	PB	C	PB	C	PB	C	PB
Total org.C (g/kg)	13.6	15.3	15	14.8	17.1	18.6	15.1	14.3
Labile org. C [1] (%total C)	18.1	20.2	21	23	24.4	31.1	24	22
Microbial Biomass (mgC/kg)	462 **(b)**	506 **(a)**	442 **(b)**	554 **(a)**	352	410	285	209
C Mineralisation (mg/kg/28days)	240 **(b)**	297 **(a)**	288	369	403	381	398	360
N Mineralisation (mg/kg/28days)	21.1	22.2	20.2 **(b)**	29 **(a)**	22.1	20.7	42.4 **(a)**	32.2 **(b)**

[1] labile organic carbon : diameter > 50 µm - a,b: significant for P<0,05

Tab. 3: Compared labour time at site A (minute/70-m long crop bed)

	Conventional tillage (plough)	Permanent beds	Time reduction (%)
Leek 2001	47 min	21 min	55 %
Lettuce 2002	42 min	32 min	24 %
Carrot 2003	68 min	48 min	30 %
Cabbage 2004	78 min	59 min	31 %
Spinach 2005	40 min	34 min	18 %
Leek 2006	64 min	49 min	23 %
Average decrease of labour time			- 30 %

Discussion

The different consequences of soil tillage with permanent beds, depending on the pedo-climatic and crop conditions, are summed up in Figure 1:

- Cultivation time with permanent beds has a strong impact on the results: mixed or poor results are obtained at the three-year-old sites, whereas all parameters (biological and physical soil properties, crop results, time savings) positively evolve at the seven-year-old site. As with any emerging technology, many years are needed before obtaining satisfactory results: adapting the cultivation techniques and using adapted custom-built tillage equipment (there is very little reduced tillage equipment available for vegetables). Soil texture is an essential factor: in soils with poor structural stability, such as the silty soil on site D with 66 % silt, "deep" soil tillage down to 25 cm is essential for permanent beds to compensate for self-compressing.

- Weed pressure (perennial weeds), can seriously hinder the elimination of ploughing.

- Finally, for sown vegetables, a particular attention must be paid to the careful preparation of the seedbed, which is difficult without rotary equipments.

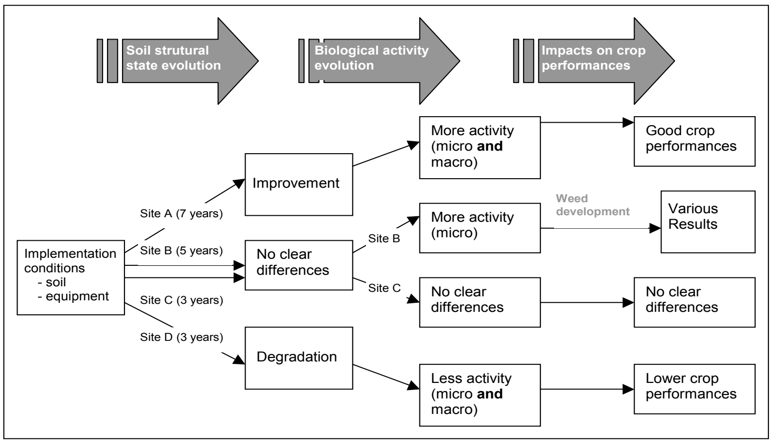

Figure 1: Permanent bed impact on soil fertility and crop performances in terms of implementation conditions and time, in comparison to conventional tillage

Conclusions

The results show that it is possible to eliminate ploughing for the cultivation of organic vegetable crops. There are very few references with conservation tillage with vegetable crops, and almost none with a permanent bed system. Our study shows that it is an interesting alternative that improves soil biological activity and decreases labour time using tractor, leading to significant energy savings. However, this method has limitations depending on pedo-climatic conditions and the lack of suitable equipment, which lead to various results.

Further researches are required to specify the soil tillage techniques according to pedological conditions (silty soils, for instance), to improve weed control and to ensure the incorporation of fresh organic matter (crop residues and green manure).

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Green manures and pulses

Grain yield of different winter pea genotypes in pure and mixed stands

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Key words: cropping, winter pea, mixed stands

Abstract

In organic farming, harvest of spring peas is a problem because of the often high density of weeds, but also the low yield stability. In the present experiments, seven different genotypes of winter peas (six regular types and one semi-leafless type) and one spring pea (semi-leafless) were examined between 2004 and 2007 in pure and mixed stands (with cereals) in terms of their suitability as a harvest crop at two different sites per season in Germany (experimental fields of the University of Kassel Frankenhausen (2004-2007), Hebenshausen (2004) and the experimental farm of the University of Applied Sciences Osnabrueck, Waldhof (2005-2007).

Grain yields of the regular leaf type in mixed stands during the first three years varied because of varying N supply (preceding crops and weather conditions). When availability of N was relatively low, pea grain yield ranged between 2.5 and 4.0 t ha^{-1} in Frankenhausen and 1.5 and 2.5 t ha^{-1} in Waldhof, and were at levels comparable to spring pea yield, which varied from 2.0-3.4 to 1.5 t ha^{-1}, respectively. In addition, mixtures contribute rye yield. At a relatively high N supply, pea yields were relatively low, but rye yields relatively high. Crude protein concentration and concentration of some amino acids (lysine, tryptophan and arginine) partially were significantly ($p<0.05$) higher in the regular leaf types than in the semi-leafless types.

Introduction

Winter pea is an old crop that has hardly been cultivated in recent decades because of the increasing imports of soybean and higher inputs of mineral fertilizers. The cultivation of regular leaf types, however, is advantageous compared to spring peas because of their efficient suppression of weeds (Graß 2003), higher yield stability (Stelling 1996), and higher yield potential (Charles 2001).The objective of the study was to investigate different genotypes of winter peas for winter hardiness and the value of cultivating them in organic farming.

Materials and methods

Field experiments were conducted in 2003/2004 on both experimental sites of thee University of Kassel, Domäne Frankenhausen (DFH; loam on loess) and Hebenshausen (HEB; loam), and during 2004/2005 and 2006/2007 on DFH and the experimental farm of the University of Applied Sciences Osnabrueck, Waldhof (WH;

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loamy sand), respectively. Four colourful flower, regular leaf type winter pea genotypes from the gene bank Gatersleben (convariety speciosum; cv. Griechische, Nischkes Riesengebirgs, Unrra and Wuerttembergische) were compared with a white flower, semi-leafless and two colourful flower, regular leaf type EU cultivars (convariety sativum and speciosum; cv. Spirit in 2004, Cheyenne in 2005-2007, and Assas and EFB 33), as well as a white flower, semi-leafless spring pea (cv. Santana). Peas were cultivated in pure stands and two substitutive mixtures with cereals (rye, cv. Danko; spring oats, cv. Aragon (2004)) and spring barley cv. Ria (2005-2007), respectively. The substitutive mixtures consisted of 25 % (M1) and 50 % (M2) of pea pure stands (80 germinable seeds m^{-2}). The experimental design was a Latin square (DFH 2004), a randomized complete block design (HEB 2004), and a split plot design in 2005-2007 (n=4). The size of plots for sampling at harvest was 20 m^2 (DFH, HEB) and 9 m^2 (WH).

Determination of nutritive quality was done by NIRS analysis (total N by Kjeldahl). Also, amino acids in pea grains of treatment M2 were determined via NIRS and by wet chemistry according to the EU and AOAC 994.12-method (Anonymous 1998, Llames and Fontaine 1994; tryptophan: Anonymous 2000, Fontaine 1998).

Results and Discussion

While the four genotypes and the EU cultivar EFB 33 consistently did not suffer from considerable losses from frost, both French cultivars Cheyenne and Assas faced severe losses as a result of weather conditions during winters 2005-2006 and 2006-2007 (data not shown) at some experimental sites, e.g. at DFH, even with complete losses in winter 2002-2003 (Urbatzka et al. 2005). As a consequence these two cultivars do not show sufficient winter hardiness for cultivation at sites with comparable climatic conditions.

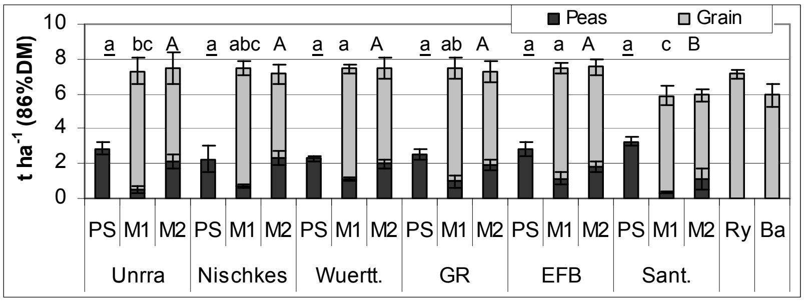

Figure 1: Pea and cereal grain yields at DFH (2006) (RY=Rye; Ba=barley; error bars = standard deviation; different letters denote significant differences between cultivars in terms of pea grain yield (T - test): small underlined letters for pure stands at p<0.05; small letters for M1 at p<0.05; large letters for M2 at p<0.001; significant interactions for cultivar by mixture)

Grain yield of regular leaf type winter peas in mixtures varied considerably depending on the preceding crop and weather conditions in autumn and the consequent N availability (DFH and HEB): at a relatively high N supply winter rye gave 4 to 7 t ha^{-1} and therefore had the highest impact on total crop yield of mixtures, whereas pea yield ranged from 0.5 to 2.0 t ha^{-1} (HEB 2004, DFH 2006, Figure 1)).

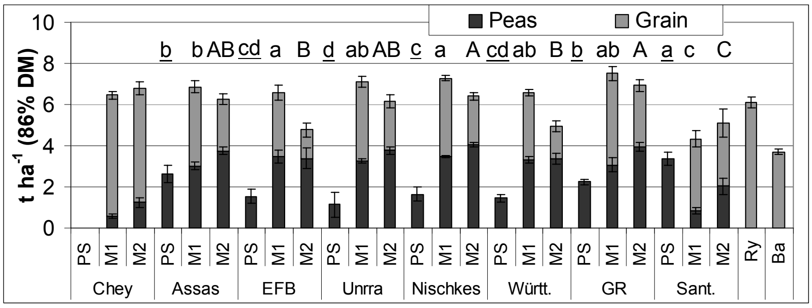

Figure 2: Pea and cereal grain yield at DFH (2005) (ry=rye; ba=barley; error bars = standard deviation; different letters denote significant differences between cultivars in pea grain yield (t-test without Cheyenne because of loss from mice): small underlined letters for pure stands at p<0.05; small letters for M1 at p<0.05; capital letters for M2 at p<0.001; significant interactions for cultivar by mixture)

At a lower N supply the same winter pea genotypes yielded between 2.5 and 4.0 t ha^{-1} (DFH 2004 and 2005) (Figure 2). As a result of a prolonged period with high precipitation and losses from birds, yield at WH from all treatments could be assessed only in 2006. The regular leaf type winter peas yielded between 1.0 and 2.0 t ha^{-1}, while grain yield of rye varied between 1.5 and 2.5 t ha^{-1}. The examined winter pea genotypes in pure stands are not suitable because of their tendency to laying down (data not shown), although only in some cases did yields differ significantly from spring peas in pure stands (Figures 1 and 2). Spring peas in pure stands yielded between 2.0 and 3.4 t ha^{-1} (DFH and HEB), depending on the degree of weed infestation, whilst at WH around 1.5 t ha^{-1} was harvested in both years. In mixtures, yields of this genotype corresponded with the expected values.

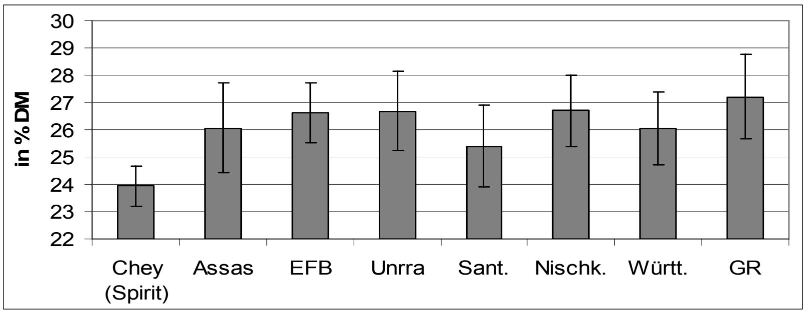

Figure 3: Crude protein concentration of pea grain, mean of three years, two sites and three stand densities (pure, M1 and M2) (error bar = standard deviation)

The yield of regular leaf type winter pea in mixture was comparable with that of spring pea in pure stands in the majority of experiments, with a supplement of the additional rye yield. Moreover, weed infestation in winter pea mixed stands was consistently at a very low level, while in pure spring peas, weed control was obligatory (data not shown). Cultivation of winter pea/rye mixtures should follow cereals in order to avoid excessive growth of rye that could otherwise suppress the growth of peas.

Crude protein content of regular leaf-type winter peas tended to be slightly higher than for spring pea Santana, and was consistently higher than with the semi-leafless winter peas Cheyenne and Spirit (Figure 3). Amino acids concentration of regular leaf type is comparable with semi-leafless winter peas, but the concentrations of lysine, tryptophan and arginine were partly significantly ($p<0.05$) higher than with the semi-leafless types (data not shown). This may be of particular importance in pig and poultry nutrition, since the two amino acids lysine and tryptophan are limiting.

Data from the year 2007 will be presented at the conference.

Conclusions

In terms of grain harvest, the four provenances and the EU cultivar EFB 33 in mixture can be regarded as an alternative to spring peas, as they may be expected to reach comparable yields of the same quality. Besides, problems such as severe weed infestation observed in cultivation of spring peas do not appear to be a problem in winter pea cropping.

Acknowledgments

We acknowledge Thorsten Haase for language help.

The experiments were financially supported by the Federal Agency for Agriculture and Food (BLE), Bonn, Germany.

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Annual clovers and medics in living mulch systems: Competition and effect on N supply and soil fertility

Baresel, J. P.[1] & Reents, H.-J.[1]

Key words: genetic resources, legumes, crop farming, plant nutrition, living mulch

Abstract

The potential of a large number of species of self-reseeding annual clovers and medics as continuous ground cover in living mulch systems with cereals in southern Germany and their effect on N supply and soil properties were assessed. Adapted legume species could be identified. The competition of the legumes on rye was limited but not on wheat. Positive effects on N supply and on indicators of soil fertility could be evidenced

Introduction

Living mulch systems are characterised by a continuous ground cover, in the most cases legumes, and by minimum tillage (see Hiltbrunner, 2005). They are of interest mainly for Organic Farming (OF). The potential advantages of such systems are an improved N supply (and thus, in the case of wheat, a better baking quality), less problems of erosion, an improvement of the biological soil characteristics and a reduced input of energy.

In Germany, almost exclusively white clover has been used as ground cover in LM systems. Scientific studies and practical experience from the past years show, that the competition of this relatively aggressive species with its undetermined growth cycle is too strong (Neumann, 2005). The aim of the present study was to asses the potential of annual self-reseeding species, which, due to their determined growth cycle, are potentially better adapted.

The following aspects are highlighted in the present contribution: (1) May annual self-reseeding species be found, which are potentially suitable as living mulches, adapted to German climatic conditions and which are able to re-establish from seed over consecutive years? (2) Are the competitive relationships really more favourable in annual than in perennial legume species? (4) Which contribution to N supply and soil fertility may be expected?

Materials and methods

In 2002 and 2003, a screening of 500 genotypes and 50 species (mainly *Medicago* and *Trifolium* species) was performed by spaced plant evaluation and replicated plot experiments, assessing mainly adaptation to German climate and growth characteristics (survival, persistence, biomass, canopy height, see Baresel et al. 2004). For subsequent studies *Trifolium subterraneum* (TS), *T. campestre* (TC), *Medicago orbicularis* (MO) and *M. minima (MM)* were selected, which turned out to be adapted to southern German climatic and, due to their growth characteristics, were supposed to be suitable for LM systems. With these species, from 2004 to 2006, 11

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field experiments were performed; due to hailstorms and a particularly cold winter in 2005/2006, a part of them could not be fully evaluated. To enable the assessment of the effect of the legumes on N supply, in some of the experiments an N-poor position within the rotation was chosen, which explains the low yield levels in those experiments. All experiments were performed in organically managed farms in southern Bavaria (Germany) on sandy loam soils.

In the first year of each experiments, the legumes were sown together with the main crop, i.e. Winter wheat (cv. „Tiger“) of winter rye (cv. „Walet“) in the second half of August. Early planting is necessary to permit a good development of the legume swards before winter. As controls, plots with perennial legumes (*T. repens* and *M. lupulina*) and *M. truncatula* as well as cereals alone were planted. *M. truncatula* grows quickly in autumn, but is not winter hardy; the use of such frost-killed LM may be a way to reduce competition. In October of the subsequent year, winter cereals (rye and wheat) were planted into the swards of legumes, which meanwhile were re-established from seed (see over-view in Table 1). To prepare a seedbed and to reduce competition by the legumes, a partial tillage was performed combining a strip rototiller with a seed drill. Double rows of cereals were sown into the strips; the distances were 48 cm between and 8 cm within the double rows. In the control plots without legumes, a conventional soil tillage was performed and the cereals were drilled commonly with a density of 400 grains/m² and a row distance of 12,5 cm (Experiments 1-6).

Nitrogen uptake of the above-ground-biomass of legumes, cereals and weeds, soil mineral N as well as, in a part of the experiments, the particulate organic matter (POM) were assessed to valuate the effect of the living mulches on N supply.

Results and Discussion

Within the frame of this contribution, only selected results, highlighting aspects of competition and effects on N supply and soil fertility, can be reported.

In normal winters (2002-2005), the legumes were only little damaged by frost, permitting a good recovery of the legume swards in spring. Only in 2005/2006, after a long period of severe frost and snow (with the formation of a layer of ice), more plants were damaged by frost than in other years. All species tested in the LM experiments (with exception of *M. truncatula*) were able to persist over several years by self-reseeding. In contrast to perennial species, the growth of all annual legumes finished after seed

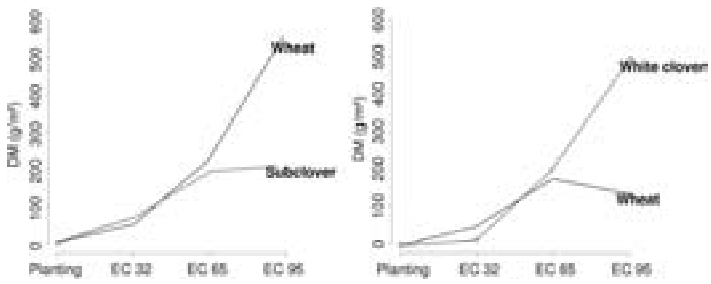

Figure 1: Development of biomasses in living mulch systems with Wheat and subclover, resp. White clover in the year of first establishment (in 2004)

ripening. Thus, the competitive relationships were more in favour of the cereals, compared to white clover (Fig. 1). This was particularly the case, when the cereals were sown into existing swards, but also in the year of establishment. In the experiments established in 2004, with rye as main crop, white clover was suppressed already from the early development stages; this might be also due to the dry conditions during early development of the white clover.

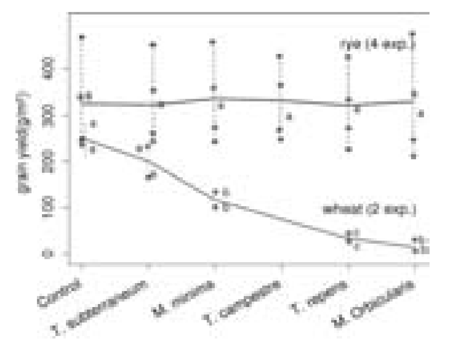

Figure 2: Yield of Rye and Wheat in various living mulches in the year of first establishment. (t-test / Bonferroni; p<0,05).

No reduction of yield of rye due to competition by ground cover legumes could be observed (Fig. 2). For *M. truncatula* (which were killed by frost, leaving moderate amounts of additional organic matter in the soil), a slight yield increase could be observed. For wheat (due to the cold winter in 2005/2006) only the data of one experiment are available: according to the legume species, yield reduction ranged from 20% in *T. subterraneum* to 100 % in *M. orbicularis*, whose development was, due to a moist and relatively cool summer, particularly strong (Fig. 2). In the experiments established in 2005, where the legumes were killed by the frost, no yield reduction by subterranean clover could be observed.

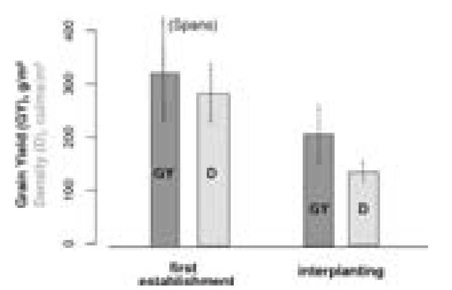

Figure 3: Comparison of cereal yields and plant densities in the year of establishment and interplanting in existing legume swards

Considerably lower yields were achieved sowing cereals in already established swards of subterranean clover (Fig. 3). This was caused by the seeding technique, which requires large distances between the double rows and leads to low plant densities. Cereal and legume biomass are negatively correlated depending on the legume and cereal species as well as on the N supply. Thus, the effect on the N supply varies widely (Fig. 4). N input and output were in an equilibrium at a yield level (for rye) of 5 t/ha. Beneficial effects on indicators of soil fertility such as soil POM content, Aggregate stability and the occurrence of AM spores (Fig. 5) could be revealed.

Conclusions

(1) Annual self-reseeding species could be identified, which were suit-able as living mulches, adapted to German climatic conditions and which are able to re-establish

from seed over more consecutive years. (2) These species were less competitive with the cereals than LM systems with white clover. (3) The contribution to the N supply of the agricultural system is modest and negatively correlated with grain yield; an equilibrium may be achieved with grain yields around 5 t/ha. (4) Due to the continuous ground cover and reduced soil tillage, the soil fertility may be improved. (5) Cultivation and seeding techniques need further improvement in order to make the system practicable for farmers.

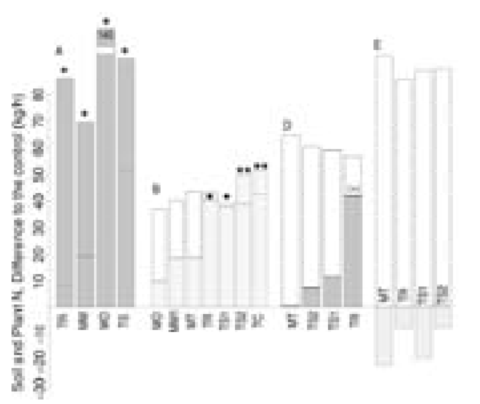

Figure 4: Effect of different legume living mulches on total N, i.e. plant biomass N, soil mineral N and N bound in the POM fraction. (Difference to the control: **: p<0,01; *: p <0.05, (+): p < 0.1, t-test /Bonferroni)

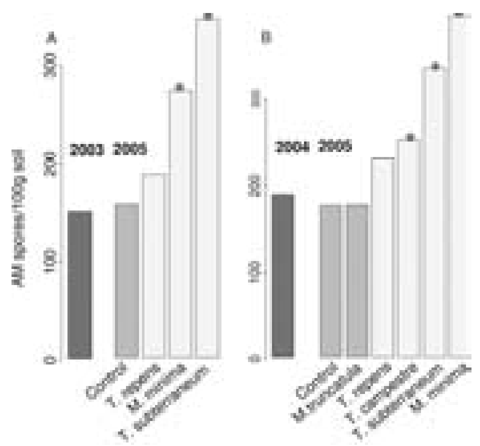

Figure 5: Effect of various living mulches on the occurrence of AM spores compared to the spore density before the establishment of the living mulches (left bar) (*: p <0,05,t-test, / Bonferroni)

Acknowledgments

This project was supported by Bundesprogramm Ökologischer Landbau (03OE99)

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Effect of green manure on weeds and soil fertility in two organic experimental agroecosystems of different ages. Results from 2 years.

Migliorini, P.[1], Vazzana, C.[1] & Moschini, V.[1]

Key words: green manure, organic fertilisers, weeds, soil fertility, Mediterranean organic farming

Abstract

In order to acquire more information about green manure practices in the Mediterranean environment, green-manure crops from two seasons (2003/2004 and 2004/2005) were compared and evaluated in two agroecosystems ("Old Organic" and "Young Organic") of the Montepaldi Long Term Organic Experiment in Tuscany. Data collection included green manure crop (biomass, weeds competition capacity, N and C content), weed biodiversity on maize, and soil fertility characteristics over three periods (in October before sowing the green manure, in April before the incorporation of the green-manure in the soil, and in September at the maize harvest). The different green manure species produced no significant effects on the weeds and N% and C% in the soil. Weeds characteristics (weed species and Shannon Index) showed statistically significant differences among the two agroecosystems, even though the initial condition of the two soils were similar.

Introduction

The maintenance and enhancement of soil fertility can be difficult in Mediterranean arable organic farms, often managed without animal husbandry. In order to maintain N balance, the use of commercial organic fertilisers has increased in Italy (Migliorini, 2005). Generally, in the conversion phase, farmers prefer to substitute chemical fertilisers with organic fertilisers despite the high cost and the uncertain quality of these products. This, in contrast with Organic Agricultural principles and regulations, causes a negative organic matter balance on farm crop rotation and an increase in external inputs. The introduction of green-manure practices in the rotation is potentially a more sustainable practice, enchaining biodiversity (planned component) and soil fertility (close nutrient cycling, soil cover) on the farm level (Mäder et al., 2002). More information about these practices in the Mediterranean area are needed (Drinkwater et al, 1998): i.e. correct choice of species, biomass and N production and C/N ratio content. All of the latter depend on their adaptability to specific soil and climate conditions, as well as on the stability of the agroecosystem. This paper reports the findings of two years of experiments, aimed at studying N and C accumulation and availability in the soil by green manure for the maize crop in two organic experimental agroecosystems of different ages.

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Materials and methods

In the 2 years 2003/2004 and 2004/2005 green-manure crops were compared and evaluated in field trials. . The experiments were carried out in the Montepaldi Long Term Organic Experiment (MOLTE) site, active since 1991 and situated in Tuscany, in 2 organic micro-agroecosystems: a) "Old Organic" (surface area of 5.2 ha, organic since 1991) and b) "Young Organic" (surface area of 5.2 ha, organic since 2001). Both experimental areas were divided in 4 fields of 1.3 hectares (260 m x 50 m) each. Following local land use, a four-year crop rotation was adopted: green manure + maize – hard wheat + red clover – red clover – barley. The average annual precipitation and mean air temperature for 2003-2005 were 800 mm and 15.5 °C, respectively. The experimental data analyzed included: aerial biomass (DM) of different green-manure crops and weeds; the effect on maize weed biodiversity (number of individuals/m^2, species/m^2 and Shannon index) and soil fertility (complete analysis once a year in October; total N and total C coinciding with the incorporation of the green-manure in the soil and the maize harvest. The green-manure crops were sown in autumn (26/09/03 and 15/10/04) and then ploughed under and incorporated into the soil in early spring (6/04/03 and 10/04/04), before the preparation of the soil for seeding the maize crop. As no irrigation was provided, the maize variety (*Zea mays var*) chosen was in the 250/300 FAO class (95-105 days). In both years, the field trial was laid out in a split-plot block design with 4 replicates. The experimental fields changed due to crop rotation but barley always preceded the green manure crop The green-manure species and seed density were: field (horse) bean (*Vicia faba L var. minor*) at 180 kg ha^{-1}, crimson clover (*Trifolium incarnatum L*) at 50 kg ha^{-1}, crimson clover+oats (*Avena sativa*) mixture at 22,5 and 60 kg ha^{-1} respectively. In 2004/05, the squarrosum clover (*Trifolium squarrosum L*) was substituted with crimson clover at a seed density of 30 kg ha^{-1} and t 15 kg ha^{-1} in the mixture, respectively. Differences between treatments were tested using the analysis of variance (ANOVA) for the following factors: year, type of agroecosystem, green-manure species. Mean comparisons were evaluated by the Bonferroni test with SYSTAT 9 software.

Results and discussion

Green-manure crops and weeds biomass (DM t/ha), the total nitrogen and total C/N content just prior to incorporation into the soil in the two cropping seasons are shown in Table 1. Due to inconsistent pedo-climatic conditions, particularly extreme variations in day-night temperatures, the green manure productions are not high compared to other experience in Central Italy (Guiducci et al, 2004). The factor "type of agrecosystem" did not produced statistically significant difference in the majority of the green manure characteristics. The variability of green-manure and weeds biomass between the two cropping seasons is very high. In fact, the more productive green manure crop was the clover+oat mixture in 03/04 (4.94 t/ha), with the field bean in 04/05 (2.79 t/ha). There is an inverse correlation (R=-0,644) between green manure crops and weeds biomass. In fact, the more productive crops are the most efficient in weed suppression. The N accumulation was highest in the field bean in 04/05 (157 kg/ha) due to a higher nitrogen concentration and in clover+oat mixture in 03/04 (124 kg/ha) due to a higher biomass. The effect of the source of variations for year, type of agroecosystems, green-manure crops and their interactions on maize weeds highlights some statistically significant differences. In particular (Table 2), the weed species and Shannon Index among the two agroecosystems were higher in the "old organic" system than in the "young organic".

Tab. 1: Effect of agroecosystem type and green manure species on crop andweed DM biomass production (t/ha),total Nitrogen (kg/ha) and the C/N accumulated in the total biomass in a 2 year field trial.

	2003/04					2004/05				
	GM DM	Weed DM	Total DM	Ntot uptake	C/N	GM DM	Weed DM	Total DM	Ntot uptake	C/N
	Ton/ha			kg/ha		Ton/ha			kg/ha	
Systems										
OO	1.52	1.75	3.28	83.45	12.011	1.30	1.33a	2.64	91.72a	10.415
YO	1.86	2.17	4.04	73.75	11.657	1.52	0.85b	2.37	76.06b	10.494
	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	*	n.s.	**	n.s.
GM										
C	0.00c	2.37a	2.37b	52.96b	11.169bc	0.00c	1.38	1.38c	45.16c	9.694c
GM1	0.47bc	3.18a	3.65ab	71.38b	11.659b	1.28b	1.09	2.37b	72.50b	10.910b
GM2	4.94a	0.52b	5.46a	124.13a	14.964a	1.57b	0.69	2.26bc	60.15bc	11.896a
GM3	1.37b	1.78ab	3.15b	65.93b	9.546c	2.79a	1.20	3.99a	157.75a	9.319c
	**	**	**	**	**	**	n.s.	**	**	**
S*GM										
OO*C	0.00	2.25	2.25	57.48	9.894cd	0.00	1.42	1.42c	51.52c	9.706c
OO*GM1	0.27	2.37	2.65	71.69	12.446bc	1.23	1.67	2.90abc	94.65b	10.350bc
OO*GM2	4.58	0.82	5.40	130.58	16.045a	1.14	0.64	1.79c	48.36c	12.215a
OO*GM3	1.24	1.57	2.82	74.04	9.660cd	2.83	1.60	4.44a	172.33a	9.390c
YO*C	0.00	2.50	2.50	48.45	12.443bc	0.00	1.34	1.34c	38.80c	9.681c
YO*GM1	0.67	3.98	4.65	71.06	10.872cd	1.33	0.51	1.84c	50.35c	11.470ab
YO*GM2	5.29	0.21	5.51	117.67	13.882ab	1.99	0.74	2.73bc	71.93bc	11.577a
YO*GM3	1.49	1.99	3.49	57.82	9.431d	2.76	0.79	3.55ab	143.17a	9.247c
	n.s.	n.s.	n.s.	n.s.	**	n.s.	n.s.	*	**	*

(GM: green manure; OO: old organic; YO: young organic; C: control; GM1: clover; GM2: clover+oat; GM3:field bean. In 2003/04 was used Crimson clover in 2004/05 Squarrosum clover. Values are the means of 3 samples in each thesis for 4 replicates in 2 fields for 4 years; ** significant for P<0.01 and * for P<0.05).

Tab. 2: weed characteristics of the two MOLTE agroecosystem in 2 years field trials

Systems	Weed number	Weed species	Shannon Index
	(n/mq)	(n/mq)	
Old Organic	65,789	4,969a	1,262a
Young Organic	56,617	3,578b	0,953b
significance	*n.s.*	****	****

(Values are the mean of 3 samples in each thesis for 4 replicates in 2 fields for 2 years; ** significant for P<0.01).

The relevance of the stability of the agroecosystem on the effect of treatments is even more important considering that the initial conditions of soil fertility in the four field trials (Table 3) were not different, except for P that was higher in the old organic system and K and N nitric that were higher in young organic. Data regarding soil N% and C% coinciding with the incorporation of green manure in April and at the harvesting of maize in September showed no significant differences statistically for the sources of variation: year, type of agroecosystem, type of green manure crop and their interactions (data not shown). This is in contrast with others researches (Thorup-Kristensen et al. 2003) that show a clear effect on soil N management, N uptake and grain yield. Probably, the no effect is due to the low production level of green-manure crops.

Tab. 3: Soil characteristics of the two MOLTE agroecosystem in 2 years trials.

AES	O.M. (%)	N tot (‰)	N nitric (ppm)	P available (ppm)	K exchange (ppm)	CN
Old organic	1,706	1,252	6,350b	62,900a	103,475b	8,180
Young organic	1,599	1,183	7,800a	53,600b	134,800a	8,311
significance	n.s.	n.s.	**	*	*	n.s.

(Values are the mean of 3 samples for 4 replicates in each fields for 2 years; ** significant for P<0.01 and * for P<0.05).

Conclusions

The maintaining of soil fertility is very important in organic farms. Green manure usage represents a viable and important practice and the correct choice of the suitable crops for the local conditions is a crucial factor in order to obtain sufficient biomass quantity and nutrient availability. In low productive organic systems, the level of stability reached after the conversion period can strongly influence the effects of green-manure biomass on weeds. However, there is not a significant effect on soil characteristics and potential productivity.

Acknowledgments

Research funded by the ARSIA project AGRIBIO (2003-2005).

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Effect of undersowing winter wheat with legumes on the yield and quality of subsequent winter triticale crops

Fuchs, R.[1], Rehm, A.[1], Salzeder, G.[1] & Wiesinger, K.[1]

Key words: undersowing, winter wheat, nitrogen catch crops, winter triticale, legumes

Abstract

The study presents results of a series of trials investigating the effects of undersowing nitrogen fixing crops (legumes) into winter wheat on the performance of the subsequent crop winter triticale. Trials were carried out between 2003 and 2006 at two sites in southern Bavaria, Germany. All species tested - black medic, birdsfoot trefoil, red clover, white clover and a legume-grass mixture - proved to be suitable. Compared to the "not-undersown" control treatment the undersown N-fixing crops had no statistically significant effect on the yield, protein content and other grain quality characteristics of the winter wheat crop, except for one site where protein yield was significantly higher in one year. There was also no difference in disease incidence between "undersown" and "not-undersown" winter wheat. Depending on the seasonal rainfall pattern the establishment of N-fixing crops in wheat had either a negative or a positive effect on the yield of the subsequent crop of winter triticale. Reductions in yield only occurred in the 03/04 season, which had an extremely dry summer in 2003. In the seasons 04/05 and 05/06, which had a more favourable distribution of annual precipitation, the establishment of certain legume crops increased the yield and protein content of winter triticale; however the effect was not statistically significant for all years and sites.

Introduction

For stockless organic arable farms the cultivation of legumes is the most important source of nitrogen. The study presented here investigated the effects of establishing an undersown N-fixing crop (small-grained forage legumes) in wheat on the yield and quality of grain of both the wheat and subsequent triticale crops. Legumes were undersown into an established winter wheat crop in spring, a procedure which is easy, cost-effective, and requires only a low labour input.

The study aimed to answer the following questions:

a) Which of the selected species of legumes are particularly suited for undersowing in winter wheat in the different sites included in the study?

b) Do the undersown legume crops affect the development of diseases, yield, protein content and other grain quality parameters in winter wheat?

c) Does the use of undersown N-fixing crops in wheat affect disease incidence, yield and grain quality in winter triticale crops grown after wheat?

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Materials and methods

Field trials were conducted in two sites in Southern Bavaria: Site S (Schönbrunn, region of Lower Bavaria) and site V (Viehhausen, region of Upper Bavaria). Site S is 385 m a.s.l., has an annual precipitation 730 mm, an average annual temperature of 7.8° C and a humus rich, sandy loam soil (brown earth). Site V is 480 m a.s.l. has an annual precipitation of 780 mm, an average annual temperature of 7.5° C, and a sandy loam soil (brown earth) with a lower humus content than site V. Both trial sites were on farms managed to organic farming standards since the mid 1990's. The trial was established on small plots (1.5m x 8m) as a 'Latin Square' design. The positions of winter wheat treatment plots in the subsequent triticale crop were identified by calibrating the corners of treatment plots from a fixed point in the field. The following species of legumes and seed-rates were tested: black medic (*Medicago lupulina*; 16 kg ha^{-1}); birdsfoot trefoil (*Lotus corniculatus*; 18 kg ha^{-1}), red clover (*Trifolium pratense*; 25 kg ha^{-1}), white clover (*Trifolium repens*; 10 kg ha^{-1}), legume-grass mixture (red clover, white clover, alfalfa (*Medicago sativa*), meadow fescue (*Festuca pratensis*), timothy (*Phleum pratense*), common oat-grass (*Arrhenaterum elatius*) – together 27 kg ha^{-1}). Legume crops were undersown after the last harrowing of the wheat in spring using a plot-drill. Crop assessments, analyses and reports were carried out according to the guidelines of the German 'Federal Office of Plant Variety testing and national listing' (Bundessortenamt 2006). The content of raw proteins was analysed according to the Kjehdahl method.

The study presented here includes results from a series of trials (winter wheat 7 trials, winter triticale 5 trials; 3 seasons in site "S" and 4 in site "V"). Owing to a lack of balance for sites and years the results have been summarised into 'environments'. For the statistical analysis of the individual experiments a mixed model with legume species as a fixed effect was used. Individual means were compared by the Least Significant Difference (LSD; Student-Newman-Keuls (SNK)) test. All analyses were carried out using the SAS statistical software.

Results

In the first year (2003) the development of N-fixing crops was affected by the extreme dry weather in summer (precipitation from July to September: 135 mm versus average annual precipitation of 267 mm). In 2003 white clover yield was only 0.1 t ha^{-1} dry matter (D.M.) while birdsfoot trefoil and black medic yielded 0.3 and 0.4 t ha^{-1} D.M. respectively. There was virtually no establishment of grass in plots undersown with the legume-grass mixture in 2003. In the two subsequent years (2004 and 2005) all catch crops established and developed satisfactorily in both sites.

In all 3 years, undersowing had no statistically significant effect on the yield of winter wheat when compared to control plots which were not undersown with legumes (individual results not shown). In most trials there was also no significant effect on disease incidence in wheat, grain protein content and other grain quality parameters (test weight, thousand kernel weight). However, in 2005 undersown winter wheat showed an increase in raw protein. This increase was significant for crops undersown with white clover, black medic or the legume-grass mixture, with black medic showing the highest content (10.8 % of raw protein D.M.), which was 1.1% more than in the non-undersown control.

In the 2003/2004 season all undersown legume crops caused highly significant ($p < 0.01$, SNK) lower yields of the subsequent winter triticale crop (fig 1). This is thought to have been due to additional water consumption of the legume crops having a negative effect on the pre-winter development of winter triticale. The grain protein content was, however, not affected.

Winter triticale, yield in t ha^{-1}, results from 5 trials

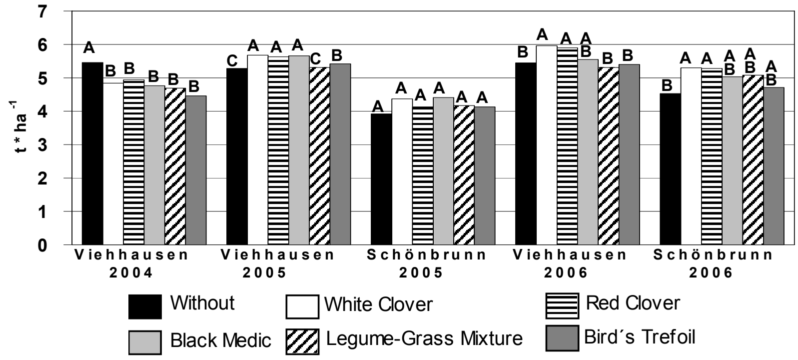

Figure 1: Crop yields of winter triticale in the 5 environments following winter wheat undersown with different species of legumes.

In all other environments undersown legume crops caused either the same or in individual cases significantly higher yields (fig 1). In three environments (V 2005, 2006; S 2006) white and red clover performed significantly ($p < 0.05$, SNK) better than all other treatments. Yields of winter triticale were higher after white clover, red clover or black medic than those of triticale grown after birdsfoot trefoil or the legume-grass mixture. The highest yields were obtained with white clover, as the N-fixing crop which increased yields by 0.77 t ha^{-1} (S 2006). Compared to plots without undersown legumes, the mean crop yield of triticale (mean of all environments, not shown) increased by 7% with white clover, 5% with red clover and 4% with black medic, but decreased by 1% with birdsfoot trefoil. The legume-grass mixture did not affect crop yield.

Discussion

Prior to the introduction of herbicides as the standard method of weed control undersowing of cereals with forage legumes was investigated as a method of weed control in Germany (Becker-Dillingen 1929, Klapp 1958). These studies were rediscovered and re-initiated in the late 1980's, especially in R&D focused on organic cereal production (Vandermeer 1989, Haas & Köpke 2000). Most published studies report positive effects of undersowing legumes on the yield of the subsequent crops such as wheat (Loes et al. 2006, Böhm 2007). This could be confirmed by the study presented here for triticale, a crop for which there was no published information with regard to green manure effects. The study also demonstrated that undersowing of winter wheat may increase baking quality in winter wheat, which addresses one of the main technological challenges in organic wheat production. Restrictions could be found for years with dry summers. Under those conditions undersown forage legumes do not perform well, nevertheless yields of subsequent crops are reduced. Further trials regarding the effects of undersowing legumes into winter rye with a subsequent spring oat crop are currently being conducted. The effect of undersowing on the yield of the subsequent spring oat crop is expected to be greater than the effects observed for winter triticale, due to the longer (up to 4 weeks) growing period of the undersown legume crop. If the crop rotation does already include a large proportion of legumes, undersowing may increase the risk of legume specific diseases (Klapp 1958).

Conclusions

The use of undersowing with small-grain legumes in organic cereal production systems is a safe approach in sites/seasons with sufficient water availability (annual precipitation 700 – 800 mm, average annual temperature 7.5 – 8° C, brown earth). The study identified a range of well-suited legume species for undersowing that do not negatively influence the winter wheat crops they are undersown into. We recommend red clover, white clover and black medic. A legume-grass mixture and birdsfoot trefoil are not advisable. The fact that undersowing resulted occasionally in positive effects on the quality (especially protein yield) in wheat further underpins the recommendation to use undersowing in organic cereal production. The finding that in extremely dry years yield reductions can occur in subsequent triticale crops, means that undersowing should only be recommended for sites with a good water supply.

Acknowledgments

We are grateful to Stefan Kimmelmann, director of the Research Station for Organic Agriculture 'Viehhausen', Technische Universtät München, and all colleagues from the 'Landesanstalt für Landwirtschaft' who contributed to the project. We would also like to thank Elisabeth Fisel, Freising, and Prof. Carlo Leifert, Newcastle, for supporting the translation.

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Contribution of N from frequently chopped green manure to a succeeding crop of barley

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Key words: cereals, plant residue, N recovery, soil N

Abstract

The aim of the present work was to study to what extent N in mulched green manure herbage contributes to spring barley grain yield the subsequent year. The green manure herbage was either chopped and left on stubble (GML) or removed (GMR). On silty clay loam with spring incorporated green manure the subsequent barley grain yield was 10% higher with GML than with GMR. The additional grain N yield of 4 kg ha^{-1} with GML corresponded to only 3 % of N in above-ground green manure biomass. On loamy soil with late autumn incorporated green manure the treatments did not affect the grain yield the subsequent year. How large part of the N that was lost through leaching or gaseous emissions and how large part that was built into soil organic matter was not measured. However, this investigation confirms that potential N losses from mowed green manure might be large. Alternative ways of using the herbage should be found.

Introduction

Nitrogen (N) supply in stockless organic cereal production is based on leguminous green manure plants within the crop rotation. In northern temperate regions both undersowing of clover in cereals and whole season green manure crops are used. Whole season green manure is managed by repeated mowing; this to control perennial weeds and encourage regrowth and N-fixation. Due to the large content of easily degradable N accumulated in the green manure crops, the potential N losses from the green manure herbage are large (Breland 1996 a, b; Askegaard *et al*. 2005). The practice of leaving the herbage as mulch after repeated mowing increases this risk of N losses (Larsson *et al.*, 1998) both through gaseous emissions (NH_3, N_2O and NO), and surface runoff or leaching of NO_3^- and soluble organic N. Such N losses are a hazard for the environment and a reduction of the N input to the system, which is not compatible with a sustainable development of organic farming. Hence, it is important to focus on strategies improving N utilization of whole season green manure in organic spring cereal production.

The aim of the present work was to study to what extent N in mulched green manure herbage contributes to spring barley grain yield the subsequent year.

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Materials and methods

Two field trials were carried out from 2005 to 2006. They were located on organically farmed soil at the Norwegian Institute for Agricultural and Environmental Research at Kvithamar (Field 1) in central Norway (63°29´N, 10°52´E) and Apelsvoll (Field 2) in central south-east Norway (60°42´N,10°51´E). The soil on field 1 is a silty clay loam and on field 2 is a loam. The precipitation during the growing season 2005, the subsequent winter and the growing season 2006 was 473, 546 and 222 mm, respectively, for field 1 and 270, 339 and 222 mm for field 2.

The experiment was designed in blocks with four replicates. The green manure crop consisting of a mixture of common vetch (*Vicia sativa* L., 80 kg ha^{-1}), phacelia (*Phacelia tanacetifolia* Benth. 5 kg ha^{-1}), ryegrass (*Lolium multiflorum var. Italicum* Lam., 10 kg ha^{-1}) and red clover (*Trifolium pratense* L., 5 kg ha^{-1}) was grown in 2005. The green manure was cut with a plot harvester and then either chopped with a stubble cutter and left on stubble (GML) or removed from the plot (GMR). The green manure on field 1 was incorporated into the soil by ploughing (depth of 23 cm on both fields) in the spring the day before barley was sown. Field 2 was ploughed in late autumn 2005. In May 2006, immediately before sowing of spring barley (*Hordeum vulgare* L.), the soil was dragged and harrowed on both sites. No fertilizer was applied.

Grain yield and biomass of green manure was recorded on all plots by harvesting subplots of 9.75 m^2 (Field 1) and 20 m^2 (Field 2). The stubble height of green manure was 5-6 cm. Grain quality parameters; thousand grain weight, hectolitre weight, content of protein and starch were analysed in samples from all plots; the last three parameters by Infratec 1241 Grain Analyzer. Above-ground biomass of barley at early stem elongation (Zadoks 30) was recorded on all plots by harvesting two subplots of 0.25 m^2. Soil mineral N (0-25 cm) was measured in late autumn (Field 1: 7th November, field 2: 19th October); one month after the last green manure cut, and in the spring the day before ploughing. Analyses were done by 1M KCl extraction.

Statistical analyses were carried out by analysis of variance (proc glm; SAS, 2002).

Results

The barley yield in field 1 was 10 % higher for plots with GML compared with GMR (Table 1). The straw yield on the same plots was 15 % higher. No differences between the treatments of green manure herbage were found in amount of N in plants at early stem elongation or in hectolitre weight, thousand grain weight, and amount of protein or starch in grain.

On field 2 no differences in barley yield, straw yield, N content or the quality parameters were found between the treatments.

Tab. 1: Barley grain and straw yields (g dry matter m^{-2}) after whole season green manure with herbage left (GML) or removed (GMR) from the plots. SE in brackets (n = 4)

	Grain			Straw		
	GML	GMR		GML	GMR	
Field 1	240 (14)	217 (11)	*	161 (8)	137 (3)	*
Field 2	237 (16)	225 (22)	n.s.	168 (3)	160 (6)	n.s.

* significant for p<0.05

On field 1 dry matter yield and N yield of the 3rd green manure harvest on plots with GMR were 36% lower than GML ($p<0.05$). There was a tendency to higher amounts of legumes at the 3rd harvest with GMR. On field 2 the dry matter yield of the 3rd harvest was not significant, but there was a tendency to be higher with GMR. On plots with GMR the total N was higher, due to a higher amount of legumes.

The amount of mineral N in soil in autumn on both fields tended to be higher on plots with GML than with GMR. In the spring no difference in mineral N content in soil was found between the treatments. The amount of nitrate in soil in autumn was highest on plots with GML on both fields. Highest amount of nitrate was found in depth 12.5-25 cm on field 1 and in depth 0-12.5 cm on field 2. The difference between treatments in ammonium content was not significant.

On field 1 the amount of N in grain yield with GML was 9% higher than with GMR. This additional N yield of 4 kg ha^{-1} corresponded to 3 % of the N in the above-ground biomass of green manure herbage the year before (Figure 1).

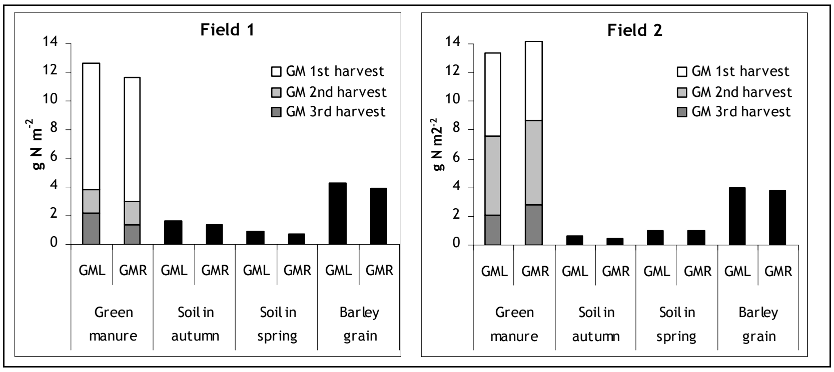

Figure 1: Amount of total N in three harvests of green manure, mineral N in soil (0-25 cm) and total N in barley grain after green manure herbage left (GML) or removed (GMR) from the stubble.

Discussion

Small differences in cereal grain yield succeeding green manure with the herbage left or removed in the field were also observed by Whitbread *et al*. (2000) and Solberg (1995). As no or only a little part of the N from green manure herbage seemed to be recovered by barley the subsequent year, the main N source for the barley was probably soil organic matter (C/N ratio of 11) and the under-ground biomass of the green manure. Autumn incorporation of the green manure on loamy soil (field 2) seemed to remove any difference between the treatments.

How large part of the N that was lost through leaching or gaseous emissions and how large part that was built into soil organic matter was not measured. However, the results indicate that N losses from mowed and mulched green manure may be substantial, as also found by e.g. Janzen & McGinn (1991) and Larsson *et al*. (1998).

Løes *et al.* (2007) found that whole season green manure in one out of four years in cereal crop rotation does not accumulate enough N to compensate for the N removed in cereals. They concluded that additional N sources are needed. Strategies to improve N utilization of whole season green manure in organic spring cereal production should be sought. An alternative strategy could be the conservation of the green manure herbage during the winter as hay, silage, compost, or biogas slurry from anaerobically digestion of green manure herbage, for early incorporation in the spring before sowing the cereal crop. This topic requires further study.

Conclusions

The results from the field experiments showed a 10% lower or no difference in subsequent spring barley grain yield when green manure herbage was removed from the field after each cut compared with green manure herbage left on the stubble after the cuttings. The additional grain N yield of 4 kg ha^{-1} with mulched herbage corresponded to only 3 % of the N in above-ground green manure biomass. This fact, together with the knowledge of high risks of N losses from remaining herbage, implies that alternative ways of handling and storage of green manure herbage should be sought.

Acknowledgments

This work was financed by the Research Council of Norway (NFR). The technical assistance of Thorbjørn Wikmark and Oddvar Bjerke is greatly acknowledged.

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Potentially mineralizable nitrogen is soils green manured with biocidal crops

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Key words: green manure, N mineralization, Brassicaceae, methyl bromide, metam sodium

Abstract

Biofumigant crops used as green manure, in addition to producing a biocidal effect on some soil-borne pathogens and pests, could represent a source of N for crop nutrition. In two laboratory experiments we compared i) the potentially mineralizable N (PMN) of a silty clay soil after incorporation of glucosinolate-containing (GLS+) and non-containing (GLS–) plants, or after incorporation of metam sodium; and ii) the mineralization rate of different types of soils (silty clay, loam and loamy sand) after green manuring with GLS+ crops. After a 3-month incubation, the PMN of the silty clay soil amended with the GLS+ Brassica juncea was significantly higher than the unamended control and the soil amended with Triticum aestivum and Eruca sativa. Metham sodium, while showing a remarkable nitrification inhibition activity, gave rise to amounts of inorganic N (mainly in the ammonium form) of the same level as B. juncea. Mineralization rate was higher in the loamy sand soil than in the loam and in the silty clay soils. Biofumigant crops used as green manure, by increasing N availability in soil, may represent an interesting source of N for the following crops in organic agriculture.

Introduction

Biofumigant crops used as green manure, in addition to having a biocidal effect on some soil-borne pathogens and pests (Brown & Morra, 1997), may represent a source of N for the following crops. Two laboratory experiments were performed with the following objectives: (i) to compare the potentially mineralizable N (PMN) of a silty clay soil green manured with glucosinolate-containing (GLS+) and non-containing (GLS–) crops. Metam sodium, which is a chemical treatment widely used as an alternative to methyl bromide, was also tested for its effect on soil PMN; (ii) to compare the mineralization rate of different kinds of soils after green manuring with GLS+ crops.

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Materials and methods

Experiment I. A silty clay soil was green manured with Indian mustard (*Brassica juncea* L. Czern., GLS+), garden rocket (*Eruca sativa* Mill., GLS+), or winter wheat (*Triticum aestivum* L., GLS–) crop species, in comparison with an untreated soil and with a soil fumigated with metam sodium (methyl isothiocyanate). *Experiment II*. Three soils belonging to contrasting textural classes: silty clay, loam, and loamy sand, were amended with *B. juncea* and *E. sativa, and* compared to an untreated control. Experimental details are reported in Tab. 1. The plant material had been harvested from small field plots at full flowering and finely cut in a grinder mill just before incorporation to soil.

Tab. 1: Selected properties of green manure (GM) and soils used in the two experiments.

GM	Exp.	Added fresh GM (g L^{-1} of wet soil)	Kjeldahl N (g kg^{-1} dry matter)	Plant moisture (% wet weight)
B. juncea	I	71	22.0	77.5
B. juncea	II	71	17.9	80.2
E. sativa	I	36	14.8	75.1
E. sativa	II	36	21.2	80.2
T. aestivum	I	71	13.3	74.8

Soils	Exp.	Bulk density (kg wet soil L^{-1})	Kjeldahl N (g kg^{-1} dry soil)	Initial moisture (% dry weight)	Sand (g kg^{-1})	Silt (g kg^{-1})	Clay (g kg^{-1})
Silty clay	I	0.79	1.58	17.0	116	478	406
Silty clay	II	0.81	1.95	22.7	98	494	408
Loam	II	1.04	0.80	12.3	466	415	119
Loamy sand	II	1.11	0.82	4.3	821	154	25

Amendments were incorporated to a known volume of wet soil in pots kept moist at ambient temperature for a week. In both experiments, PMN was then determined according to Drinkwater et al. (1996): 25 g of wet soil were added to 40-mL scintillation vials, the soil moisture was adjusted at 75% plant available water content and the vials were incubated at 30°C for 3 months (91 days), with 3 replicates for each treatment and date (i.e., at time 0 and after 91 d after the start of the incubation). In the first experiment the PMN was expressed as the net cumulative inorganic N released in soil in the 3-month incubation period. As short-term aerobic incubations quantify a portion of the total PMN (Drinkwater et al., 1996), which, in turn, depends on the total soil organic N content (measured as Kjeldahl N), in the second experiment mineralization rate (MR) was estimated from PMN, as the mean daily amount of net inorganic N released per unit of Kjeldahl N measured at the beginning of the incubation period in both amended and control soils (MR, mg N g^{-1} N d^{-1}= (PMN/91) / soil Kjeldahl N). Statistical analysis was performed using the SAS PROC MIXED (SAS Institute, 1996).

Results

Experiment I. After 3-month incubation the PMN value of the silty clay soil amended with *B. juncea* was significantly higher than the control (Tab. 2; +51 mg N kg^{-1} soil), mainly due to the accumulation of nitrate N. The PMNs of the soil amended with *E. sativa* and *T. aestivum* were not significantly different from the control, even though the former was higher, and the latter lower than the PMN of the control. In soil added with metam sodium, the PMN was significantly higher than the control soil, due to a remarkable increase of ammonium, but not of nitrate N.

Tab. 2: Potentially mineralizable N (PMN) in a silty clay soil 3 months after the incorporation of different amendments. Inorganic N is the sum of net cumulative nitrate (NO_3–N) and ammonium (NH_4–N) N.

Treatment	PMN, total inorganic N and N forms (mg N kg^{-1} soil dry weight)[1]		
	Inorganic N	NO_3-N	NH_4-N
B. juncea	102ab	122a	˜21b
E. sativa	68bc	71b	˜3b
T. aestivum	27d	41c	˜14b
Metam sodium	111a	5d	106a
Control	51cd	51bc	0b
$LSD_{0.01}$	40.8	27.6	22.8

1 For each column, means followed by the same letters are not significantly different for P<0.01.

Tab. 3: Mineralization rate (MR, mean daily amount of net cumulative inorganic N per unit of organic N in soil) of different soils green manured with Brassicaceae plant material.

Treatment	MR (mg net cumulative inorganic N g^{-1} Kjeldahl N day^{-1}) in soil[1]			
	Loam	Loamy sand	Silty clay	Means of Treatment
B. juncea	0.79b	1.11a	0.54cd	0.74A
E. sativa	0.71bc	0.87b	0.46de	0.63B
Control	0.25f	0.33ef	0.30f	0.30C
Means of Soil	0.59B	0.77A	0.43C	

[1] Upper-case letters were used for comparisons of the mean effects, lower-case letters for the comparison of the first-order interaction effects. For each source of variation, means followed by the same letters are not significantly different for P<0.01. $LSD_{0.01}$ for comparisons between soils or treatments = 0.104 mg inorganic N g^{-1} Kjeldahl N day^{-1}. $LSD_{0.01}$ for comparisons between soils and treatments (soil □ treatment effect) = 0.181 mg inorganic N g^{-1} Kjeldahl N day^{-1}.

Experiment II. Green manured soils showed significantly higher MRs than the control soils. The highest MR was observed in the loamy sand (Tab. 3). Not significantly different MRs were observed between control soils.

Discussion

In the first experiment the highest PMN was observed in soil green manured with *B. juncea*, the lowest in soil green manured with *T. aestivum.* Trinsoutrot et al. (2000) reported a net N mineralization in soil amended with *Brassica napus* leaves throughout 168-d incubation, in contrast with net N immobilization for maize straw. The short-term reduction of N availability following the incorporation of winter wheat crop residues, as a result of N immobilisation, is well known, and confirmed by our results. Metam sodium, while showing a remarkable nitrification inhibition activity (in agreement with the findings of Welsh, 1996, in laboratory conditions), greatly stimulated the release of ammonium N from indigenous soil organic matter. In the second experiment, nitrogen mineralization in green manured soil was faster in the loamy sand than in the loam and silty clay soils. This is in agreement with the observations of Pare and Gregorich (1999) for sand soils added with crop residues having a low C:N ratio.

Conclusions

Biofumigant crops used as green manure, by increasing N availability in soil, may represent an interesting source of N for the following crops in organic agriculture.

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Agronomic performance of annual self-reseeding legumes and their self-establishment potential in the Apulia region of Italy

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Key words: annual self-reseeding legumes, *Trifolium* spp*., Medicago* spp*., biological* nitrogen fixation, Mediterranean region.

Abstract

The agronomic performance, biological nitrogen fixation (BNF) ability and self-establishment potential of seven species of annual self-reseeding legumes were investigated in Apulia region, Italy. For the first cropping cycle (2005-2006) preliminary results showed that Trifolium spp. *performed better than* Medicago spp. *Among the seven species, five were more suitable to the site's conditions.* T. angustifolium *and* M. polymorpha *gave the best results.* T. angustifolium *fixed 131.7 kg ha^{-1} year of nitrogen (^{15}N isotope dilution method), produced 1976 kg ha^{-1} of seeds and 8.7 t ha^{-1} of dry matter (DM).* M. radiata *and* M. rigidula *were the less performing. During the second cropping cycle (2006-2007) results showed that* Trifolium spp. *self-established better than* Medigaco spp. *Regenerated species appeared to sustain optimum level of BNF.* Again T. angustifolium *was the best performing species producing the highest DM (7.7 t ha^{-1}) and fixing nitrogen (146.7 kg) N ha^{-1} symbiotically. In contrast,* M. polymorpha, *was the less performing (0.3 t ha^{-1} of DM and 11.5 kg ha^{1} of BNF) while* M. rigidula *and* M. radiata *did not regenerate. Given the overall performance of all species, it was determined that* T. angustifolium *had the greatest potential for further development in this environment.*

Introduction

Successful establishment of annual legumes is achieved only with the use of varieties that have both high persistence and high productivity within the specific environment in which they are used (Rochon *et al*., 2004). In the Mediterranean areas, native ecotypes are more persistent and better adapted than commercial varieties. Self-reseeding annual legumes can play an increasingly important role in Mediterranean organic farming systems. They are flexible components within the whole farm systems, and can be used as cover crop, living mulches, green manure and forage crops to increase economic, environmental and social sustainability (Caporali *et al.*, 2004). Nitrogen fixed by legumes is the main nitrogen source in organic farming systems (Loges *et al*., 2000). Moreover, in order to design strategies for optimizing management of biological nitrogen fixation (BNF) for maximal production with minimal nitrogen pollution of water resources, it is essential that nitrogen inputs by legumes and the subsequent fate of this nitrogen be quantitatively assessed (Unkovich and Pate, 2001).Therefore, the agronomic performance, ability of nitrogen fixation and self-establishment potential of seven self-reseeding legumes (four *Trifolium* species *as* well as three *Medicago* spp.) were investigated in comparison with *Trifolium*

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subterraneum cv. Antas *(T.su.)* used as reference crop during the period between autumn 2005 and spring 2007 in South of Italy.

Materials and methods

The experiment was carried out at the experimental field of IAMB located in Apulia region, South of Italy (41°03'16"N, 16°52'45"E, 72 m a.s.l.). Apulia region is characterized by a Mediterranean climate with humid mild winter and hot dry summer. Precipitation varies from 400 to 500 mm/ year and is mainly concentrated between October and April. Annual average temperature ranges from 15 to 16 °C, with a maximum of 35°C recorded in July and a minimum of 0°C in January (IAMB's Agrometerological Station). The soil type was a sandy clay. Soil pH was 8.1, soil organic matter 1.6%, P and K (0-20 cm) were approximately 85 and 514 mg kg^{-1}, respectively at experimental site. Seven accessions of annual self-reseeding legumes (*Trifolium angustifolium (T.a.), T. campestre (T.ca.), T. cherleri (T.ch.), T. stellatum (T.st.), Medigago polymorpha (T.p.), M. rigidula (M.ri.) M. radiata (M. ra.*) and two reference crops *Trifolium subterraneum (T.su)* cv. ANTAS (Crl1) and barley *Hordeum vulgare* (Crl2) (as reference for ^{15}N isotope dilution method) were arranged in a randomised completely block design with four replicates. Each block was composed of 9 plots of 9 m^2.

Legumes were sown in November 2005 at a rate of 28 kg ha^{-1}. The first growth cycle extended over seven months until the end of May 2006. Legumes were left on the field over the summer after seed production. In autumn (October 2006), legumes self-established after the first rain and grew until April 2007. Legumes were then incorporated (no cutting regime) as a green manure for further investigation. During the two growing cycles, plant height and crop ground cover were measured every two weeks. Before full-flowering stage April 2006 and March 2007, BNF was quantified using ^{15}N isotope dilution method (Unkovich and Pate 2001). In each plot, a quadrat of 2.25 m^2 was identified and two grams of ammonium sulphate $(^{15}NH_4)_2SO_4$ diluted in 10 liters of water were sprayed. At the end of each growing cycle a representative sample per plot was used to measure DM, seed yield (only for the first cycle) and ^{15}N (mass spectrophotometer) for BNF quantification. Statistic analysis was performed on each variable by analysis of variance followed by Duncan's test.

Results and brief discussion

Highly significant differences of DM production were obtained between *T.a*, *T.ca*, *M.p.* and *T. su* (Crl1) in which Crl1 showed the lowest DM value. Highly significant differences were also observed between the Crl1 and *M.ri* and *M. ra,* in which Crl1 showed a higher value (Tab.1). The lowest DM production of *M. p.* and *M. ri.* were far inferior to these reported by Walsh *et al*., (2001) in a study for annual medic production, with large differences in experimental design and sites conditions (i.e. soil pH=6.1) in Western Australia. Amount of BNF ranged from 0.7 to 147 kg ha^{-1} (Tab.1 & 2) and this is confirming results of Peoples *et al*., (1998) and Evers (2003). *T. a.* resulted in the highest BNF (146.7 kg ha^{-1} year), *M. p.* and *T. ca*. resulted in the lowest amounts (11.5 and 9.9 kg ha^{-1} year) in the second cropping cycle while (90 and 70 kg ha^{-1} year) in the first, respectively. This is due to the high DM production of *M. p.* and *T. ca*. in the first cropping cycle (5.5 and 5.1 t ha^{-1}) in comparison with only (0.3 and 0.3 t ha^{-1}) in the second cycle, respectively. A clear reduction in BNF was also determined for *T.ch*. and *T. st*. for the second cropping cycle.

Tab. 1: Agronomic performance of annual self-reseeding legumes (at the end of the 1st growth cycle November 2005- May 2006)

Species	Plant height (cm)	Crop ground cover (%)	DM ($t\ ha^{-1}$)	Seed yield ($kg\ ha^{-1}$)	BNF ($kg\ ha^{-1}$ year)
T. angustifolium	43.4 b	100 a	8.7 a	1976 a	131.7 a
T. campestre	33.9 b	100 a	5.1 b	472 cd	66.7 c
T. stellatum	32,6 c	100 a	3.2 c	683 d	35.2 d
T. cherleri	28.5 cd	99 a	3.6 c	1089 b	47.2 d
M. polymorpha	55.6 a	100 a	5.5 b	732 c	89.6 b
M. rigidula	23.6 d	53 b	0.9 d	60 e	1.9 e
M. radiata	6.1 e	8 c	0.2 d	22 e	0.7 e
T. subterraneum cv. Antas (Crl1)	51.4 a	100 a	2.8 c	527 cd	32.6 d

Means with different letters are significantly different (Duncan test, α=0.05)

Highly significant differences were assessed between *T. a*. and *T. su.* (Crl1) for mainly DM and BNF in which the Crl1 showed the lowest value. Highly significant differences were also obtained between the Crl1 and the rest of the tested species in which the Crl1 showed the highest value (Tab. 2).

Tab. 2: Self-establishment of annual self-reseeding legumes (at the end of the 2nd growth cycle September 2006- April 2007)

Species	Plant height (cm)	Crop ground cover (%)	DM ($t.ha^{-1}$)	BNF ($kg\ ha^{-1}$ year)
T. angustifolium	97.5 a	40.6 a	7.7 a	146.7 a
T. campestre	20.6 b	3.0 c	0.3 c	9.9 d
T. stellatum	63.8 b	6.8 b	1.2 c	39.6 c
T. cherleri	55.0 b	7.0 b	1.7 c	40.8 d
M. ploymorpha	4.6 b	3.8 c	0.3 c	11.5 c
M. rigidula	Not regenerated			
M. radiata				
T. subterraneum cv. Antas (Crl1)	100.0 a	39.8 a	5.4 b	125.2 b

Means with different letters are significantly different (Duncan test , α=0.05)

Generally, the legumes (except *T.a)* did not perform as well during the second cropping cycle compared to the first. This result confirms the results of an experiment conducted by Thorup-Kristensen and Bertelsen (1996) in Denmark, as well as the results of another experiment conducted in Italy at Mediterranean Agronomic Institute of Bari (IAMB) (Al-Bitar, 2005). These results are not only based on the amount of nitrogen fixed, but also on others parameters like legumes plant height, crop ground cover and DM production.

Conclusions

The genus *Trifolium* appeared better adapted to the pedo-climatic conditions of the studied area than the genus *Medicago*. Both *Medicago radiata* and *Medicago rigidula* did not regenerate while *Medicago polymorpha* regenerated very poorly. We conclude that *Trifolium angustifolium* is suitable for Apulian conditions due to its higher BNF and rapid soil covering. After their incorporation, all legumes treatments (except *T. ra.* and *T. ri.*) showed a positive precrop effects on all growth parameters of the subsequent crops (Zucchini and lettuce) compared to controls without legumes preceding. *T.a* induced the best effect on the zucchini and lettuce crop yields (42.66 and 48 t ha^{-1}) respectively. Consequently, *T.a.* may play an important role in managing soil fertility and be considered as a key-element in enhancing field biodiversity. It can further be recommended to integrate *T.a* in Apulian organic cropping systems (i.e. organic vegetable crops) as a winter cover crop for the purpose of green manure under a rotation program.

Acknowledgements

This work was carried out in the framework of a joint PhD programme (Driouech, 2005-2007) between Tuscia University-Viterbo and Mediterranean Agronomic Institute of Bari (IAMB). Gratitude is also extended to International Center of Agricultural Research in the Dry Areas (ICARDA) for legume seeds supply.

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Performance of grain legume crops in organic farms of central Italy

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Key words: pea, faba bean, lupin, grain legumes, Mediterranean crop

Abstract

In the 2005-2006 growing season, eight varieties of faba bean, pea and lupin were compared in two organic farms, located in two regions of Central Italy (Tuscany and Marche), to evaluate their adaptation to local environment and agronomic performance in terms of grain yield and competitive ability against weeds. Pea showed a higher grain production than faba bean and lupin, which were negatively effected by the environmental conditions during winter 2005 and spring 2006. Time of seeding seems to be very important for the competitive ability against weed of the different varieties. In Tuscany the lupin Italian variety Multitalia, the only one Italian variety, obtained interesting performance in terms of grain yield and weed competition, although the spring seeding.

Introduction

Grain legumes such as faba bean (*Vicia faba L var. minor*), field pea (*Pisum sativum L.*) and lupin (*Lupinus albus L.*) play a fundamental role in organic agriculture and livestock (Siddique et al, 1999) to improve soil fertility, to close the cycle of nitrogen and as protein sources alternative to soybean which could reduce the risk of GMO contamination in the food chain. Even though field pea and faba bean are mainly diffused in Italy as grain legumes for animal feeding, recently a strong interest has been developed for white lupin (*Lupinus albus L.*) due to its interesting performance in France, Germany and Australia. In Italy only one lupin variety (Multitalia) is enrolled in the national registry; moreover lupin cultivation was reduced from 60.000 hectars in 1931-35, with an average seed production of 0,93 t/ha, to 3.000 hectars in the period 1986-1990, with an average seed production of 1,27 t/ha. At present, due to the need of identifying an alternative to soybean in the organic livestock sector, the cultivation of lupin can gain a renewed interest. The purpose of the research was to evaluate the adaptability to environments of Central Italy and to evaluate the agronomic performances of grain legumes such as field pea, faba bean and lupin in organic cropping system.

Materials and methods

The field experiments were carried out in the growing season 2005/06 in two organic farms of the Central Italy, one (S1) located in province of Florence (Tuscany) and the

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other (S2) in province of Ancona (Marche region). The soil characteristics in the two locations are reported in Table 1.

Tab. 1: Soil characteristic (0-30 cm) in the two experimental fields

Experimental site	Clay content %	organic matter %	pH	N tot ‰	P2O5 avail. mg/kg	K20 exch. mg/kg	Ca exch. mg/kg
S1	65,00	1,67	6,86	1,21	150,60	351	2321
S2	41,40	1,68	8,20	1,10	19,00	228	81000

The eight varieties (2 of faba bean, 3 of field pea, 3 of white lupin) of Italian and French origin used in both field trials are listed in Table 2. Both in Tuscany and in the Marche region sowing was carried out in November. Lupin seeds were inoculated with *Bradyrhizobium lupins* (souche LL13). In the trial carried out in the Marche region also the pea varieties Speleo and Pacific were included.

Tab. 2: Characteristics of the varieties of leguminous used in the experiment

Species	Variety	Constitutor	Seed density (seeds/m^2)	Distance between rows (cm)
Vicia faba L var. minor	Vesuvio	Iscf/SIS	50	18
	Chiaro di Torre Lama	Università di Napoli/ Agroservice	50	18
Pisum sativum L. leafless type	Classic	Cebeco	100	18
	Hardy	Serasem/Florisem	100	18
	Ideal	Serasem/SIS	100	18
Lupinus albus L.	Multitalia	Università di Napoli/ Agroservice	50	36
	Lumen	Inra-AgriObtentions/ Jouffrey Drillaud	50	36
	Luxe	Inra-AgriObtentions/ Jouffrey Drillaud	50	36

In both locations lupin crop has endured strong damages from winter cold and in the S1 trial a spring seeding of lupin was executed. The field trial was laid out in a randomized block design with two and three replicates in the S1 and S2 location, respectively. Plot size was 1020 m^2 (6x170m) in S1 and 420 m^2 (6x70m) in the S2 location. In the S1 site, the presence and density of weeds (number of species and number of individuals for each species) was determined in April 2006 with two samplings of 0,25 m^2 within each plot. In June 2006 average plant height and time of the reached maturity (expressed as number of days after sowing) were assessed. Moreover, at maturity plants were harvested by hand with 3 samplings of 1 m^2 within each plot. Weeds were separated from leguminous crop plants and both were oven dried at 80 °C to constant weight to assess dry matter (DM) production. In both experimental sites, mechanical harvesting was performed when grain reached 13% of relative humidity. Differences between treatments were tested using an analysis of variance (ANOVA) and mean comparisons were evaluated by the Bonferroni test.

Results and Discussion

In the location S1, faba bean and field pea reached maturity with slight differences (tab. 3) while the varieties sown in spring didn't manage to mature properly before the warmth.

Tab. 3: Reached maturity of leguminous crop in Days After Sowing (DAS) in S1

Crop	Variety	Sown period	Maturity DAS (gg)
Faba bean	Vesuvio	autumn	214
Faba bean	Chiaro T.L.	autumn	213
Pea	Classic	autumn	214
Pea	Hardy	autumn	216
Pea	Ideal	autumn	216
Pea	Hardy	spring	88
Lupin	Multitalia	spring	102
Lupin	Luxe	spring	102

At maturity faba bean plant were higher than the other species but both field pea and faba bean sown in autumn accumulated equivalent biomass (tab. 4). However, field pea varieties sown in autumn obtained greater grain yield than faba bean. The performances of lupin Multitalia is interesting as it reached equivalent height and biomass of pea and faba bean varieties sown in autumn and greater grain yield than faba bean.

Tab. 4: Average height (cm) and dry matter of leguminous crop (gr/m^2), dry matter of weed (g/m^2), grain yield at 13% of humidity (t/ha) in S1

Source of variation	n weed plant	n weed species	DM weed		H Leg		DM Leg		Grain Yield	
			(g/m^2)		(cm)		(g/m^2)		(t/ha)	
Species			***		***		***		***	
Faba Vesuv.	95	8,0	45,58	c	98,00	ab	940,63	a	3,16	f
Faba Chiaro	117,5	8,0	56,16	c	107,33	a	1036,60	a	3,49	e
Pea Class.	43,5	8,5	49,66	c	92,83	b	1039,98	a	5,36	b
Pea Hardy	94,5	10,5	43,50	c	95,16	ab	1117,66	a	6,03	a
Pea Ideal	98	8,5	34,33	c	91,00	b	1040,35	a	5,15	c
Pea Hardy	59	8,0	140,00	b	52,16	c	263,33	b	0,00	g
Lupin Multi.	42,5	4,0	36,95	c	91,50	b	874,25	a	4,50	d
Lupin Luxe	9,5	1,5	251,00	a	26,66d	d	170,83	d	0,00	g

* significant for P<0.05; *** significant for P<0.001

The weed DM biomass is inversely proportional to the biomass developed by the cultivated plant. Spring pea Hardy was the less competitive against weed and lupin Multitalia was competitive as the crops sown in autumn. Results concerning grain production obtained in the field trial carried out in the Marche region are summarized in Table 5. Field pea varieties showed significantly higher seed productions than faba bean. In particular, the varieties Speleo and Hardy showed seed yield higher than 4 t/ha, which can be considered of relevant interest for organic farms of Central Italy. Pacific was characterized by the lowest yield among the field pea varieties tested. The low grain yield of faba bean varieties (low vegetative growth, a low density of the faba bean crop in terms of number of plants/m^2 and a low number of legumes per plant) could be a consequence of the environmental conditions of winter and spring in the growing season 2005-2006. This trend was observed also in most of the farms which cultivated faba bean in the area where the field trial was conducted. Lupin cultivation completely failed in the S2 location, probably due to the high pH and $CaCO_3$ concentration values of soil (tab. 1). This result, compared to the success of the lupin crop in the Tuscany trial, support the need of new lupin varieties with an increased tolerance to high soil pH values to extend this crop in wider areas of Central Italy.

Tab. 5: Average grain yield at 13% of humidity (ton/ha) obtained in the field trial carried out in the Marche region. All lupin crops failed

Source of variation	Grain (t ha^{-1}	
Species/Variety	*	
Pea Speleo aut.	4,34	a
Pea Hardy aut.	4,23	ab
Pea Ideal aut.	3,80	ab
Pea Classic aut.	3,51	b
Pea Pacific aut.	2,61	c
Faba bean Chiaro T.L. aut.	2,07	c
Faba bean Vesuvio aut.	1,89	c

* significant for $P<0.05$; *** significant for $P<0.001$¨

Conclusions

Pea was shown to have higher grain yield in both sites than faba bean and lupin. The proper choice of variety and right time of seeding are fundamental for the pea cultivation in organic agriculture. Faba bean and lupin were influenced by winter cold and adverse environmental condition. However, lupin Multitalia sown in spring managed to develop a good biomass in order to compete against weeds and to produce grain yield greater than autumnal faba bean.

Acknowledgments

The work was partly funded by the interregional project EQUIZOOBIO. Special thanks are due to Coop. E. Sereni and to Mr. V. Luciano for hosting trials on their farms.

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Influence of intercropping and irrigation frequencies on leaf development and taro (Cocoyam) productivity under organic management

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Key words: Organic Agriculture, *Colocasia esculenta*, *Crotalaria juncea* und Green Manuring

Abstract

The objective of this work was to evaluate the influence of the intercropping and irrigation frequencies on the leaf development and productivity of taro (Colocasia esculenta) under organic management. The experiment was set up as a randomized complete block design, a factorial 2 x 2, with four replications. Taro was cultivated in monoculture or intercropped with Crotalaria juncea under two irrigation frequencies: every 3.5 days for 30 minutes and every 15 days for 2 hours. The intercropping increased taro petiole length but did not increase leaf area. The same effects were observed for irrigation frequency on the leaf area and petiole, length at the 30th and 60th days after C. juncea cutting. The amount of taro yield and offshoot number of class 1 (category up to 40g) were affected negatively by the intercropping. However the total number, total yield and average weight of the offshoot were not affected by the intercropping. The irrigation frequency promoted positive effects in the number and weight of offshoot (category of 80g weight or higher), as well as in the total taro yield and average offshoot weight. The conclusion was that the short frequency irrigation contributed for the development and productivity of taro offshoots and the intercropping with C. juncea did not decreased the total productivity of taro cropping.

Introduction

The taro (*Colocasia esculenta*) is a food with great potential for exploration, because it has a good rusticity and adaptation capacity to different conditions of soil and climate (Nolasco, 1983) of the tropics and is well suitable for organic production. The cycle of the culture of taro is influenced by several factors, including: temperature, variety, brightness and availability of water and nutrients. In Brazil, the cycle varies between 5 and 9 months in the Central Regions and Southeast of the country (Filgueira, 2003). The initial growth of taro is slow, only reaching maximum development between the fourth and sixth month. That phase is marked by the increase in the leaf area, in the number of leaves and plant height. In the next phase, the leaf development decreases in intensity and the plant growth is reduced. Under irrigation, the cycle is prolonged and the maturation point is more difficultly recognized, and the harvested period can be reduced, because tillering starts faster (Soares, 1991). Some of those factors such as availability of nutrients and plant variety characteristics have been studied, however, the factor water supply and shading still need more information, primarily in planting systems intercropped with legume. The objective of the present work was to

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determine the influence of the intercropping and irrigation frequencies in the leaf development and productivity of taro (*Colocasia esculenta*) under organic management.

Materials and methods

The experiment was conducted in the Experimental Station of Pesagro-Rio (Rio de Janeiro State Agricultural Research Organization) in Avelar, Municipality of Paty do Alferes, State of Rio de Janeiro, Brazil. The Station is located in a mountain area at 575m of altitude with climatic condition of "tropical humid of altitude" according to the Köppen system. The soil of the experimental area is an Oxisol previously cultivated during several years with horticultural crops. Soil was ploughed down once and disked in twice before planting. The experiment was set up as a randomized complete block design, a factorial 2 x 2, with four replications. The treatments were two crop systems, taro in monoculture or intercropped with *Crotalaria juncea*, and two different irrigation frequencies: 30 minutes every 3.5 days (short frequency) and 2 hours every 15 days (long frequency), being four hours/month with the same volume of water for both cases. The taro was planted in the spacing of 1.0 x 0.3 m. At planting time it was applied bovine manure equivalent to 100 kg ha^{-1} of nitrogen. The *C. juncea* was sowing in double lines (spaced 0.5m with 30 seeds/linear meter) between the taro raw 90 days after the taro planting, and cut 60 days after planting. The attributes evaluated in the taro plants, after the legume cutting, consisted in measurements of the leaf area and height of taro plants in a follow up of three months. In the harvesting time it was evaluated the number and yield of the taro offshoots separated in three categories: class 1 - up to 40 g; class 2 - between 40 g and 80 g and class 3 - above 80 g. For statistics interpretation, it was applied the F test and Scott-Knott test ($p<0.05$).

Results

The statistical analysis showed significant effects for factors, but no interaction among them. The leaf area was the same in monoculture or intercropped with *C. juncea* (Figure 1), declining significantly in the end of the cycle, not happening the same with the height of the plants.

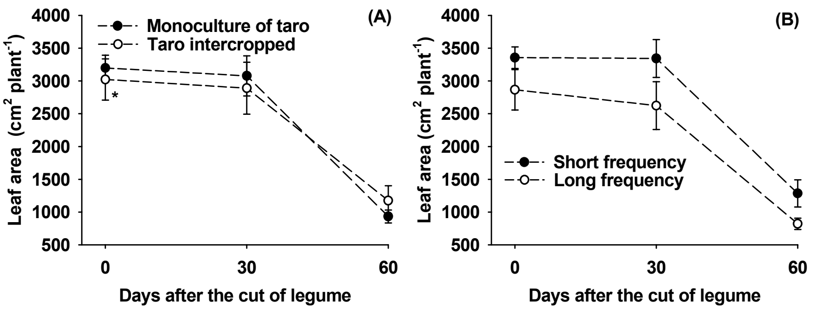

Figure 1: Leaf area of taro plants (A) in monoculture or intercropped with *C. juncea,* and (B) with different irrigation frequency at 0, 30 and 60 days after the cut of the legume. *Vertical bar indicate ± standard error of the mean.

The taro petiole was longer in the intercropping system with a legume cut at 60 days (Figure 2). The same effect was observed for the irrigation frequency, being the larger leaf area and taller plants at 30t and 60 days for the short frequency irrigation.

The taro yield and offshoot number (class 1) was affected negatively by the intercropping system. However, the total number and offshoot yield were not affected by the intercropping, as well as the weight of the taro corms and offshoots (Table 1). The short irrigation frequency promoted effects significantly larger in the number and weight of offshoot of the class 3, as well as in the total productivity and medium weight of offshoot, not affecting the weight of the central taro corm (Table 1).

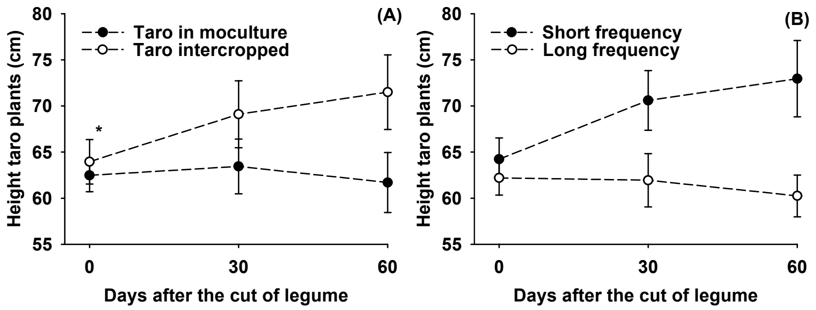

Figure 2: The taro plant height (A) monoculture or intercropping with *C. juncea,* and (B) irrigation frequency at 0, 30 and 60 days after legume cutting. *Bars in vertical indicate ± standard error of the mean.

Tab. 1: Mean values of total number and yield of taro offshoots and corms in monoculture and intercropped with *C. juncea* under different irrigation frequency.

Treatments[1]	ONC[2] ha^{-1} x 10^3			TON ha^{-1} x 10^3	WC (Mg ha^{-1})			TOW Mg ha^{-1}	WCC Mg ha^{-1}	WMS (g)
Irrigation frequency	1	2	3		1	2	3			
Long frequency	102,20 a	70,63 a	37,30 b	210,13 a	1,87 a	3,15 a	2,66 b	7,68b	3,12 a	35,53 b
Short frequency	112,50 a	80,67 a	66,72 a	259,90 a	2,21 a	3,42 a	5,66 a	11,29 a	3,63 a	43,83 a
Crop system										
Monoculture	124,15 a	80,06 a	54,03 a	258,24 a	2,35 a	3,27 a	4,20 a	9,82a	3,19 a	37,65 a
Intercropped	90,55b	71,25 a	50,00 a	211,80 a	1,73 b	3,30 a	4,12 a	9,15a	3,55 a	41,71 a
C.V. (%)	17,52	30,14	45,69	21,02	22,75	28,27	44,20	28,57	24,25	16,87

[1]Means followed by the same letters in the column for the same treatment are not different by Scott-Knott test (p>0.05).
[2]Taro offshoot number per class (ONC), total taro offshoot number (TON), weight per class (WC), total offshoot weight (TOW), weight of central corm (WCC) and mean offshoot weight (WMS).

Discussion

The growth of *C. juncea* caused progressive increases of shading on taro plants. Although the majority of the species of the family Aracea is considered shade-tolerant (Rubatzky & Yamaguchi, 1997) taro intercropped with *C. juncea* showed increasing on petiole length, and in consequence taller plants were produced in comparison to taro cropped alone. This result was different than what could be expected for a shade tolerant specie (Rubatzky & Yamaguchi, 1997). During the taro cycle some leaf blights occurred due to excess of sun shinning, what might have affected the leaf area in monoculture, as well as in the long frequency irrigation for monoculture and intercropping treatments. In a shading condition, the reduction in taro offshoot number (class 1) in the intercropping treatment may be due to decreasing in energy and nutrients availability for the central taro corm and the use of this energy and nutrients for prolongation leaf petiole. Oliveira (2004) also found in an alley cropping of taro with pigeon pea (*Cajanus cajan*) the incidence of leaf blight where legume was pruned.

Conclusions

The intercropping of taro with *C. juncea* stimulates the development of taller taro plant but not altering taro leaf area.

The intercropping affects negatively the number and yield of offshoot of the class 1 but not affecting the total yield and total number of offshoot all classes together.

Short irrigation frequency increases in the taro: the leaf area, the plant height, the mean offshoot weight, and the total offshoot yield.

Acknowledgments

We acknowledge the support received from FAPERJ, CNPq, CAPES and Pesagro-Rio.

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Effect of crop management on weeds, pests and diseases

Effects of husked oat varieties, variety mixtures and populations on disease levels, crop cover and their resulting yields

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Key words: husked oats; varieties; variety mixtures; diseases; crop cover

Abstract

Two seasons (2005/06 and 2006/07) of field experiments which aimed to study the suitability of new and established husked oat varieties, variety mixtures and a husked oat population for organic systems were established at two sites in the west and east of the UK. The ground cover and leaf area indices of the varieties had significant effects on final yields in the 2005/06. Mixtures generally yielded similarly to the means of component varieties but the mixtures in 2005/06 and 2006/07 had 25 % and 18 % less disease, respectively, than the average of the component varieties at one site.

Introduction

Oats have many qualities that make them suitable for organic production including high nitrogen use efficiency (Sylvester-Bradley, 1993) and competitiveness against weeds (Seavers & Wright, 1999). The aim of this project was to identify, in existing and novel husked oat varieties, traits that are key for organic farmers. These traits include competitiveness (measured by crop cover and maximum leaf area index (LAI)), pest and disease resistance and good combining ability in variety mixtures that may help to overcome variability caused by biotic and abiotic stresses.

This paper discusses crop cover, LAI and disease results of two years of the husked oats experiments and their influence on final yields. Further details of the trials can be found in Clarke *et al.* (2007) and Jones *et al.* (2006).

Materials and methods

Organic trials examining husked varieties of winter oats were established at both Sheepdrove Organic Farm, Berkshire, UK and Wakelyns Agroforestry, Suffolk, UK in October 2005 and 2006. The experiments tested three varieties (Gerald, Tardis, Brochan) in 2005/06 and four (original three plus Mascani) in 2006/07, plus their three (or four) -way mixture and a selection of lines bulked at F2 ('population') and then grown at only Sheepdrove or Wakelyns. The experiments were carried out as the first cereal in the rotation (after a grass-clover ley) in 2005/06 and the second cereal in the rotation in 2006/07. The experiments were of a replicated split-plot design with 1.45m x 10m split-plots. Variety assessments included numbers of plants emerged and established, early crop cover (percentage of ground covered by crop) at growth stage (GS) 29 (Zadoks *et al.*, 1974), crop height, diseases on the flag leaf (GS 70-75), lodging, maximum canopy cover, and grain yield.

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Results

Trial season 2005/06

The first differences among husked varieties were detected when crop cover was determined early in the season. The significant ($P < 0.001$) differences in early crop cover among varieties were evident at Wakelyns only (Table 1), where Tardis had the highest crop cover, Brochan was slightly, but not significantly lower, and Gerald had a significantly lower level of crop cover than Tardis and Brochan. This trend was seen again, but this time at both sites, later in the season when maximum Leaf Area Index (LAI) was determined (Table 1). For both assessments, and at both sites, the mixture performed better than the mean of the components, although the differences were small at Wakelyns. At Wakelyns the mixture had a 2 % higher leaf area index than the component varieties and at Sheepdrove, this was higher at 10%.

There were generally low levels of the foliar diseases crown rust (*Puccinia coronata*) and powdery mildew (*Erysiphe graminis*) this season. However, at Sheepdrove, there were significant ($P < 0.001$) differences among varieties in terms of disease; Tardis had the lowest levels and Gerald the highest (Table 1). The variety mixture had 25% less foliar disease than would have been expected from the average of the component varieties.

Yields were generally high, with yields at Wakelyns averaging 9.8 t ha^{-1}. At both sites, the significant ($P < 0.05$) differences among varieties showed the same effects (Table 1); Tardis had the highest yield and Gerald the lowest. The mixtures yielded 2 % higher than the mean of the component varieties and the 'population' yields were similar to those of the mixture.

Tab. 1: Mean early crop cover, Leaf Area Index (LAI), percentage disease on the flag leaf and yield of husked varieties grown at Sheepdrove, Berkshire and Wakelyns, Suffolk in 2005/06.

Site	Variety	Early crop cover (%)	Maximum LAI	Total Disease (%)	Yield (t/ha at 15% moisture concentration)
Wakelyns	Brochan	46.4	9.96	-	9.55
	Tardis	50.1	9.75	-	10.48
	Gerald	36.3	8.98	-	9.04
	Mixture	45.3	9.80	-	9.90
	Population	46.7	9.89	-	9.96
	l.s.d.	4.34	0.455	-	0.357
Sheepdrove	Brochan	16.0	6.60	11.0	6.98
	Tardis	17.8	6.31	1.7	7.70
	Gerald	17.3	5.97	14.4	6.93
	Mixture	17.8	6.95	6.8	7.35
	Population	18.8	6.48	7.7	7.23
	l.s.d.	4.74	0.632	2.78	0.465

Trial season 2006/07

Differences were detected in early crop cover among the entries only at Sheepdrove. Tardis had a significantly (P = 0.015) higher level of crop cover than the other varieties and mixture (Table 2). However, there were no significant differences in LAI among the varieties, the mixture and populations at either Sheepdrove or Wakelyns.

This season was notable in terms of the large amounts of disease present, especially crown rust (*Puccinia coronata*). There were significant (P < 0.001) differences in total disease levels on the flag leaf among the varieties, mixture and populations (Table 2) at both Sheepdrove and Wakelyns. At Sheepdrove, Gerald had significantly higher levels of disease than the other varieties, with Mascani having slightly, but not significantly, lower levels than Brochan and Tardis. At Wakelyns, Gerald had the lowest level of disease of the varieties, but was still greater than the population. The disease results of both sites are reflected in the yields of the varieties with Gerald having the lowest and Mascani the highest yields at Sheepdrove and Gerald the highest yields at Wakelyns (Table 2). The mixture had 18 % less disease than the average of its component varieties at Sheepdrove (Table 2), but only 3% higher yields. The populations yielded relatively well at both sites.

Tab. 2: Mean early crop cover, Leaf Area Index (LAI), percentage disease on the flag leaf and yield of husked varieties grown at Sheepdrove, Berkshire and Wakelyns, Suffolk in 2006/07.

Site	Variety	Early crop cover (%)	Maximum LAI	Total Disease (%)	Yield (t/ha at 15% moisture concentration)
Wakelyns	Brochan	28.9	2.74	81.6	3.99
	Tardis	25.9	2.91	85.6	4.02
	Gerald	26.7	2.68	65.8	4.75
	Mascani	22.8	3.11	83.8	4.41
	Mixture	27.2	2.76	80.0	4.09
	Population	34.2	2.86	58.2	4.65
	l.s.d.	6.82	0.349	7.20	0.371
Sheepdrove	Brochan	39.4	4.74	11.4	6.23
	Tardis	52.8	4.58	10.3	6.66
	Gerald	37.0	4.26	22.3	6.15
	Mascani	42.5	4.55	8.9	7.05
	Mixture	41.3	4.69	10.8	6.71
	Population	45.1	4.49	14.4	7.20
	l.s.d.	8.85	0.63	5.23	0.590

Discussion

In 2005/06 differences in canopy cover and LAI throughout the season had major effects on final variety yields. This is likely to have been due to the greater level of photosynthesis in the denser crops, but may also have resulted from the better weed smothering ability of the larger plants, a trait especially important early in the season (Bond & Grundy, 2001). Effects were not found to the same extent in 2006/07, but this was related to very unusual weather patterns during the season which may have influenced tillering.

Disease levels were also important in determining final yield, especially in 2006/07 where severity was greater due to a wet summer. The results from both seasons show the effectiveness of mixtures at controlling the spread of disease, with 25% and 18% less disease present on the flag leaves of the mixtures than the average of the component varieties at Sheepdrove in 2005/06 and 2006/07, respectively.

The use of populations gives an extra level of diversity over and above that found in mixtures, leading to complementation of genotypes and the ability to buffer environmental variation (Phillips & Powell, 1984). In 2006/07 this ability may have lead to the populations having the highest and second highest yield at Sheepdrove and Wakelyns, respectively, when unusual weather patterns resulted in lower than average yields.

Conclusions

Tardis and Mascani were the best performing varieties in 2005/06 and 2006/07, respectively. However, mixtures were useful in reducing disease levels, and populations performed consistently well.

Acknowledgments

Thanks to all OATLINK project partners. OATLINK is sponsored by Defra and SEERAD under the Sustainable Arable LINK programme and lead by IGER.

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Exploiting weed management benefits of cover crops requires pre-emption of seed rain

Gallandt, E.R.[1], & Molloy, T.[1]

Key words: cropping system; green manure; weed seedbank

Abstract

To manage weeds with reduced reliance on, or without herbicides, cropping systems require intervals during which rapid and significant reductions in the germinable portion of the weed seedbank occur or, if already small, management to maintain a low density. Cover cropping systems and component studies have identified single-season cover cropping practices that will lower the density of the germinable weed seedbank, offering an effective means for managing the weed seedbank while maintaining or improving soil health. Specifically, field experiments demonstrated that soil disturbance events associated with cover cropping encouraged germination and seedling establishment thereby reducing the density of germinable seeds in the weed seedbank. Of notable importance, however, are the disturbance events that preempt weed seed rain. If weeds are permitted to reach reproductive maturity in cash or cover crops, the "debits" to the seedbank resulting from early season disturbance will likely be overwhelmed by the resulting seed rain "credits."

Introduction

Cultivation generally kills a constant proportion of established weed seedlings (Mohler, 2001). High levels of weed control in organically-managed fields thus requires a low density of germinable seeds in the weed seedbank, and consequently a low initial density of weed seedlings. Seedbanks in agricultural systems may be managed by maintaining low densities of weeds, by enhancing the competitive advantage of the crop, by increasing seed mortality, and by manipulation of the soil environment to reduce the probability of weed establishment (Gallandt 2006. Cover cropping practices may be useful in this regard, contributing soil disturbance events that preempt weed growth and stimulate germination of additional weeds, and establishing a competitive environment that can reduce seed production of surviving weeds. Moreover, cover crops often offer flexible management opportunities that can prevent weed seed rain. They also contribute residues that reduce weed establishment in subsequent crops. A further advantage of cover cropping practices is their potential beneficial contribution to soil quality.

We compared single-season cover cropping practices, varying in intensity, for their ability to directly or indirectly reduce the density of germinable seeds in the weed seedbank. We hypothesized that the decline in the weed seedbank would be proportional to the intensity of cover cropping as reflected by the amount of time live cover crop biomass is present in a system, and the frequency of unique disturbance (tillage/mowing) events.

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Materials and methods

To evaluate the contribution of cover cropping practices to the management of the weed seedbank, field experiments were established in the spring of 2004 and repeated in the spring of 2005, in a randomized complete block design with four replications. Treatments included four cover crop systems and a fallow control. We considered the intensity of cover cropping to be based on the length of time a field is kept in a living cover crop, the biomass production of the cover crop, and the number of tillage or mowing events before the next cash crop (Figure 1). Back-to-back cover cropping involves more soil disturbance and was therefore hypothesized to decrease the soil seedbank faster.

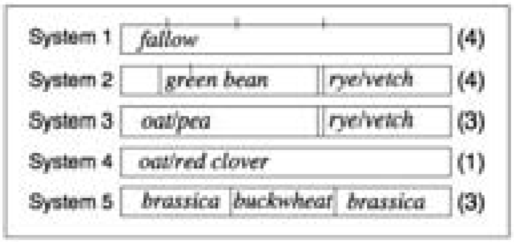

Figure 1: Cover cropping systems established in 2004 and repeated in 2005. Numbers in parentheses indicate major disturbance events that would preempt weed growth.

Synthetic seedbanks were established in the areas to be planted to the cover crop Systems. Weeds were dispersed at 2100 viable seeds m^{-2} in the early spring ("frost-seeded") prior to cover crop establishment. The synthetic seedbanks included a 2 m^{-2} area seeded with an equal number of *Setaria lutescens*, *Chenopodium album*, and *Abutilon theophrasti*. Ceramic beads, similar in size and density to *C. album*, were included to evaluate the efficiency of recovery. Greenhouse germination was used to estimate the readily germinable (non-dormant) fraction of the seedbank. Direct extraction using specialized wet sieving equipment was used on sub-samples to enumerate dormant seeds and ceramic beads.

Results

Greenhouse germination. The initial germinable seedbank densities were unaffected by System (Figure 2). Poor timing of late-season disturbance resulted in considerable *C. album* seed production and an increase in the seedbank in the field pea/oat-rye/vetch system (Figure 2 A). Other treatments responded remarkably similar over time and species, demonstrating that systems with more soil disturbance events result in greater depletion of the seedbank over a single season (Figure 2). Notable is the consistently dramatic single-season reduction in *C. album*, *S. lutescens* and *A. theophrasti* in the systems that included three or more unique disturbance events (Figure 2 A-C).

Direct extraction. Thirty nine percent of the sown "surrogate" seeds (ceramic beads), averaged over years, were recovered in the spring following sowing, and 25% in the following spring. The density of *S. lutescens* seeds remained the greatest in the oat/red clover system (data not shown), consistent with the theory that season-long cover crops may act to preserve the preceding years seedbank compared to systems managed with more frequent disturbance events.

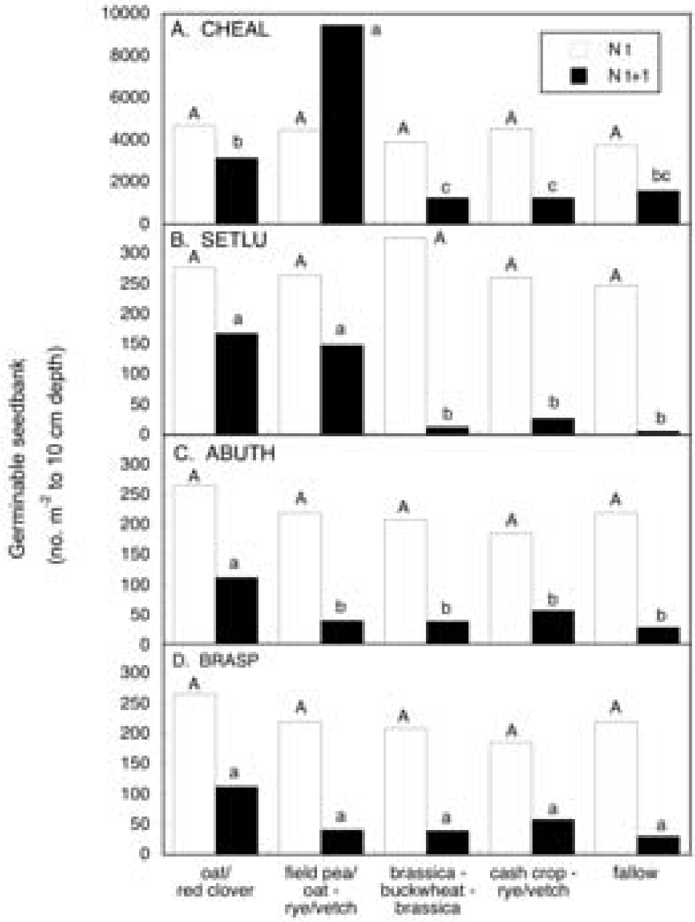

Figure 2: Density of germinable seeds sampled in the spring, prior to implementing cover cropping sytems (N t), and sampled the following spring (N t+1), in Maine, U.S.A. *Oat/red clover* included a single unique disturbance event whereas *fallow* and *cash crop/rye vetch* received four disturbance events; other systems included three disturbance events. Species included *Chenopodium album* (A), *Setaria lutescens*, *Abutilon theophrasti* (C), and several brassica species (D), primarily *Sinapus arvenses*, *Brassica rapa*, and *Raphanus raphanistrum*. Means labeled with common letters within year (N t or N t+1) are not significantly different (P > 0.05).

Discussion

Cover crops may contribute multiple benefits to organic farming systems that aim to function with greater biodiversity, notably linking management to improve soil quality with multiple direct and indirect stresses that may reduce weed problems (Bàrberi 2002; Gallandt 2004). While the beneficial contributions of cover crops are frequently discussed, without strategic implementation, cover cropping may actually exacerbate existing weed problems. A long period of a perennial cover crop will, for example, preserve the seedbank of relatively persistent species. If the growth of a cover crop is not terminated prior to weed reproduction, the cover crop can contribute significant seed rain. Thus, deployment of cover crops should be guided by the timing of unique disturbance events to avoid "crediting" the seed bank while maximizing opportunities for "debiting" the seedbank (Forcella 2003). For example, post-harvest management should aim to keep seeds on the soil surface to encourage predation (Westerman et al., 2006), and timing of tillage events, i.e., summer fallowing, should aim to maximize germination losses.

Conclusions

Single-season cover cropping practices including three or more unique soil disturbance events resulted in a marked reduction in the germinable weed seedbank. Despite their apparent competitive ability, and likely benefits to soil quality, full season cover crops lacking soil disturbance may result in considerable weed seed rain and therefore an increasing weed problem in subsequent years. While we do not discourage growers from considering these full-season cover crops, they must be monitored carefully so that they are terminated prior to production of viable weed seed.

Acknowledgments

This work was part of a collaborative project "Threshold-based Cover Cropping Strategies for Weed Management," supported by the Northeast Regional Integrated Pest Management program, and conducted in collaboration with S. Mirsky, W.S. Curran, D.A. Mortensen, and M.E. Barbercheck, Penn State University.

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Direct Seeding of Faba Beans in Organic Agriculture

Köpke, U.[1] & Schulte, H.

Key words: weed control, high residue reduced tillage system, mulch, precrop oats, gross margin

Abstract

Field experiments carried out at two experimental sites over two years showed that temporary direct seeding (DS) of faba beans (FAB) is possible in Organic Agriculture (OA) when weed pressure of perennials is low. Weed density of DS treatments was significantly lower when compared with mouldboard plough (MP, control) although no clear effects on annual weeds were given by the precrop oats neither by the amount of crop residues (0, 4, 6 t ha^{-1}) nor the sowing density of autumnal sown oats (0, 600, 1200, 1800 seeds m^{-2}) simulating hail-shattered grains. No significant differences in grain yield but lower costs of labour and fuel were determined for DS compared with MP. Estimated DS gross margins exceeded MP gross margins when DS yield losses remained lower than 0.95 t ha^{-1} as compared with MP yields.

Introduction

The aim of reducing tillage intensity is to prevent soil compaction and erosion, to improve top soil trafficability and to save labour and energy costs. All non-inverting tillage procedures usually show higher microbial activity or microbial biomass in the upper topsoil compared with the lower topsoil. Correspondingly, it is often suggested that tillage procedures in Organic Agriculture (OA) should avoid disturbance and mix of the different soil layers. However, the use of loose soil husbandry (LSH) which is mostly performed with the mouldboard plough (MP) and combined with secondary tillage is still common practice. Only a few organic farmers in Central Europe are using the extreme option of firm soil mulch husbandry (FSMH), i.e. direct seeding (DS), mainly due to two reasons: i. under temperate climate conditions omitting deep loosening and thorough inversion of the topsoil results in cooler and wetter soils in early spring and hence in reduced mineralization and nitrification of soil-borne nitrogen and its transformation into crop yield of non-leguminous crops. ii. tillage, and in particular ploughing, is one of the most effective tools to directly control annual and perennial weeds as well. Synthetic total herbicides that enable mainstream farmers to conduct no-till systems over years are not allowed to be used in OA, and their natural counterparts ('bioherbicides') that are officially certified in other regions of this globe (e.g. natural vinegar, corn gluten, pine wood extracts) are currently not considered as adequate to be used in Europe's OA (Kühne et al. 2005).

In contrast to non-legumes, grain legumes do not depend on soil-borne nitrogen due to their ability to fix nitrogen symbiotically. Competitiveness against weeds is high for faba beans (FAB) which can satisfy their high demand for water to germinate in wetter no-tilled soil.

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Mulch layers of precrops may suppress weeds. For efficient weed suppression Barberi (2002) considers homogeneous distribution of at least 4-6 t ha^{-1} crop residues necessary. Additionally, allelopathic action of some oats genotypes has been assumed (Chou 1986). For the conditions of European temperate climate, competitiveness of yellow oats (*Avena sativa* L.) is considered as relatively high when compared with other cereals (Davies & Welsh 2001). Our own previous experiments have shown that yellow oats performed better, i.e. more residues and higher crop ground cover were produced when compared with black oats (*Avena strigosa* Schreb). Based on the experience in year 2004 when hail-shattered grains and reduced yield of yellow oats by 60%, leaving the field with a thick mulch layer of straw and shattered germinating seeds weed free, we established field trials in order to test the following hypotheses: (i.) Direct seeding of FAB into a mulch layer of precrop oats enables sufficient control of annual weeds. (ii.) Increasing density of autumnal germinating oats can further increase weed suppression. (iii.) Perennial weeds can limit FAB grain yield also in a system that omits tillage only temporarily.

Materials and methods

Two two-factorial field trials with four replicates were carried out in 2006 and 2007 at the organic research farm Wiesengut (WG) of the University of Bonn in Hennef (Germany) on a clayey-silty to sandy-silty floodplain sediment (fluvisol, 50°48´ N, 7°17´ E; 62 m a.s.l.; mean annual temperature 10.2°C; mean annual precipitation 750 mm). The experimental site was homogeneously covered with *Ranunculus sardous*, an endangered 'red list' annual weed species that could develop vigorously in autumn and overwintered with about 15 winter rosettes m^{-2} . Thus, *R. sardous* was considered as realizing early competition comparable to perennial weeds. A further trial was conducted in 2007 under the conditions of low weed pressure on a conventional experimental farm Frankenforst (FF) on a stagnic luvisol derived from loess (50°42' N, 7°12' E; 182 m a.s.l.). Since data of 2007 are still not fully exploited predominantly results of 2006 are presented here. DS-treatments were: (a) straw residue: 0, 4, 6 t ha^{-1}, resp.; (b) autumnal seeding density of oats: 0, 600, 1200, 1800 grains m^{-2}, resp., hand sown broadcasted into oats stubble. MP control consisted of oil radish as winter cover crop, ploughing and seed bed preparation in early spring. FAB (45 grains $m^{-2)}$ were sown in all treatments of WG-2006 trial on March 24, 2006 with a direct seeding machine (John Deere 750 A). Crop establishment was determined. Weed ground cover, weed density and weed dry matter were determined four times over the growing season in 0.5 m^2 subplots. Besides combine harvesting on 11 m^2 $plot^{-1}$ grain yield and yield components were determined also in weedy and manually weeded 1m^2 subplots Soil nitrate and ammonium were determined. ANOVA was performed by using SPSS (version 14) followed by Shapiro-Wilk's test. In a first step factors 'residues' and 'seeding density of oats' were tested omitting the control. In a second step a pairwise comparison of each DS treatment with MP control was performed by using the Dunett's test.

Results and brief discussion

Seeding density and crop establishment of FAB were equal in DS and MP treatments (38 plants m^{-2}). According to our hypothesis, density of annuals apart from *R. sardous* was significantly lower in DS treatments compared with MP control (FIG 1). Pairwise comparison of weed dry matter including *R. sardous* resulted in some DS treatments significantly higher compared with MP control that eliminated *R. sardous* completely. Weed parameters did show neither a significant effect of increasing amount of straw residue nor the seeding density of oats whose seedlings were totally destroyed by frost over winter as expected. Soil nitrate in DS treatments was significantly lower compared with the MP treatment. Retarded early development of FAB in DS treatments was considered as resulting from cooler and wetter soil as well as high competitiveness of *R. sardous*. Significantly higher shoot d. m. production was determined in MP compared with DS until 90 DAS (FIG. 2). FAB did overgrow weeds in DS after *R. sardous* finished flowering. 130 DAS (harvest date) differences of shoot mass of tillage treatments no longer existed.

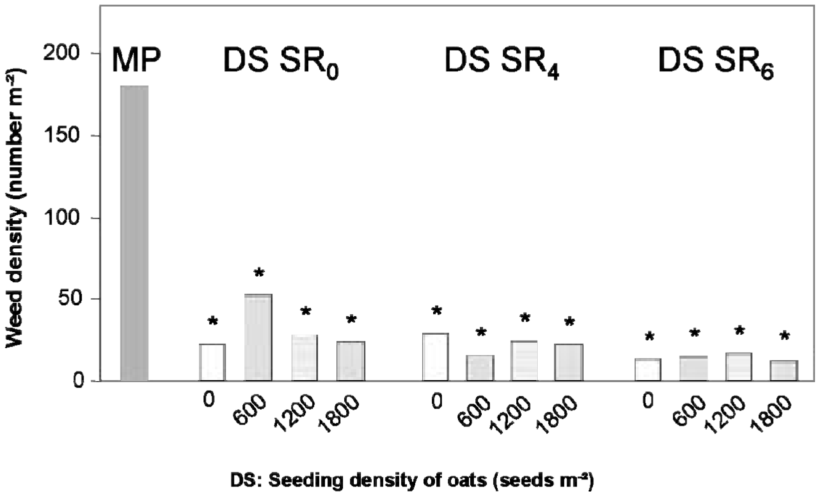

Figure 1: Weed density (*R. sardous* not included) in faba beans (30 DAS), as affected by tillage treatment (mouldboard plough MP, direct seeding DS), amount of straw residues (SR in DS: 0, 4 and 6 t ha^{-1}) and seeding density of oats (sown in autumn). Pairwise comparison of MP with DS treatments: Dunett's test, * significant for P<0.05

The early competition of *R. sardous* in DS plots was indicated by higher pod insertion in DS plots (not shown). Competitiveness of R. *sardous* in DS plots resulted in significantly lower grain yield compared with the hand weeded plots. Nevertheless, retarded FAB development resulted in no significant yield losses in DS treatments. No significant yield differences were determined between MP (3.80 t ha^{-1}) and DS (3.44 t ha^{-1}) treatments which showed no tendency of lower grain yield neither influenced by the amount of straw residues nor the seeding density of oats. Costs for labour and fuel inputs were more than five-fold higher in MP (€ 275 ha^{-1}) compared with DS (€ 48 ha^{-1}) resulting in a 0.95 t ha^{-1} lower grain yield for DS that might be accepted at least to equalize gross margin of the MP treatment when based on a FAB market price of € 240 t^{-1}. Low weed pressure and vigorous growth enabled DS FAB in the 2007-FF-trial to yield 3.83 t ha^{-1} grain compared with 3.40 t ha^{-1} (MP) (not significant).

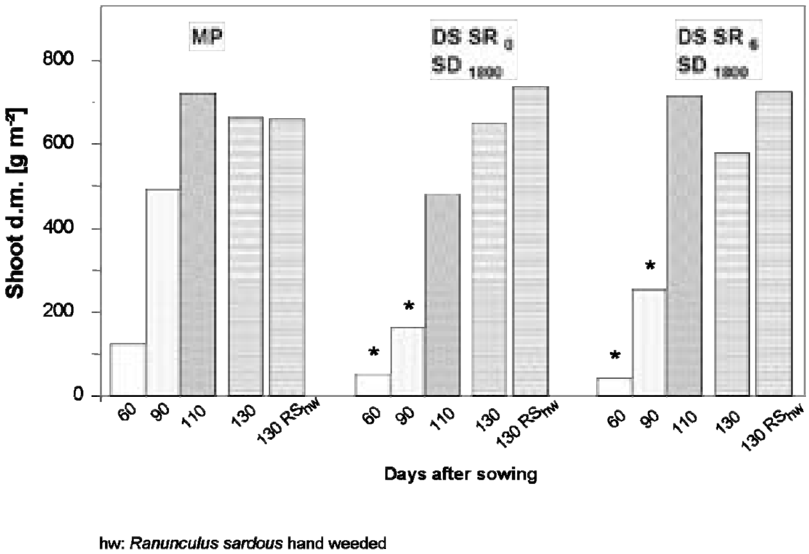

Figure 2: Shoot dry matter of faba beans as affected by tillage treatment (mouldboard plough MP, direct seeding DS), amount of straw residues (SR in DS: 0, and 6 t ha^{-1}), seeding density of oats (SD: 1800 seeds m^{-2} sown in autumn) and hand weeding of *R. sardous* and time. Pairwise comparison of MP and SR in DS treatments with Dunett's test, * significant for P<0.05

Conclusions

Temporary use of DS of FAB is considered as a suitable approach to save labour and fuel in those cases where perennial weeds do not play an important role or can be accepted for one season due to sufficient crop competitiveness. Failure of clear effects of weed suppression assumed for the amount of oat crop residues and seeding density of oats in autumn makes further investigations necessary.

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Soil tillage in organic farming: impacts of conservation tillage on soil fertility, weeds and crops

Peigné, J.[1], Aveline, A.[2], Cannavaciuolo, M.[2], Giteau, J.-L.[3] & Gautronneau, Y.[1]

Key words: no tillage, mouldboard ploughing, soil structure, earthworms, weeds

Abstract

Organic farmers are encouraged to adopt conservation tillage to preserve soil quality and fertility and prevent erosion. In the framework of a national study, we compared conservation (no tillage NT and reduced tillage RT) and conventional (mouldboard ploughing MP and shallow mouldboard ploughing SMP) tillage systems in 3 field experiments and 2 on-farm surveys. We measured the impacts of soil tillage on: (1) soil compaction: more compacted soil under NT and RT, (2) earthworm populations: more earthworms under NT, (3) weed infestation: weed level tends to be higher under NT, but it is not a general trend, and (4) crops: crop yields are lower under NT according to weed infestation. Then, independent of soil type and experimental year (2 to 5 years), it seems that soil physical fertility decreases under NT and RT. But, the first reason of a decline of crop yield under NT is the weed infestation.

Introduction

Conservation tillage leaves organic mulch at the soil surface, which reduces runoff, increases the soil organic matter content and improves aggregate stability which limits soil erosion (Franzluebbers 2002). These benefits can improve soil fertility and environmental impact of organic crop production. However, Koepke (2003) reported that organic farmers generally use conventional tillage systems with a mouldboard plough, and occasionally till to a greater depth than in conventional agriculture. In the framework of a French national study, we compared conventional (ploughing) and conservation tillage systems in organic farming for arable and vegetable systems. Fields experiments and on-farm surveys were conducted in several regions of France in order to assess the effects of different tillage systems on soil fertility (physical, chemical, biological) and on weed and crop developments. This paper compares the effects of 4 tillage systems on soil physical and biological fertility and on weed and crop developments in arable systems.

Materials and methods

Three fields' experiments associated with 2 on-farm surveys have been carried out in 3 regions of France: Rhône Alpes (A), Pays de la Loire (B) and Bretagne (C). On each experimental field (table 1), 4 tillage systems were compared on a completely randomised block design with 3 replicates: 1) mouldboard ploughing (MP) (30 cm depth), 2) shallow mouldboard ploughing (SMP) (20 cm depth for A and B, 15 cm for C), 3) reduced tillage (RT) with tine tool (15 cm depth for A and B, 12 cm for C) and 4)

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no tillage (NT). For A and C, NT was managed under a cover crop during the first year of experimentation. Otherwise, mechanical weed control is carried out on each plot.

Tab. 1: Description of the 3 sites

Area	Organic farming conversion	Start of the essay	Soil type	Crop rotation
A	1999	2004	Sandy loam (fluvisol)	Alfalfa (3 years) – Maize – Soybean – **Winter wheat (2007)** – Soybean - Maize
B	2000	2005	Silty (cambisol)	Maize – Field bean – Winter wheat – **Lupin crop (2007)**
C	1996	2003	Silty	Maize – Triticale – Winter wheat – Winter pea - Triticale **(2007)**

The on-farm survey in Rhône-Alpes was composed by 7 farmer-fields where 2 tillage systems were compared: (1) MP, traditional tillage system of the farmer, and (2) RT or SMP (1 farmer). The 7 fields are representatives of the arable systems and soil-climate diversity in Rhône Alpes. Mechanical weed control (harrowing/hoeing) is carried out on each plot. On-farm survey in Site B is not presented.

We used a morphological description of the soil structure. It allowed us to integrate and explain temporal and spatial variation of the soil structure at the field scale. We characterised the spatial arrangement of the peds and clods as well as pore space on a pit (3 m in length, 1 m deep) according to Roger-Estrade et al. (2004). This method quantifies distinct structural zones in the soil profile: % of zones with loose structure noted □ clods and % of compacted zones, noted □ clods. Moreover, bulk density was measured from soil cores of 5 cm diameter (5 replicates / soil layers).

We measured the earthworm abundance (number / m^2) and species diversity (grouped in ecological category) with the formaldehyde method (Bouché et al. 1984). Each sample was taken plumb of the pit used for soil structure description in order to connect soil structure with earthworm characteristics.

Weed diversity and density were measured on 0.25 m^2 areas (4 replicates / plots / blocks in experimental fields, 8 replicates/ tillage management in farmer field). Crop components and yields were measured on the same 0.25 m^2 areas than weeds. Determination of weed biomass was done at the flowering stage on an adjacent area.

Results

Soil structure: For each experimental field MP and SMP develop a more porous structure than under RT and NT soil profiles: the proportion of □ clods (porous) is higher under MP (table 2). These results are confirmed in farmer fields (table 2): after 2 years of treatments differentiation the proportion of □ clods is higher under MP than under RT systems (6/7 cases). No differences are observed between MP and SMP excepting for the 20-30 cm layer where MP exhibited a more porous structure. Thus, independent of the soil type (clay and silty loam), RT and NT tend to degrade soil structure compared to MP. Modification of soil structure is confirmed by measurements of soil bulk density (figure 1). After 5 years of differentiation, bulk density of soils under MP and SMP are significantly lower at 15 cm depth than under RT and NT (site C). However, after 2 years of reduced tillage in farm fields or field experiments, no statistical difference was found (data not shown).

Tab. 2: Comparison of observed spatial arrangement and porosity of clods of soil structure created by MP, SMP, RT and NT in area A, B and C and On-farm survey 2007 (2 years)

Area	Comparison (% □ clod)	
Experimental fields		
A (3 years)	0-20 cm : MP>SMP=RT=NT	20-30* cm :MP>SMP>RT=NT
B (2 years)	0-20 cm: MP>SMP=RT=NT	20-30* cm: MP>SMP=NT>RT
C (5 years)	0-15 cm : MP>SMP=RT=NT	15-30* cm :MP=SMP>RT=NT
Farmer fields (2 years)		
Silty loam	MP>RT (3/4) - MP=SMP (1/4)	
Clay	MP>RT (3/3)	

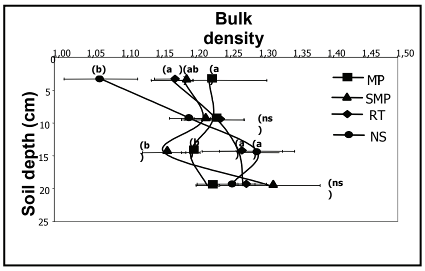

Figure 1: Comparison of bulk densities of MP, SMP, RT and NT for 0-5 cm, 5-10 cm, 10-15 cm, 15-20 cm soil layers - Site C - 2007 (5 years)

Abundance and diversity of earthworms: In area A, B and C, more earthworms were found under NT than MP, SMP and RT (significant difference with Kruskal-Wallis test). NT presents higher epigeic (in crop residues or cover crop at the soil surface) and anecic species (vertical channels). No data are available for on-farm survey.

Weeds and yields: Soybean (site A) and winter pea (site C) yields were lower for NT compared to the other treatments. Weed level was significantly higher under NT (figure 2a and b). The same trend was observed in the on-farm survey (figure 3a and b). Independent of soil type and crop, when NT or RT systems exhibited a high weed development, crop yields tend to decrease significantly compared to MP and SMP.

Discussion and conclusion

A better soil structure is obtained under MP than SMP, RT and above all NT. Soil structure degradation under NT during the first years of transition have been reported by Munkholm et al. (2001). In silty and sandy soils, soils with low shrinking- welling effect, quality of soil structure can decrease in conservation tillage with time. However, in clay soils, we could expect similar soil structure between RT and MP. Nevertheless, we observed a deterioration of soil structure under RT compared to MP as no freezing day occurred during winter 06-07. Moreover, in each field experiments, we found more earthworms under NT compared to SMP and MP. Even if higher earthworms are found under NT, no more earthworm channels are found in depth. At short term, earthworms are not able to improve soil structure in conservation tillage in organic farming.

Whereas soil compaction is higher under NT, weed level plays the main role considering fall of crop yields under NT. Indeed, when weed infestation is controlled under NT and RT, no difference in crop yields is found. According to Kouwenhoven et al. (2002), RT is difficult in organic farming regarding weed infestation. Our first results do not confirm this hypothesis: if weeds are well mechanically managed, no decline of yield is observed under NT and RT compared to MP despite of the degradation of soil structure.

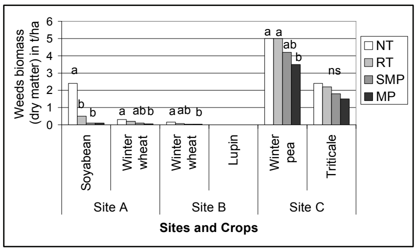

Figure 2a: NT, RT, SMP and MP weed biomass (t/ha) at flowering or harvesting, field experiments Site A – B - C (2005/06 2006/07

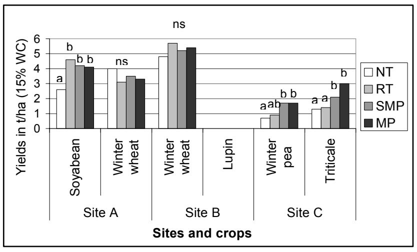

Figure 2b: NT, RT, SMP and MP crop yields (t/ha), field experiments Site A – B - C (2005/06 2006/07)

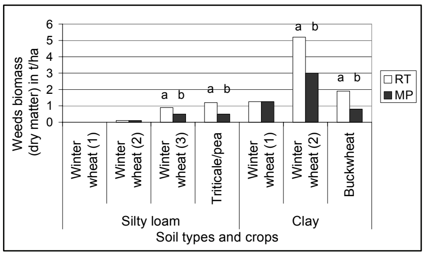

Figure 3a: RT and MP weed biomass (t/ha) at flowering or harvesting, farmers' fields (2006/07)

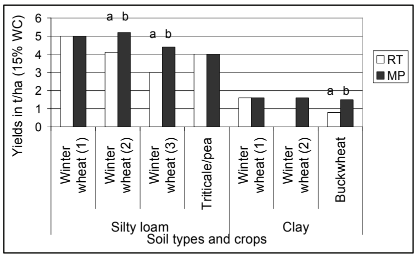

Figure 3b: RT and MP crop yields (t/ha), farmer's fields (2006/07)

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Effects of crop management factors and the environment on pest and disease incidence in vegetables

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Key words: organic production, pesticides, *Delia radicum*, *Sclerotinium sclerotiorum*, *Phytophthora infestans*

Abstract

The Nafferton Factorial Systems Comparison (NFSC) experiments are part of a long-term field trial that compares organic and conventional systems of crop rotation, crop protection and fertility management, in a factorial design. Pest and disease incidence in vegetables in the 2005, 2006 and 2007 season are reported. Cabbage root fly damage was always reduced under organic crop protection, but there were no consistent trends for the effects of fertility management on this pest. Sclerotinia in lettuce was consistently higher under conventional fertility management. Blight in potatoes was enhanced in the 2007 season by the combination of conventional fertility management and organic crop protection practices. Mechanisms for these effects, including the role of plant nutrition and the environment, are discussed.

Introduction

The Nafferton Factorial Systems Comparison (NFSC) experiments have provided a unique opportunity to study the interactions between crop rotation, soil fertility management, crop protection practices, and the environment, and their effects on the incidence of pests and diseases in a variety of crops. Previous results from these experiments showed that while some diseases were enhanced by organic fertility management, e.g. *Septoria* spp. in wheat (Cooper et al., 2006), other diseases were more prevalent under conventional fertility management, e.g. powdery mildew in barley (Cooper et al., 2007). Proposed mechanisms for these effects include the creation of optimum conditions for biotrophic pathogens when nutrients are provided to the crop in excess, and the weakening of plant defense mechanisms under nutrient-limited conditions. Trends in pest and disease incidence have varied from year to year, indicating the additional effect of environmental conditions on pests and disease. This paper further examines the role that crop management and the environment play in the incidence of pests and diseases in cabbages, lettuce and potatoes

Materials and methods

The incidence of cabbage root fly (*Delia radicum*), *Sclerotinium sclerotiorum* (in lettuce) and potato blight (*Phytophthora infestans*) were studied in the 2005, 2006 and 2007 field seasons in the Nafferton Factorial Systems Comparison (NFSC) experiments, near Stocksfield, Northumberland, in the UK. The experiments are a long-term trial set up in a split-split plot design with crop rotation (pre-crop factor) as the main plot and two levels of both crop protection and fertility management as the subplot and sub-subplot factors respectively. Cabbages under conventional crop

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protection (CP) are sprayed with Chlorpyrifos and Toppel 10 for insects and Bravo and Amistar for fungal infections while CAPATEX netting is used for organic crop protection (OP). Lettuce under conventional crop protection was sprayed as needed with Amistar and RovralFlo fungicides; no fungicides or insecticides were applied to lettuce under organic crop protection. Potatoes under conventional crop protection were grown in soil treated with Temik 10 G for cyst nematodes, and sprayed regularly with Shirlan and Fubol Gold for late blight control. Under organic crop protection, potatoes received regular treatments with Headland Copper for blight control. Crops under conventional fertility management (CF) receive recommended rates of NPK supplied as mineral fertilizer, while under organic fertility management (OF) nutrients are supplied from composted dairy manure. The experimental design allows analysis of both the main effects (pre-crop, crop protection and fertility management), and comparisons among four production systems: organic (OP-OF), 'low input' (OP-CF and CP-OF) and conventional (CP-CF). All of the experiments within the trial are replicated four times.

Results are reported here for cabbage root fly incidence (percentage total plants affected) assessed at GS (growth stage) 43 in 2005, GS43-45 in 2006, and in the harvested crop in 2007. The incidence of *Sclerotinia* in lettuce (percentage total plants affected) is reported for GS49 in 2005, GS49 in 2006, and GS46 in 2007. Potato blight incidence (visual estimate of percentage of plot affected) was assessed in all three years, but only detected in 2007. The area under the disease progress curve (AUDPC) for 2007 was calculated using the blight incidence data from 10 dates between 25 July and 3 August.

The data was analyzed using the linear mixed effects (lme) function in R (Crawley, 2007; R Development Core Team, 2006). The normality of the residuals of all models was tested using QQ-plots and data were cube root transformed when necessary to meet the criteria of normal data distribution. Models were simplified to remove the pre-crop factor where it did not contribute significantly to the variance of the data (Crawley, 2007). Main effect means were compared using the F-statistic from the ANOVA and subplot means were compared using linear contrasts.

Results

In every year crop protection had a significant effect on cabbage root fly incidence, with lower values under organic crop protection, due to the use of CAPATEX netting for protection of cabbages from insect pests ($p<0.01$). In 2005 crop protection was the only significant effect, however in 2006 and 2007; there was also a significant effect due to fertility management. This effect was not consistent over both years: in 2006 organic fertility management increased the incidence of cabbage root fly ($p=0.0143$), while in 2007 conventional fertility management enhanced cabbage root fly incidence ($p<0.0001$).

For *Sclerotinia* in lettuce, fertility management was a significant factor in every year, with consistently higher incidences of this disease where conventional fertility management was used ($p<0.05$). Conventional fungicide treatment (CP) did not have a significant effect. In 2006 the main effect for pre-crop was significant ($p=0.0292$) with higher incidences of *Sclerotinia* when lettuce was grown after a crop of beans. When barley was a pre-crop there was a significant fertility management by crop protection interaction ($p=0.0145$) with significantly higher *Sclerotinia* due to conventional fertility management under organic crop protection, but no fertility management effect under conventional crop protection.

In 2007 potato blight was closely monitored. There was a significant fertility management by crop protection interaction with higher AUDPCs where conventional fertility management was used in combination with organic crop protection (p=0.0003, Figure 1 treatment OP-CF).

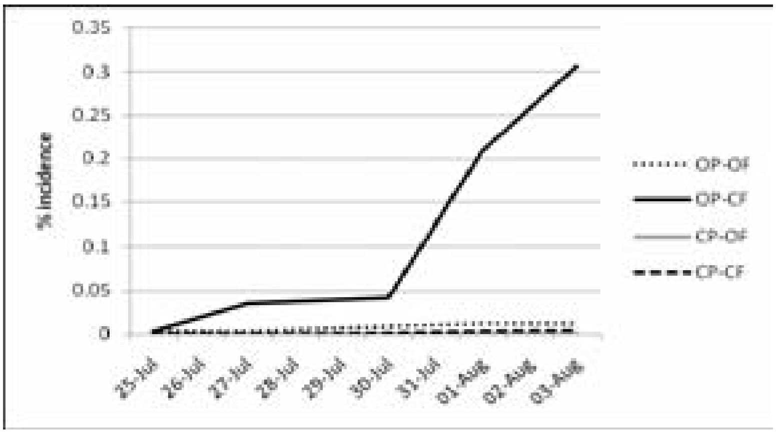

Figure 1: Potato blight incidence during the 2007 cropping season

Discussion

For some of the crops in the NSFC trial the use of conventional fertility management enhances disease and pest problems, regardless of the type of crop protection used. This is clearly the case for *Sclerotinia*, which was not significantly affected by conventional fungicide treatment. For some crops the use of mineral fertilizers may elevate leaf tissue N contents creating conditions more favourable for disease (Daane et al., 1995; Hofmeester, 1992); however, in the NFSC trials mineral fertilizer use did not result in higher tissue N contents in lettuce in 2005 (data not shown). The fertility effect on *Sclerotinia* incidence may be an inhibitory effect on growth of the organism in soils that have received compost additions. This effect has been previously reported in the literature (Asirifi et al., 1994; Nico et al., 2003).

The results for the potato blight incidence are similar to those previously reported for mildew in barley and wheat (Cooper et al., 2007; Cooper et al., 2006) in the same experiment: increased disease incidence under conventional fertility management in the absence of pesticides. For the 2007 potato crop, conventional fertility amendment also resulted in higher leaf greenness readings (by SPAD meter, data not shown) which is indicative of higher leaf N contents. High leaf N contents are favourable for biotrophic pathogens such as mildew, which affected cereals in previous years in the NFSC trials, and blight which affected the potatoes in 2007. There is therefore some evidence to suggest that the use of conventional mineral fertilizers encourages the development diseases caused by biotrophic fungi.

The environment as a driving factor for disease and pest incidence should also be considered. 2007 was a particularly wet year with 273 mm rain falling between May 1 and Aug 31, compared to approximately 180 mm during the same time period in 2005 and 2006. This created optimum conditions for the development of blight.

Environmental factors may also help explain the varying effects of fertility management on cabbage root fly incidence. In 2006, a relatively dry year, the survival of the larvae may have been improved in the soils of the organically fertilized crops, which would have higher moisture contents due to their higher soil organic matter contents (unpublished data). In 2007, it is not likely that soil moisture limited larval survival. Other factors, possibly related to plant nutrition, may have enhanced the incidence of cabbage root fly in the conventionally fertilized plots.

Conclusions

The long-term NFSC trials have allowed detailed studies into the effects of crop management and the environment on the incidence of pests and disease. Fertility management is frequently a significant factor contributing to the development of pest and disease problems although the mechanism for this effect is not likely the same in every case. While for *Sclerotinia* in lettuce organic fertility management may result in the inhibition of the pathogen within the soil, for biotrophic pathogens, conventional fertility management may create conditions within the plant that are optimum for infection. The role of the environment in controlling year to year variations in pest and disease incidence is also key. Future research will focus on identifying the mechanisms underlying the effects of crop management on pest and disease incidence.

Acknowledgments

The authors gratefully acknowledge funding from the European Community financial participation under the Sixth Framework Programme for Research, Technological Development and Demonstration Activities, for the Integrated Project QUALITYLOWINPUTFOOD,FP6-FOOD-CT-2003- 506358.

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Effects of Conservation Tillage on Canada Thistle (*Cirsium arvense*) in Organic Farming

Gruber, S.[1] & Claupein, W.[1]

Key words: Soil tillage, weed management, crop rotation

Abstract

*A long-term experiment was established to examine the crop yield and the weed infestation, focussed on Canada thistle (*Cirsium arvense*), as effect of different intensity of primary tillage (mouldboard plough deep or shallow, double-layer plough, chisel plough) in combination with or without stubble tillage. The most effective ways to keep the infestation of* C. arvense *at a low level were deep mouldboard ploughing and the use of a double-layer plough. After the experiment had run seven years, the thistle biomass was < 2 g DM m^{-2} in these treatments, compared to 23–26 g DM m^{-2} in the treatments with chisel ploughing or shallow ploughing. In all treatments, stubble tillage in addition to primary tillage significantly reduced the thistle biomass by 30–80 %. A high density of lucerne/grass re-growth occurred in the chisel plough treatment. The soil seed bank of thistles ranged between 220 (deep plough) and 6,400 seeds m^{-2} (chisel plough) in the sixth year of the experiment. Stubble tillage is essential if the chisel plough or shallow ploughing is used for conservation tillage in organic farming. The double-layer plough can control* C. arvense *comparable to deep ploughing.*

Introduction

Conservation tillage practices have been adopted by conventional farmers in many regions throughout the world (Derpsch 2005). The idea of conservation tillage subsumes a wide range of tillage practices which all have in common that a deep soil inversion by a mouldboard plough is abandoned. Many ecological benefits are associated with conservation tillage due to less intensive soil disturbance. Microbial life and soil organic matter increase (De Souza Andrade *et al*. 2003), infiltrability and trafficability of the soils is improved, and the soil is better protected against wind and water erosion (Ehlers & Claupein 1994). Conservation tillage also means a reduction in labour, time and costs. All these benefits correspond well with the objectives of organic farming. On the other hand, reduced tillage intensity in conventional farming is accompanied with the use of herbicides. Traditionally, weed control is achieved by the use of a mouldboard plough which shifts weeds and their seeds to deeper soil horizons from where germination and emergence is reduced (El Titi 2003; Pekrun *et al*. 2003). Therefore, organic farmers usually adhere to ploughing to ensure weed control. Particularly a higher infestation with perennial weeds, accompanied by lower yields, is expected by farmers in the absence of the mouldboard plough (Peigné *et al*. 2007). A lower N-net mineralisation (Pekrun *et al.* 2003) with conservation tillage may additionally lead to a reduction in yield. The question emerges whether there are tillage practices which combine the ecological benefits of conservation tillage with the capacity for weed control. Aim of this study was to examine the development of the

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Canada thistle *(Cirsium arvense)* population in a long-term experiment over one organic crop rotation under different levels of conventional and conservation tillage. Furthermore, the effect of stubble tillage in addition to primary tillage should be analysed in one experimental year.

Materials and methods

A long-term experiment was established in a split plot design with four replicates in the year 1999 on the Experimental Station Kleinhohenheim, University of Hohenheim, south-west Germany. The crop rotation was spelt (2000) – potatoes (2001) – triticale (2002) – lucerne/grass (2003, 2004) – winter wheat (2005) – oats (2006). The experiment had four main treatments of primary tillage as a main factor and stubble tillage as a secondary factor (levels: with or without stubble tillage). The main factor primary tillage had following levels: deep (25 cm) or shallow (15 cm) mouldboard ploughing, double-layer ploughing (15 cm + 10 cm) or chisel ploughing (15 cm, no soil inversion). The sub-plot size was 10 × 40 m. The double-layer plough combines a shallow inversion of the topsoil with a non-inversive soil loosening of the subsoil by a goosefoot-shaped chisel (operating in 62 % of the field width), thus the natural soil stratification of the subsoil is maintained. For stubble tillage, the “Stoppelhobel”, a modified skimmer plough (100 % of the field width undercut), was used one time after each harvest, and was followed by primary tillage usually in the mid of October. Thistle shoots were counted every year after harvest (August/September), i.e. before the first tillage operation; a distinction between seedlings and shoots from roots was not made. The soil seed bank was examined in spring 2005 for the first time. Soil samples were taken in a depth from 0–30 cm using an auger with a core of 1.2 cm. Seeds were washed out from the soil by sieving (mesh width 4.0 and 0.25 mm), and then dried and determined (after Hanf (1990), and in comparison with a seed collection of the institute). The total above-ground biomass production of *C. arvense* was determined on 21.06.2006, when the thistle plants had a height of 80 cm and were shortly before flowering. All shoots were cut on 100 m^2 in the centre of each plot, then dried at 80° C for 48 hrs and weighed. The statistical analysis was performed using the procedure ‘MIXED’ (for crop yield and thistle biomass) or GLM (seeds) in the statistical programme SAS. If necessary, data were square root-transformed for the statistical analysis to obtain the normal distribution and homogeneity of variance, and then retransformed.

Results

The *C. arvense* infestation was higher in the shallow plough and in the chisel plough treatments in comparison to the deep plough and double-layer plough treatments over a period of seven years (Fig. 1, last five years shown). The period during which lucerne/grass was grown clearly reduced the density of thistle shoots in the year 2004, which increased again as soon as cereals were grown as succeeding crops. Lucerne/grass re-growth occurred in the chisel plough treatment with a mean of 37 plants m^{-2}, compared to one plant m^{-2} in the deep plough treatment in the year 2005 (data not shown). Deep mouldboard ploughing and the use of the double layer plough significantly reduced the thistle biomass compared to shallow ploughing and chisel ploughing (Tab. 1). Stubble tillage in addition to primary tillage significantly reduced the total biomass production of thistles in all treatments by 30–80 %. There was no significant interaction between stubble tillage and primary tillage. *C. arvense* seeds were present in the soil seed bank in spring 2005 in an amount of 6,400 seeds m^{-2} in the chisel plough treatment while all other treatments showed less than 440 *C.*

arvense seeds m^{-2}. The yield of oats did not significantly vary between all treatments in the year 2006.

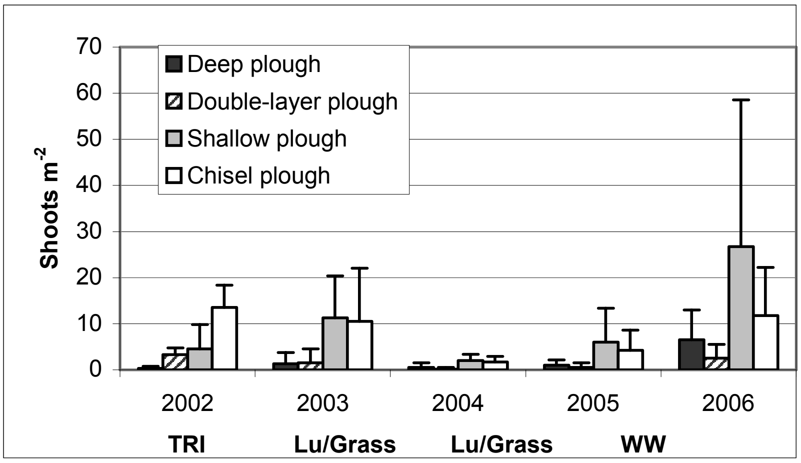

Figure 1: Development of the *C. arvense* population (no. of shoots) in the course of five years with different treatments of primary tillage, without stubble tillage. Error bars: standard deviation. TRI: Triticale, Lu/Grass: lucerne/grass, WW: winter wheat, OA: oats. Data 2002, 2003: after Pekrun & Claupein 2004.

Tab. 1: Soil seed bank (March 2005) and above-ground biomass (June 2006) of *C. arvense*, and grain yield of oats (2006) as effect of tillage. Primary tillage: upper case, stubble tillage: lower case, comparison on the same level of primary tillage only); data "shoots" detransformed; P< 0.05. DM: dry matter

Primary tillage	Deep Plough		DL-Plough		Shallow Plough		Chisel Plough	
Stubble tillage	yes	no	yes	no	yes	no	yes	no
2005								
C. arvense seeds m^{-2}	221 b	n.d.	442 b	n.d.	442 b	n.d.	6411 a	n.d.
2006								
C. arvense shoots g DM m^{-2}	1.1 a	0.8 b	1.6 a	0.2 b	25.6 a	1.9 b	22.5 a	4.8 b
	B		B		A		A	
Grain yield oats t DM ha^{-1}	4.5 n.s.	4.3 n.s.	5.0 n.s.	5.2 n.s.	4.4 n.s.	4.3 n.s.	3.0 n.s.	4.8 n.s.

n.d.: not determined

Discussion

Shallow tillage in a depth of 15 cm, independently from inversion or non-inversion of soil, was not sufficient to keep the population of *C. arvense* on a similar low level as deep ploughing and double-layer ploughing. The extent to which the weed infestation increased shortly after the lucerne/grass period did not match the hypothesis that perennial legumes have a long-term effect in weed control in organic farming. One reason may be the re-growth of lucerne/grass in the chisel plough and shallow plough treatment which affected emergence and growth of the crop and provided an undisturbed habitat for the thistles. Additionally, there was a large soil seed bank of *C. arvense* in the chisel plough treatment which had persisted for two years of lucerne/grass. Though weed surveys were not specifically targeted at distinguishing between thistle seedlings and shoots from roots, germination of new thistle plants might have been occurred. The reason for the effect of stubble tillage on yield in the chisel plough treatment in 2006 is probably not only caused by a reduction of thistles but also by a reduction of lucerne/grass re-growth and other weeds by stubble tillage. A weed-controlling effect of stubble tillage toward perennial weeds in organic farming was clearly shown by Pekrun & Claupein (2006). Though some concerns remain about conservation tillage in organic farming (Peigné *et al.* 2007), *C. arvense,* at least, can be managed by the reduced mechanical intervention of the double-layer plough.

Conclusions

Stubble tillage is essential if the chisel plough is used for conservation tillage in organic farming. The use of a double layer plough had similar effects on the control of the perennial weed *C. arvense* as a deep soil inversion by a mouldboard plough. Therefore, presuming that a better preservation of the natural resource soil and other benefits of conservation tillage are achieved, the double-layer plough can be recommended to replace the traditional mouldboard plough.

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Monitoring of click beetles (*Agriotes lineatus* and *A. obscurus*) in organically managed farms in Northern Germany

Böhm, H.[1], Koppe, W.[2] & Dreyer, W.[3]

Key words: potato, click beetle, pheromone traps, wireworm

Abstract

Wireworms, the larvae of Agriotes *spp., are an increasing problem on many organically managed farms with potato or vegetable production. The damage caused by wireworms is economically significant. With the use of pheromone traps it is possible to get more information about the habitat requirements of click beetles. In 2005 and 2006 click beetles were monitored at different locations in northern Germany. Because of the warmer springtime in 2005, the first peak of click beetles was about two weeks earlier than in 2006. The second peak was found one month later. The presented data show the highest occurrence of click beetles in ryegrass-clover mixtures in both years. The catches in cereals were much lower than in ryegrass-clover. The reasons for the differences of the trapped click beetles in the different cereal fields cannot been explained so far. In the majority of cases the trapped number of* Agriotes lineatus *was higher than for* A. obscurus.

Introduction

The damage caused by wireworms, the larvae of click beetles (Coleoptera: Elateridae), in potatoes and other vegetables is high and has increased on many organically managed farms in recent years. Knowledge of the ecology and the habitat requirements of wireworms and click beetles is very low (Schepl and Paffrath 2003). With the use of pheromone traps the occurrence of click beetles can be monitored in different regions and crops, with the aim of getting more information about their occurrence and habitat requirements. Blackshaw and Vernon (2006) have used pheromone traps for describing the spatiotemporal stability of click beetles in an agricultural landscape. Based on such data sets it may be possible to figure out new strategies for reducing the populations of click beetles.

Materials and methods

In 2005 and 2006 pheromone traps were installed at different locations on organically managed farms in northern Germany. The traps were installed during the vegetation period in different crops, such as ryegrass-clover mixture, oat, summer barley, summer wheat, and spelt. At every site four traps, two baited with pheromone lures specific for *Agriotes lineatus* and two baited with *Agriotes obscurus*, were installed 30

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m from each other. The pheromone lures and traps were obtained from Plant Research International (PRI), Pherobank, Wageningen (NL). The lures of pheromones were changed after 45 days; the traps were emptied every week.

In 2005 the traps were located on one farm in two different crops (ryegrass-clover mixture and summer wheat) from the end of April until early August. In 2006 the traps were installed from the beginning of May until the middle of July on four different farms in Lower Saxony and Schleswig-Holstein.

Results

From the end of April until the beginning of August 2005, on average 1831 click beetles were caught per trap in a ryegrass-clover mixture and 1631 click beetles per trap in summer wheat. In both crops the number of *A. lineatus* was higher (1448 and. 1047 respectively) than for *A. obscurus* (383 and 585 respectively). Figure 1 shows the number of click beetles during the vegetation period. The first peak of click beetles was early in May, the second nearly one month later at the end of May/beginning of June, and the third around the 20th of June. The time the peaks appeared was similar in ryegrass-clover and summer wheat, but the peaks were more pronounced for *A. lineatus*.

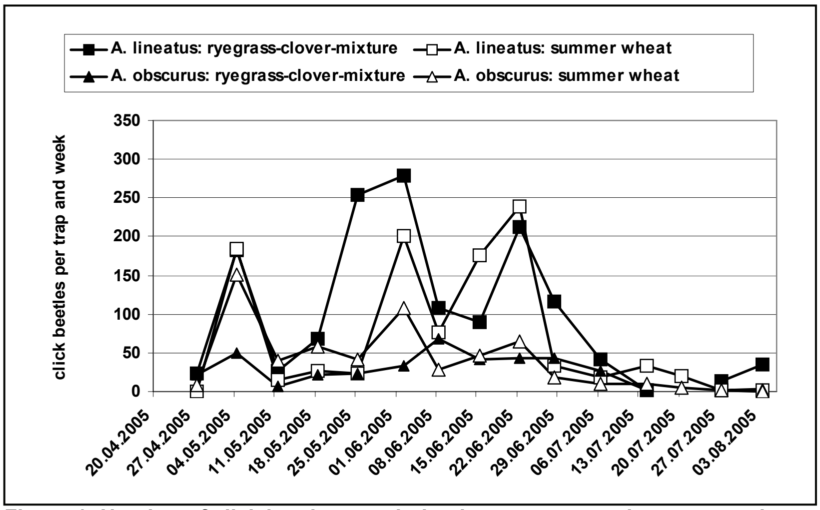

Figure 1: Number of click beetles caught in pheromone traps in ryegrass-clover mixture and summer wheat in 2005

Comparing the same collecting period and the same location, the number of click beetles caught was similar in the two years in the ryegrass-clover mixture (1492 vs. 1502 adults of *Agriotes* spp.). Also, the catches of click beetles were lower in cereals than in ryegrass-clover (Table 1). Obviously the location and the particular cultivated cereal had an influence. For example, at location 2 the number of click beetles was much higher in winter barley than in winter wheat.

Tab. 1: Number of trapped click beetles (*Agriotes lineatus* and *Agriotes obscurus*) during the vegetation period 2006 in different crops and locations in northern Germany

Location	Crop	A. lineatus	A. obscurus	Total
1	Ryegrass-clover-mixture	1250	242	1492
1	Oat	678	326	1004
2	Winter barley	745	84	829
2	Winter wheat	263	35	298
3	Winter barley	190	310	500
4	Spelt	169	176	345

Figure 2 shows the number of click beetles during the course of the catching period in 2006. Compared with 2005, the first peak was about two weeks later in 2006. One month later the second peak was evident. Because of the shorter catching period, no third peak was evident. At location 1, where the period was still going on, a third but low peak was evident. The timing of the peaks differed only a little among the locations.

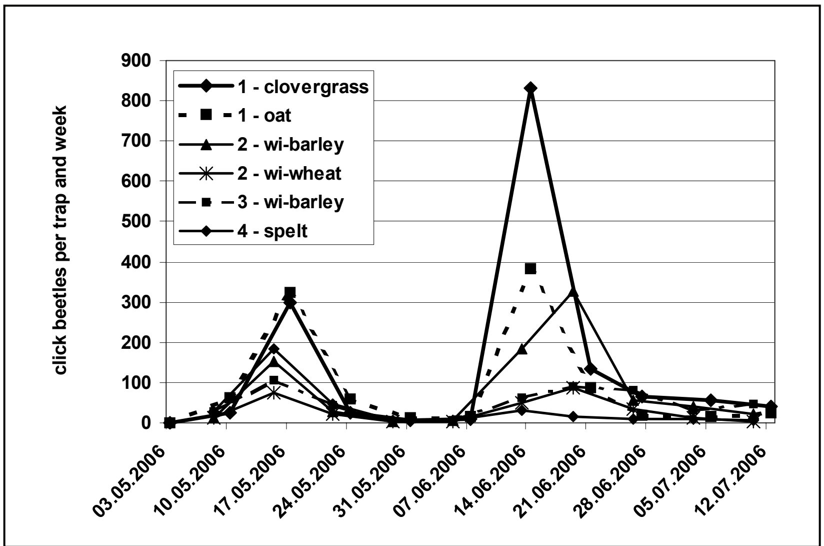

Figure 2: Number of click beetles (sum of *A. lineatus* and *A. obscurus*) caught in pheromone traps in different crops and locations in northern Germany in 2006

Discussion

Other authors reported the occurrence of click beetles in early to mid-May (Böhm and Krause 2005; van Rozen et al. 2007). The first occurrence of click beetle depends on the weather in spring: warmer conditions enable earlier appearance of the click beetles. First calculations showed good correlations between the sum of soil temperature and the appearance of click beetles. The preference for crops with a high plant density also is described in the literature (Parker and Seeney 1997; Schepl and Paffrath 2003). Therefore it is obvious that the number of click beetles in the investigation would be highest in ryegrass-clover mixtures. However, other factors such as plant height or landscape with refuge areas must also determine the occurrence of click beetles.

Conclusions

The results showed the high attractiveness of ryegrass-clover mixtures to click beetles and corroborate that a high percentage of rye-grass in the crop rotation increased the population of wireworms. In Organic Farming, ryegrass-clover mixtures are necessary in the crop rotation for fodder production, N_2-fixation and humification. However, in the case of potato production the ryegrass-clover mixture creates out a risk of wireworms. For direct control, no pesticides are allowed in organic farming. Therefore the wireworm population must be reduced by agronomic practices or by the use of pheromone traps. Both possibilities will be checked in a new project in the coming years.

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Monitoring *Agriotes lineatus* and *A. obscurus* in organic production using pheromone traps

Sufyan, M.[1], Neuhoff, D. & Köpke, U.

Key words: pheromone traps, *Agriotes* spp., range of attractiveness

Abstract

Wireworms, particularly Agriotes lineatus and A. obscurus are becoming a problem in organic crop production causing economically severe damage on potatoes and other arable crops. Since pesticide application for direct control is not allowed in organic farming, reliable methods for quantifying wireworm infestation levels and forecasting damage are urgently needed for any control strategy. In the present work, the assessment of the range of attractiveness of pheromone traps to male A. lineatus and A. obscurus beetles was investigated in 2006 and 2007. The results indicated that the trap recovery rate of released beetles was more dependent on release distance than on time. Recovery rates greater than 40% were only noted for short release distances (up to 10 m), while less than 10% of the beetles released at a distance of 60 m returned to the traps. Recovery rates of click beetles were also negatively affected by cold and wet weather conditions. Most of the beetles were recovered within the first 3 days.

Introduction

Wireworms, the larval stage of click beetles (Coleoptera: Elateridae), have become one of the most serious polyphagous insect threats to many agricultural crops worldwide (Parker and Howard 2001). They live in the soil for 4-5 years where they cause germination failure and injury of underground organs e.g. potato tubers. There are different species of plant damaging click beetles in Europe, but *Agriotes lineatus* and *A. obscurus* are most abundant in Germany (Furlan et al. 1999). Problems are particularly high in Organic Farming, due to favouring crop rotations with leys and the absence of chemical control options. For these reasons, the development of alternative control strategies has become an essential task. A pheromone trapping system (Furlan et al. 2001 and Toth et al. 2003) proved to be a highly sensitive risk assessment tool to complement existing baiting techniques (Parker 1994) and other risk assessment methods (Parker and Seeney 1997). The sex pheromone mixtures give a good indication of presence and flight peaks of the male beetle populations (Ester et al. 2002) and are permitted according to EU regulation 2092/91 on OF. Currently click beetle flight behaviour is monitored by using pheromone traps, but it is still unclear whether apart from monitoring, a control of soil wireworm population is possible by mating disruption. Mating disruption has been tested against some tortricid pests and was successful for controlling the codling moth, *Cydia pomonella* (Moffitt and Westigard 1984) and the European grape moth, *Eupoecilia ambiguella* (Charmillot et al. 1987). Any potential control by mating disruption needs to consider the range of attractiveness of the pheromone. Despite the significance of pheromone traps, information on the range of attractiveness of pheromone traps to *Agriotes* species is

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lacking. The objective of this work was to assess the effectiveness of pheromone traps to attract *A*. *lineatus* and *A*. *obscurus* on clover grass field and bare soil for forecasting wireworm damage and for considering their use in mating disruption.

Materials and methods

The experiments were conducted at the experimental farm for organic agriculture ´Wiesengut`, University of Bonn, Germany located in River Sieg Valley/Rhineland (longitude: 7°17' east latitude: 50°48' north). The soil is acid alluvial loam and the climate is comparatively mild with an annual average temperature of 10.2° C. The farm has been under organic management since 1987.

Experimental set up and trap types

Mark release recapture experiments were carried out in 2006 and 2007 in order to determine the average range of attractiveness of pheromone traps. Experiments were carried out on two types of soil coverage (clover grass and bare soil) in natural dispersal peaks i.e. May and June of both years.

Traps were placed at least 100 m distant to each other. Each group of 25 beetles was released both upwind (west) and downwind (east) at distances of 2, 5, 10, 15, 20 and 60 m from a central YATLOR funnel trap baited with fresh lures for both *A. lineatus* and *A. obscurus*. After the release, trap catches were recorded at 1hr, 1d, and every day up until 30d. For every assessment date the absolute (i.e. not cumulative) number of captured beetles was recorded. Data were analysed by ANOVA followed by Tukey's test ($\alpha \leq 0.05$) using SPSS.

Source of beetles

The adults of the male click beetles, *A. lineatus* and *A. obscurus* were collected by putting pheromone traps in different highly infested fields on the farm. Field collections were made as early as possible according to species biology. All captured beetles were sexed, identified and put in aerated boxes filled with moist soil and fed with fresh gramineae leaves until experiments.

Marking of beetles

Different colours (red, green, white and blue) were used to paint the elytrae of beetles. One marking color was used for each of six distances and randomly assigned to the captured beetles. For each treatment (release distance) 25 males were marked by painting the elytrae with non washable pencils resulting in a total of 150 beetles per trial and species. One hour later, marked beetles were released in the field.

Results

Recovery rate of *A*. *lineatus* and *A*. *obscurus*

Of total of 1260 beetles released of *A. lineatus* in two years, 517 were recovered (Fig. 1). The moving behaviour of *A. obscurus* followed a similar pattern to *A*. *lineatus* and of a total of 1260 beetles released in two years, 536 beetles were recovered. High recovery rates were noted only for short release distances (up to 10 m), while less than 10% of the beetles released at 60 m returned to the traps. High recovery rates were only noted for the early assessment dates (up to 3 days). Beyond the third day, beetles were caught in small numbers, and appeared to approach the traps passively. The results further suggest that the recovery rate of released beetles (*A. lineatus* and

A. obscurus) to the traps was more dependent on release distance than on time, while the wind direction had no effect on the recovery rate. Recovery rates of beetles appeared to be reduced by cold and wet weather conditions during both years.

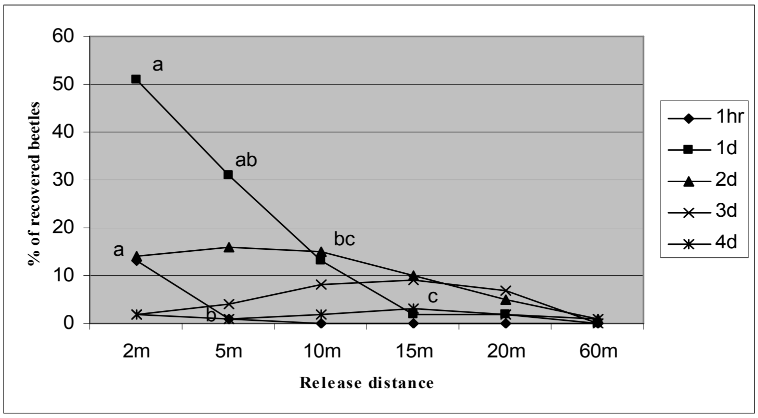

Figure 1: Influence of different release distances and assessment date on the recovery rate of A. lineatus averaged over two years and four trials. Values followed by different letters are significantly different, Tukey's test (α < 0.05).

Discussion

There were two important factors that influenced the range of attractiveness of the pheromone traps: release distance and time. Soil type and wind direction had no effect on the recovery rate. On average, the recovery rate did not exceed 40% for either beetle species, suggesting that on average 60% of the beetles were lost, killed, or were attracted to- and chose to mate female beetles. The high recovery rates for short release distances suggested that painting the beetles was not the main reason for decreasing their recovery. However, the studied parameters were strongly affected by stress and climatic factors, particularly by rainfall. Apparently the range of attractiveness is quite low and is also influenced by the fact that beetles travelling on the soil may encounter the pheromone traps by chance.

Information on the moving behaviour of beetles is still insufficient in the literature. However, current results are supported by Vernon et al. (2001) who observed low flight activities of both *A. lineatus* and *A. obscurus* under the field conditions in Canada. The efficacy of various alternative control methods under consideration (e.g. mass trapping, mating disruption and physical exclusion) would likely be affected by flight activity of beetles. Implications of these findings for practical control of wireworms by mating disruption are part of our ongoing research programme (Sufyan et al. 2007).

Conclusions

The presented experiments suggest that a relatively high number of traps or an extension of the trapping periods need to be considered in order to adult monitoring. The results regarding the range of attractiveness show that the applied technique for male trapping is suitable for limited areas like greenhouses and small areas with high value crops sensitive to wireworms such as asparagus. Whether pheromone traps for click beetles can be used for reducing wireworm populations in the soil is still unclear. Regardless of direct control of click beetles via pheromones, the technique can play an important role in detecting the presence of the beetles, making prevention strategies more efficient. For organic agriculture the pheromone technique is a promising tool to cope with pest problems, which are still a major reason for yield losses in many crops.

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The effect of companion plants on Lygus feeding damage to bean

Szafirowska, A..[1] & Kolosowski, S.[1]

Key words: Lygus, bean seeds, organic farming, companion plants

Abstract

The aim of research was to find out the protective effect of companion plants against lygus bugs (Lygus spp.) in organic production of bean (Phaseolus vulgaris L..). The field experiment was conducted during 2004 and 2005. Bean were sown on three dates: May 10, 25, June 10. As companion plants the following species were applied: red beet (Beta vulgaris L.), dill (Anethum graveolens L.), marigold (Tagetes erecta L.) and sage (Salvia officinalis L.). At harvest the bean seeds were examined for the presence of seed-pitting caused by lygus bugs. The lowest percentage of damaged seeds, demonstrated the samples obtained from plots cultivated in the close proximity of dill and marigold The number of pitted seeds depended on the date of seeds sowing and the year of experiment.

Introduction

Pest occurrence is a severe problem in organic vegetable cultivation, especially in the area of an intensive vegetable production. Less mobile pests and those of a specific host range could be controlled by crop rotation. However, this method is not effective in the control of highly mobile, non specific pests such as aphids and lygus bugs (*Lygus* spp). In Poland the escalation of the occurrence of lygus bugs on many vegetable species had been noticed in recent years (Szwejda 2006). In bean cultivation the pest causes reduction of the yield quality and quantity. Lygus bug's saliva contains the enzymes and amino acids toxic for the plant tissue, thus causing buds and flowers shedding and casting off young pods (Hori 1975). The pests also feed on immature seeds by spitting on the seed surface making shallow hollows (pits) with irregular jagged edges (Szwejda 1978). These pits can be found on the whole seed surface except for the stigma vicinity.

While looking for natural methods of pest control the allelopathy effect of plants can be used. It is known that some plant species stimulates or inhibits other species growth. However, the allopathic relation between plant and insect is not well recognised. Some authors obtained promising results when planting the main crop in the close proximity of species controlling insects occurrence. Kostal & Finch (1994) found a significant reduction in the number of eggs laid by cabbage root fly owing to the companion effect of some plant species. Legutowska and Klepacka (2001) observed a reduction of *Trips tabaci* L. on leek grown in an intercropping with snap bean.

The aim of studies was to examine the effect of several plant species used for companion planting in organic bean cultivation to protect against lygus bugs seed piercing.

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Materials and methods

The experiments were conducted in the experimental organic field in the Research Institute of Vegetable Crops at Skierniewice in Poland during 2004-2005. The field had been subjected to the control-certified system accepted for organic production in the EU (EC Regulation 2092/91). Bean seeds were sown on the 10 m^2 plots with 5 rows on the plot spaced by 45 cm. Two side rows were planted with companion species such as: red beet, dill, marigold and sage. Bean plants used as the companion plant made the control treatment. Bean was sown on three dates: May 10, 25 and June 10. At the same time the companion species were sown. Marigold and sage were used as transplants. The experiment was set by the random block method in four replicates.

Lygus bugs were caught with an entomological net (4x25 catching per plot). The dynamics of lygus bug occurrence was observed at the onset and at full blossoming, the beginning of pod formation and fully formed pods, which means from the second decade of June until the end of August. The number of larvae and imagoes per 1 row meter was counted. The seeding plants were harvested according to the sowing date at September 1, 10 and 20. The total seed yield was examined for the presence of pitted specimens. The seeds with hollows on the seed coat with traces of puncturing on the cotyledons endosperm were recognized as contaminated, following the method of Szwejda (1978). The composition of the *Heteroptera* division was determined down to species following Korcz methods (1977). Results were subjected to the statistical analysis of variance with the significant differences pointed out on the basis of Newman-Keuls test at p=0.05

Results

In both years of research, lygus bugs appeared in a high intensity although more numerously in 2005 (fig.1). The average number of bugs caught on 1 row meter during the whole observation period amounted to 69,5 in the first year and 82,8 in the second one. There were some differences in the occurrence and number of insects in both years of research. In 2005 lygus bugs were noted in the high intensity from the second decade of June until the end of July. In 2004 the pests were less frequent and appeared about two weeks later. This fact, as well as both experimental factors, affected the number of pitted seeds as it is shown in the table 1. Less damaged seeds was observed in 2004 than in 2005. The average percent of pitted seeds was 9,20 and 12,07 respectively as compared to the total yield of bean seeds. The later the sowing date, the more pitted seeds were observed. It was especially visible in the first year, when the seed pods of the earliest sowing were too hard as the lygus started feeding. The most delicate pods of the last sowing date were damaged the worst. The very dynamic occurrence of insects in the second year did not give much chance to the earliest sown bean. The longer feeding period of lygus resulted in a higher level of damage to seeds of all the examined sowing dates. The selected companion plant species significantly influenced the percentage of pitted bean seeds especially in the second an third date of sowing. In the last two cases there were large differences between control and other treatments and in 2005 the differences were significant. The most effective plant species were dill and marigold, which caused a significant decrease in the number of damaged seeds during both years of research. The stage of companion plant development played some role in bean protection. Better developed companion plants in July and August provided the stronger protection against lygus feeding.

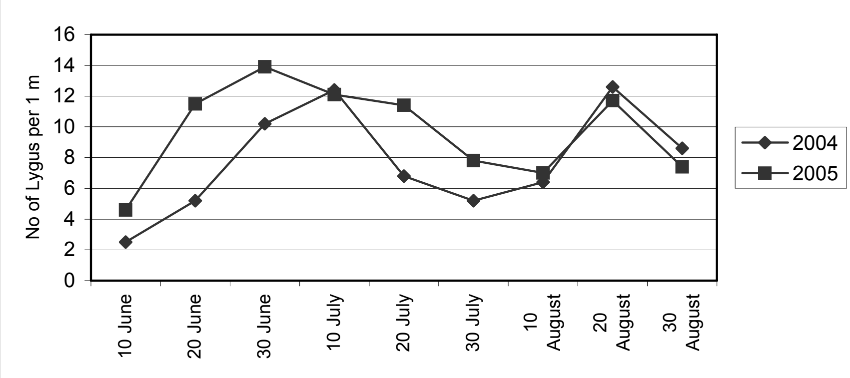

Figure 1: Occurrence intensity of Lygus spp.

Tab. 1: The effect of companion plants on the percentage of pitted seeds in the total bean yield.

Compa-nion species	2004			Mean	2005			Mean
	10 May*	25 May	10 June		10 May	25 May	10 June	
Red beet	3,75	14,11	17,48	11,78	9,70aA	16,83abB	10,59aA	12,37
Dill	1,23	8,70	14,93	8,29	11,60aA	10,72aA	6,55aA	9,62
Marigold	1,85	6,95	10,67	6,49	8,66aA	10,84aA	7,33aA	8,94
Sage	3,23	8,15	11,71	7,69	11,49aA	14,14abA	7,79aA	11,14
Control	3,82	13,54	17,83	11,73	13,10aA	19,35bB	22,43bB	18,29
Average	2,78 a	10,3 b	14,52 c	9,20	10,91	14,38	10,94	12,07

*date of bean sowing; the small letters refer to data in columns, the big ones to data in rows

Discussion

The use of a diversified pest suppressive agro-ecosystem is of growing interest in agriculture. Plant cultivation in a well established ecosystem facilitates pest management and the biodiversity can be used as an important tool in pest control. As Finch and Collier (2000) stated, insects found a host plant faster and easily, when it was clearly visible and not surrounded by weeds or other plants. On the other hand the majority of pests prefer to colonise on a green surface, therefore appropriate companion plants can easily deceive females and invite them to resign from laying eggs on the main crop.

There is scarce literature on the discussed particular subject. The best examined pest in the context of companion plant cultivation are aphids, cabbage root fly or trips. Wiech (1993) received a positive effect in the reduction of aphid occurrence on cabbage by papilionaceous companion planting. Legutowska and Klepacka (2001) found a positive influence of carrot, snap bean and clover on the percentage of strongly damaged leek plants by trips (*Trips tabaci*). In Finch et al. (2003) studies three marigold species (*Tagetes erecta, Tagetes patula* and *Tagetes tenuifolia*), which reduced the number of eggs laid by cabbage root fly females.The obtained results proved that appropriate species used as a companion plant can control the bean seed pitting to some extent. The best protection against lygus feeding provided dill and marigold used as the companion plants in organic bean cultivation.

Conclusion

Bean sown in the first decade of May produced the lowest percentage of pitted seeds. The biggest number of damaged seeds was obtained from the latest sowing date (June 10). The early sowing and right companion species like dill or marigold seems to be useful in protecting against bean seed piercing. It is an important tool, especially in organic farming, because of the lack of effective pesticides allowed to use in this kind of agriculture production.

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Direct and cultural control of pests and diseases

Effects of homeopathic and mineral treatments on dark leaf spot caused by *Alternaria brassicicola* on cauliflower

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Key words: homeopathic treatments, dark leaf spot, cauliflower, arsenic trioxide, *Alternaria brassicicola*

Abstract

This research aimed at verifying the efficacy of some homeopathic and mineral treatments on Alternaria brassicicola/cauliflower interaction. Growth chamber experiments and a field trial were performed, using Brassica plants artificially inoculated with the fungus. In growth chamber experiments, infection was significantly reduced by arsenic trioxide 35 decimal potency (As_2O_3 35 d) and in field trial by both As_2O_3 35 d and bentonite treatments.

Introduction

The aim of this work is to give a contribution on the effects of homeopathic treatments on dark leaf spot caused by *Alternaria brassicicola* (Schw.) Wiltshire on cauliflower. This disease, very common in *Brassica* crops (Humpherson-Jones, 1983), appears as small dark spots at all growth stages of the plant. In organic agriculture, the control of dark leaf spot, as well as of most fungal diseases, is based on the use of mineral products such as copper, that has a high efficacy and a long-lasting action. Unfortunately, copper use presents some disadvantages: it can be phytotoxic, and it can accumulate in the ground with negative consequences on soil microflora and microfauna. For these reasons, European Union delivered a directive (Commission Regulation EC no. 473/2002) that mandates a reduction in copper use in organic agriculture. In this context, homeopathic preparations, due to their extreme dilutions, could represent suitable treatments, complementary to copper, in organic agricultural protocols. Homeopathic treatments are prepared starting from a mother tincture of different substances, according to a standardized protocol which consists in serial aqueous dilutions (decimal or centesimal, d and c, respectively) coupled with dynamization phases (mechanical agitation of the dilution). An hypothesis of the action mechanism of homeopathic remedies is the following: the manufacturing process employed for the preparation of homeopathic remedies would induce a dynamic ‘ordering’ of water’s constantly switching network of intermolecular hydrogen bonds (Chaplin 2007). This could lead to a long-range molecular ‘coherence’ between trillions of mobile water molecules (Elia et al, 2004; Milgron 2006). The literature on the effects of homeopathy on plants provides several papers on germination and growth tests on different species, some on phytopathological models, whereas very few descriptions concerning field trials are available (Betti *et al*., 2007).

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Materials and methods

Plants of *Brassica oleracea* L. cultivar clx 33247 were used for both growth chamber and field experiments. Plants, at the stage of three true leaves, were artificially inoculated by spraying a fungal suspension (1x10^7 conidia ml^{-1}) on the leaves. In the first experiment, arsenic trioxide, As_2O_3 35 d (As) and a bentonite treatment (bent., provided by the company Cosmoonda s.n.c.) at 10 g/l were compared with copper oxiclorure (Cu) at 0.3, 1, and 3 g/l, the control being water. In the second experiment, the treatments with As, bent. and Cu 3 g/l (as positive control) were repeated and compared with As diluted 1:5000 (As dil.) and ß-aminobutyric acid (BABA, 5 mM). As_2O_3 was chosen according to the homeopathic law of similarity (Bellavite *et al.*, 1997): in ponderal concentration it induced on leaves necrotic spots similar to those provoked by *A. brassicicola* infection. Bentonite was chosen because of its inhibiting effect on *in vitro* spore germination and BABA because it is a well-known resistance inducer (Cohen 2002). In the field trial, the same treatments of the first growth chamber experiment were tested. The field was divided in plots consisting of 6 plants/treatment (separated each other by two not-treated healthy plants), each treatment being replicated four times in a randomized complete block design. Treatments were sprayed weekly on the leaves 3 times before and 4 times after artificial fungal inoculation. The evaluation of infection level on leaves (growth chamber experiments) or head (field trial) was carried out blind by two different operators (in order to exclude unconscious influences). A visual assessment of the necrotic area on each plant was performed on the basis of an infection scale, previously defined and then reported in percentage, referred to control. Data were subjected to analysis of variance (ANOVA), followed by Dunnett post-hoc test.

Results

In the preliminary screening of homeopathic treatments, the best disease control was obtained by As, which induced a reduced infection of about 20% (data not shown).

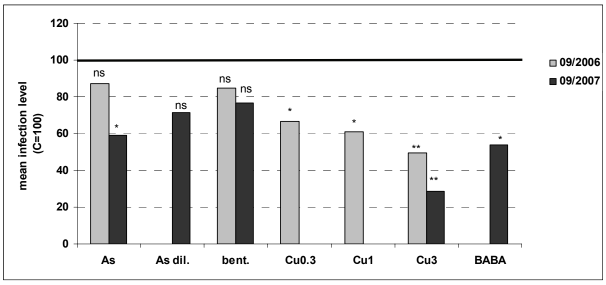

Figure 1: Different treatment effects on mean infection level in growth chamber experiments. Bold line represents control equal to 100.
n = 12 and 18 plants/treatment in 2006 and 2007 experiments, respectively
*** significant for $p<0.05$; ** significant for $p<0.01$**

Growth chamber experiment results, shown in Figure 1, confirmed the significant effect in disease control of As in the second experiment (infection level reduction vs. control of about 40%). A reduction of 15-25%, but not significant, was obtained with bent; Cu at all concentrations and BABA significantly reduced disease severity. In the field trial, disease assessments on cauliflower heads, performed in 3 successive times (Figure 2), showed in the last measurement a similar and significant reduction of disease symptoms for As, bent. and Cu 3 g/l, with a relative efficacy vs. control of 46%, 42%, 45%, respectively.

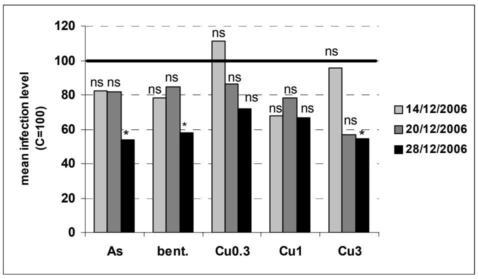

Figure 2: Different treatment effects on mean infection level in field trial. Bold line represents control equal to 100.
n = 4 replicates/treatment ; * significant for p<0.05

Discussion

In literature there are some evidences on the efficacy of homeopathic arsenic in the control of plant diseases (Scofield, 1984) and a resistance increase in tobacco plants against tobacco mosaic virus following treatments with As_2O_3 45 d has been already reported (Betti *et al*., 2003). The growth chamber experiment showed that As_2O_3 35 d significantly controlled dark leaf spot disease only in one case, even if a trend towards a symptom reduction can be observed. It is noteworthy that in different plant/pathogen interactions different homeopathic dilutions of the same treatment can have different efficacy. Moreover, since As_2O_3 35 d is diluted above Avogadro's number, there are no arsenic molecules in the treatment and thus it can be used in agricultural practice. Cu treatments confirmed the well known antifungal activity, particularly at 3g/l, and BABA its characteristics of resistance inducer. In particular, BABA was chosen because in a recent work a protection of *Brassica* plants against *Aternaria brassicae* following BABA treatment has been reported (Kamble and Bhargava, 2007). In the field trial, significant positive effects in the last assessment of infection level on corymb have been observed following arsenic, bentonite and copper oxiclorure at 3g/l. Since fungal inoculation was performed on the leaves before flowering, we can hypothesize that arsenic homeopathic treatment and bentonite induced a plant resistance increase to fungal infection. The symptom reduction due to copper oxiclorure, similar in our experimental trial to that induced by arsenic and bentonite, confirms the well known inhibiting effect of Cu^{2+} ions on fungal spore germination (Borkow *et al*., 2005).

Conclusions

The obtained results need further investigations to indicate a real measurable effect of homeopathic treatments, and rather the existence of a significant effect by chance. Our experimentation is still in progress with another field trial. The aim is to check the effects of the above mentioned treatments against a natural infection of *A. brassicicola*. Besides phytopathological analyses, an evaluation of organolectic characteristics and nutraceutical properties of differently treated plants will be performed. In particular, glucosinolates, a class of plant secondary metabolites typical of *Brassicacae*, will be analysed: these organic compounds seem to participate in the plant resistance mechanisms (Ménard *et al*., 1999) and present a potential activity as "plant food protection agents" (Talalay *et al*., 2001). If homeopathic treatments will induce significant effects, an agricultural application of homeopathy ("agrohomeopathy") could be possible, at least as integrative to conventional agricultural practices. The privileged target of agrohomeopathy could be small farms (and in particular, those of nutraceutical and herbalist sectors) practicing organic farming that strive to be environmentally responsible, economically viable, and socially just.

Acknowledgments

This research has been supported by Marche Region for the years 2004-2006. A grateful acknowledgement to Dr. Leonardo Valenti for his support to this research.

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Late blight in organic potato growing: managing resistance and early tuber growth

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Key words: late blight, organic potatoes, resistance, physiological age, yield formation

Abstract

In organic potato production yields are often reduced by potato late blight (Phytophthora infestans). Two aspects are important in late blight management: a sufficiently high (field) resistance to late blight, and early tuber formation. With early tuber formation the period of tuber growth is extended at the beginning, and with a high resistance level at the end.

In 2006 and 2007 experiments were carried out in which the effects of the physiological age of seed tubers on field resistance to late blight and on tuber yield of potatoes (Solanum tuberosum L.) were tested for early and moderately late varieties. The results indicate that with the use of physiologically older seed tubers (by pre-sprouting) the field resistance to late blight is generally lower than with younger seed tubers. With physiologically older seed tubers, however, yields are generally higher at the time the crop has to be defoliated because of late blight.

It is concluded that especially when the growing period of a potato crop is short, for example as a consequence of an early late blight epidemic, or when a late variety is grown, early tuber growth by the use of older (pre-sprouted) seed tubers is highly important to assure an acceptable yield level at the end of the growing season. Even in years with a long growing season, a late variety like Agria may yield up to 12 t/ha more when physiologically older seed tubers are used.

Introduction

In organic potato growing, late blight, caused by the oömycete *Phytophthora infestans*, is one of the most devastating diseases, shortening the available growth period and thus reducing yields of potato crops (*Solanum tuberosum* L.) (Tamm et al., 2004). Because chemical-synthetical pesticides are not allowed under organic regulations farmers have to achieve a sufficient yield before the potato crop becomes infected with late blight.

The period of tuber growth can be extended at both ends: at the beginning, by using an early variety or physiologically older seed tubers, resulting in early onset of tuber formation, or at the end, by growing a variety or a crop with a high level of field resistance, allowing the crop to continue to grow despite late blight pressure.

Variety choice is generally considered the first and most important step in late blight management, but early varieties are generally too susceptible, and more resistant late varieties may, especially in years with an early late blight epidemic, not yet have

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reached an acceptable yield level when late blight strikes.

The use of physiologically older seed tubers, for example by pre-sprouting, results in earlier crop establishment and earlier onset of tuber growth (Struik & Wiersema, 1999). Pre-sprouting is a generally accepted technology in organic potato growing, but many farmers do not adopt it because of technical problems (work load, required planting equipment, etc.). Moreover, pre-sprouting may give a crop with a lower field resistance (Hospers-Brands et al., 2005).

In 2006 and 2007 we carried out experiments to optimize the balance between early crop establishment by using physiologically older seed tubers on the one hand and enhancing field resistance by using younger seed tubers on the other hand, with four contrasting varieties.

Materials and methods

Variety choice. The varieties were selected to cover a range of early to moderately late maturity type, and a range of late blight resistance levels (Table 1).

Tab. 1: Characteristics of the tested varieties

	Earliness[a]	Late blight resistance foliage[b]
Junior	9	4
Ditta	6	6
Nicola	5.5	4.5
Agria	5	5.5

[a] 1 = very late, 9 = very early, [b] 1 = very susceptible, 9 = resistant

In 2007, the quality of the de-sprouted seed tubers of Junior was too low to allow normal crop growth. Emergence was delayed and after a poor crop development, yields were very low. Results for Junior in 2007 are therefore not presented here.

Seed tuber treatments. We tested young tubers with young sprouts (control) (2006 and 2007), old tubers with old sprouts (pre-sprouted) (only in 2006), and old tubers with young sprouts (de-sprouted) (2006 and 2007). The control tubers were kept in cold storage until one week before planting and then mini-chitted at 16 °C. The pre-sprouted and de-sprouted tubers were kept in cold storage until five weeks before planting, and then pre-sprouted at 16 °C. From the de-sprouted tubers the sprouts were removed two weeks before planting; then the tubers were mini-chitted at 16 °C.

Test sites. The experiment in 2006 was carried out on an organic clay location and in 2007 on an organic sand location in the Netherlands. Crop management was according to the management of the commercial potato crops grown on the farms. The test sites were subjected to natural infection by late blight. The crops were defoliated by burning the foliage as soon as 7% or more of the leaf area in a given plot was infected by late blight, according to Dutch legislation.

Assessments. Emergence rate, soil cover, late blight infection (field assessments and laboratory tests on detached leaves) and fresh tuber yields were recorded. Using the statistical program Genstat (version 7.2) for both years least significant differences (LSD) were calculated, for the interaction variety*seed tuber treatment.

Results

Weather conditions differed between the two experimental years. In 2006, after a cold and wet spring, the summer was warm and dry. As a result, the late blight epidemic started late, at a moment when some organic potato crops were already showing natural senescence. In 2007 the early spring was very warm and dry, but the summer was very wet, and the late blight epidemic extremely early and aggressive.

Crop development. In both years older seed tubers (pre-sprouted or de-sprouted) emerged 1 – 5 days earlier than young seed tubers (control) (differences significant at the 5% level), and canopy development was faster during the first half of the growing season. In 2006, however, when, because of the late onset of the blight epidemic, the growing season was rather long, in the second half of the growing season the canopy from the oldest (pre-sprouted) seed tubers of the earliest varieties already started to senesce, when the canopy from the youngest seed tubers was still expanding. The effects of differences in canopy development were reflected in tuber yields (see below).

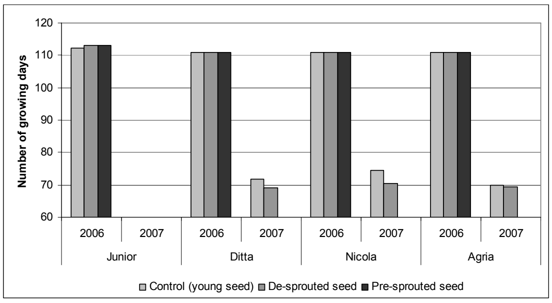

Figure 1: Growing days from planting until defoliation (7% of leaf area infected by late blight). 2006: LSD=0.39; 2007: LSD=4.60 (5% level, variety*seed tuber treatment).

Late blight. Generally, crops from the youngest seed tubers were less infected by late blight than crops from the oldest seed tubers. In 2006, with a late onset of the late blight epidemic, almost no differences in number of growing days were found, but in 2007 crops from the younger seed tubers could grow 1 – 4 days longer than crops from the older seed tubers (Fig. 1) (differences in 2007 not significant). Crops from pre-sprouted seed tubers seemed to be slightly more susceptible to late blight than crops from non-sprouted seed tubers, but crops from the de-sprouted seed tubers were in 2006 as resistant as the non-sprouted crops (results not presented).

Yield. Final yields were dependent on variety, seed tuber treatment and timing of the late blight infection. In 2006, infection by late blight was rather late, and for the earliest variety (Junior), the youngest seed tubers gave a 5.5 t/ha higher yield than the older seed tubers, whereas for the latest variety (Agria) the opposite was true: the older seed tubers gave a 9 – 12 t/ha higher yield than the young seed tubers (differences significant at the 5% level). In 2007, with much lower yield levels in general, yields from the older (de-sprouted) seed tubers were up to 3 t/ha higher than yields from the younger seed tubers (differences not significant) (Fig. 2).

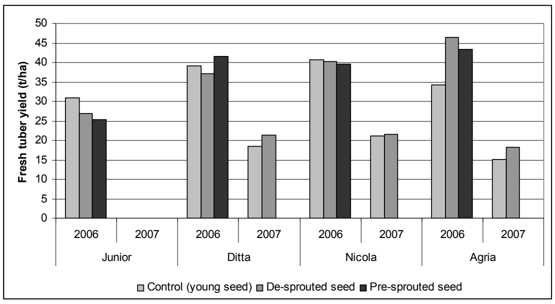

Figure 2: Final fresh tuber yield. 2006: LSD=4.42; 2007: LSD=4.83 (5% level, variety*seed tuber treatment).

Discussion

Especially late varieties seemed to profit from the yield-enhancing effects of physiologically older (pre-sprouted or de-sprouted) seed tubers. The effects, however, depended on the timing of the late blight infection: when the infection was early (2007), all varieties had higher yields with the older seed tubers, but when the infection was late (2006), only the late varieties had higher yields with older seed tubers. In this situation for early varieties the yield was highest for the younger seed tubers, because the canopy of this crop continued to expand when the canopy from the older seed tubers was already senescing. With respect to tuber yields, the yield-enhancing effects of pre-sprouting were more importance than the resistance depressing effects.

Conclusions

Early crop establishment is especially important when a late variety is grown and / or when the crop has only a short growth period because of an early late blight epidemic.

Acknowledgments

The authors thank the farmers at the test sites, and all technical staff for their cooperation. The research has been partially funded by the Dutch Ministry of Agriculture, Nature Conservation and Food Safety.

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Quassia, an Effective Aphid Control Agent for Organic Hop Growing

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Key words: Hop, *Humulus lupulus*, *Phorodon humuli*, plant protection, quassia

Abstract

In the first three decades of the 20th century, quassia extract was widely used in hop growing as a chemical agent to control Phorodon humuli *and other insect pests. In the first years of the 21st century this compound was rediscovered by German organic hop growers. In several efficacy trials conducted during five field seasons, quassia products proved to be effective control agents for* P. humuli *in organically grown aroma cultivars. A systemic variant developed by painting a suspension of quassia extract to the bines was the best method of application. This method proved not only to be very effective, but was also best from an environmental point of view. The optimal systemic application rate was determined as 24 g/ha of the active ingredient quassin. In order to generate the data necessary for registration of quassin in Annex I of the EU Council Directive 91/414/EEC, further efficacy trials were conducted during 2007. The results emphasize the importance of this compound as currently the only suitable aphid control agent in organic hop growing, especially when applied systemically.*

Introduction

In organic hop growing, the control of diseases and pests is a crucial problem. The most prevalent pests are damson-hop aphid *Phorodon humuli* (Schrank) and two-spotted spider mite *Tetranychus urticae* Koch. Without control measures, both are able to damage the quantity and quality of harvested cones, and in some years they may completely destroy a crop (Neve 1991). The earliest materials used to control *P. humuli* by spraying were nicotine, soft soap and quassia (*e.g.* Theobald 1909). The latter two compounds are still listed today as approved substances for pest control in German organic farming (*e.g.* Bioland 2007). According to these guidelines today's quassia products have to originate exclusively from the wood of the South American tree species, *Quassia amara*, with quassin as active ingredient (a.i.). At the beginning of the 21st century, aphid control by the pyrethrins registered for organic farming proved unsatisfactory, and German organic farmers rediscovered that spraying of quassia solutions, extracted by homebrews from *Q. amara* wood chips was an alternative. This option for aphid control was accompanied with efficacy trials from the first day onwards (Engelhard & Weihrauch 2005), and was advanced in the following five years (Engelhard *et al*. 2007). The best method of application was a systemic variant, developed by painting a suspension of quassia extract to the bines. This was not only very effective, but was also best from an environmental point of view, because sprayed quassia extracts from homebrews had side effects on non-target organisms such as

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leafhoppers (Cicadellidae) (Engelhard & Weihrauch 2005). The optimal systemic application rate was determined to be 24 g/ha quassin.

Therefore, previous results show that organic growers in Germany are dependent currently on quassia products in order to ensure satisfactory control of *P. humuli*. No other effective compounds or control strategies are registered for organic farming in Germany. At the moment no industrial quassia product is registered for aphid control in the EU, and the current modus operandi of organic growers, *i.e.* the use of homemade quassia brews, occupies a legal grey area. Hence, in order to make this compound available within the EU, it is most important to register quassin as an active ingredient for the control of aphids in Annex I of the EU Council Directive 91/414/EEC. The first and most important step towards registration is to generate sufficient data so further efficacy trials were performed with a new industrial quassia extract and these are presented below.

Materials and methods

The study was conducted during 2007 in the Hallertau, Bavaria, Germany. The Hallertau is the world's largest coherent hop-growing region, with almost 30 % of the world's area of this crop. It is situated south of the River Danube in central Bavaria and has an area totalling 1,500 km². Three hop gardens of three farms were chosen as study sites: Haushausen (cv. Hallertauer Tradition), Eichelberg (cv. Perle), and Schweinbach (cv. Hallertauer Magnum). As the experimental procedures and results from all three sites were similar, only Haushausen – the site with the highest aphid infestation level during 2007 - is presented below as that site was representative for all three. Plots of 84 hop plants (six rows with 14 plants each; *c.* 300 m^2) were laid out in three replications, respectively, for the following applications of quassin: 12 g/ha sprayed; 18 g/ha sprayed; 18 g/ha applied systemically; 24 g/ha applied systemically; and untreated control. The experimental dry quassia extract (0.6 % a.i.) was provided by Trifolio-M GmbH, Lahnau, Germany. The date of the single systemic application, a manual painting of quassin in an oily suspension to the bines, was 31 May, when the hop plants were in full extension growth. Quassin was sprayed twice at the above rates a.i., on 14 June, when the aphid migration was finished completely, and on 13 July, when it became obvious that the first spraying was not sufficient. Aphid population development was monitored weekly on 50 leaves sampled from each plot, respectively, for 14 weeks from late May to late August. These counts were compared by repeated measures ANOVA followed by a Bonferroni post hoc test. An experimental harvest was conducted on 29 August, which assessed yield and alpha acids (measuring unit for hop quality) from 10 bines per application in four replications taken from two experimental plots, respectively, and was compared to the grower's own treatment, which included three sprayings of quassia homebrew ('practice' in Fig. 1). Harvest data was compared by ANOVA followed by a Bonferroni post hoc test.

Results

All treatments significantly reduced the aphid population density on the plants throughout the field season (df = 4, F = 2580.402, P<0.001). Among all treaments, the 24 g/ha systemic treatment gave significantly the best control of aphid population development (P<0.001). The 18 g/ha systemic treatment had significantly fewer aphids than the two sprayed treatments (P<0.001), between which there were no significant differences. Compared to the untreated control, on 24 June – the day with the highest recorded aphid numbers - the 12 g/ha spray application reduced aphid numbers by 69.5 % and the 24 g/ha systemic variant by 87.6 %. Table 1 shows the progress of aphid population development in the different plots at that site which, as noted above, had the highest general infestation level during 2007.

Tab. 1: The influence of various quassia applications on the aphid population development in an organic hop garden. Haushausen, Hallertau, 2007, cv. HT. Mean numbers of aphids leaf $^{-1}$ ± s.e. of 50 assessed leaves (n = 3 replications each). Systemic application 31 v 2007, spray applications (full amount) 14 vi and 13 vii 2007.

date / treatment	control untreated	[12 g/ha] sprayed	[18 g/ha] sprayed	[18 g/ha] systemic	[24 g/ha] systemic
30 v	8 ± 5	6 ± 3	8 ± 1	6 ± 1	5 ± 1
06 vi	25 ± 3	23 ± 2	25 ± 4	17 ± 5	13 ± 4
12 vi	70 ± 16	62 ± 16	79 ± 27	20 ± 5	13 ± 2
18 vi	124 ± 7	63 ± 11	88 ± 4	31 ± 8	12 ± 3
25 vi	545 ± 37	228 ± 47	285 ± 37	25 ± 13	12 ± 7
03 vii	415 ± 20	239 ± 28	316 ± 52	44 ± 25	22 ± 15
09 vii	722 ± 145	315 ± 83	337 ± 150	43 ± 23	16 ± 4
17 vii	662 ± 168	170 ± 35	122 ± 13	131 ± 127	39 ± 21
24 vii	1229 ± 280	375 ± 214	305 ±180	343 ± 271	153 ± 97
30 vii	1138 ± 170	288 ± 81	240 ± 180	228 ± 216	64 ± 40
07 viii	325 ± 109	82 ± 33	70 ± 44	75 ± 51	28 ± 12
14 viii	43 ± 11	47 ± 19	34 ± 17	10 ± 4	14 ± 4
20 viii	8 ± 3	8 ± 2	9 ± 1	6 ± 3	7 ± 1

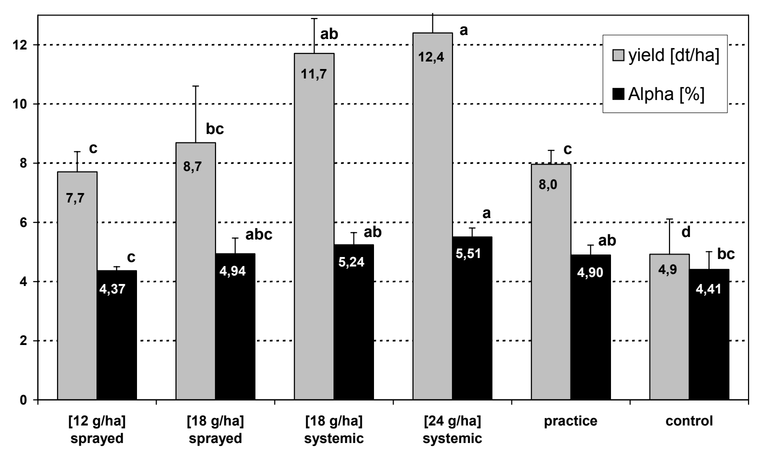

Figure 1: The influence of various quassin applications on hop yield and alpha acids in an organic hop garden. Haushausen, Hallertau, 29 viii 2007, cv. HT

Bars with the same letters are not significantly different by ANOVA, at P<0.05.

The aphid infestation records were mirrored by the results from the experimental harvest. The systemic treatments were significantly the best, and the control plot was significantly lower in yield than any quassin treatment (Fig. 1).

Discussion and Conclusions

The results achieved during the 2007 quassia efficacy trials confirm the conclusions of Engelhard *et al*. (2007). The 24 g/ha quassin systemic treatment proved to be the best and most reliable treatment. Although we tried to reduce the amount of a.i. to 18 g/ha, as a consideration to the costs of this compound, the higher quassin application rate was needed to ensure satisfactory aphid control. As we detected some heterogeneity in the aphid infestation of single plants in the systemic plots, especially in the 18 g/ha treatment, we think that probably those plants with increased infestation did not receive sufficient a.i. during the application. The amount of a.i. painted to each bine is intended to be only 4.5 mg in the 18 g/ha variant, and if the oily suspension prepared for the application is not absolutely homogeneous, some bines will get more and some probably too little quassin. This problem seems to occur less frequently with the higher dosage, which additionally may help to postpone the probable development of aphid resistance to this compound.

The spray applications were generally less effective than bine painting and led to only an approximate reduction of 70 % of aphids. This efficiency, however, may be unsatisfactory when the general infestation level is very high, as was the case at Haushausen during 2007. Furthermore, the painting of bines in the systemic application is not dependent on the calm weather conditions required for spraying, and a tractor with power sprayer is not needed, which will lead to less soil compaction in the fields. In conclusion, the systemic application of 24 g/ha quassin has to be regarded currently as the method of choice for aphid control in organic hop growing.

Acknowledgments

Thanks to Trifolio-M GmbH, Lahnau, Germany, for the pleasant cooperation, to Colin A.M. Campbell, Ditton, UK, for polishing our English, to Andreas Woppmann, Vienna, Austria, for statistical advice, and to the hop growers Georg Loibl, Georg Pichlmaier and Helmut Schmid for letting us use their fields for this study.

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The two-spotted spider mite can be controlled by water

Conte, L.[1] *& Chiarini, F.*[2]

Key words: *Tetranychus urticae*, *Phytoseiulus persimilis*, biological control, water

Abstract

The effects of a fogging system on the control of the two-spotted spider mite (Tetranychus urticae) were studied in greenhouse cultivation of eggplant, cucumber and strawberry during the period 1999-2006. At the beginning the pest and the phytoseiid predator Phytoseiulus persimilis were released on the crops and then observations were made on the development of the populations of both mites. Fogging system effects were found in terms of lowering the T. urticae population and hindering the growth of powdery mildew fungus. Furthermore there was a yield increase in the cases of strawberry and cucumber in 2001 but no negative impact on pest management was ever detected, particularly on the biological control of the melon aphid (Aphis gossypii) achieved using multiple releases of parasitoids.

Introduction

The two-spotted spider mite *Tetranychus urticae* (Acari, Tetranychidae) is one of the most dangerous greenhouses pests: when the climate is hot and dry, its populations increase rapidly (Crooker, 1985); while in presence of high air humidity (e.g. more than 70%) and, above all, direct contact with water (e.g. rain) the rate of increase of its populations is considerably reduced (Tulisalo, 1974; Holtzer *et al.*, 1988).

At present, in organic farming there are no acaricides effective on this pest and so biological control is necessary: in this case the most common technique relies upon multiple releases of the predator *Phytoseiulus persimilis* (Acari, Phytoseiidae). Unfortunately the rate of increase of the populations of this beneficial is restrained by a hot and dry climate: in fact, when air temperature is between 20°C and 30°C and air humidity is lower than 60% most of its eggs do not hatch and die. When temperature rises, the critical threshold of air humidity rises too (Stenseth, 1979): for this reason, in the Mediterranean regions during the summer, populations of *T. urticae* grow faster than those of *P. persimilis*.

In greenhouses we could get over this limit using an air moisturizing system (Fogging System) which releases tiny droplets of water to hinder the growth of *T. urticae* populations and to favour the growth of those of *P. persimilis*: in order to verify this hypothesis, during the period 1999-2006, experimental trials were done at the Experimental Center 'Po di Tramontana' of Veneto Agricoltura (in Rosolina, 60 km south from Venice).

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Materials and methods

The trials were made on different crops grown inside greenhouses of 340 m^2, in different years: in 1999 on eggplant (April-September), in 2000 and 2001 on cucumber (April-July), in 2006 on strawberry (April-September).

In each trial the greenhouse was divided in two halves by a plastic screen, giving 2 sectors of 170 m^2: "fog" and "no fog". In each sector the same species, varieties and number of plants were cultivated. In the "fog" sector only, a fogging system was assembled. The fogging system consisted of several sprinklers arranged under the roof of the greenhouse at the density of $1/m^2$. It was programmed to work every day from 9 a.m. until 6 p.m. only when the air humidity inside the greenhouse fell under 65%: in this case, droplets of water were sprayed upon the plant canopy for 2 seconds. The frequency of the sprinkles was regulated in order to avoid the persistence of a layer of water on the leaves and to prevent the development of fungal and bacterial diseases; in other words an alternation of wet and dry phases was accomplished on the leaf surface.

If there was not an equal, natural presence of *T. urticae* in the two sectors, the plants were artificially infested so that the trial could begin with equal populations of the pest. The fogging system started sprinkling from May until the end of the cultivation in 1999, 2000, 2001 and from April in 2006. During these periods the releases criteria of the predator *P. persimilis* changed (tab. 1).

Tab. 1: Releases of *P. persimilis* in the different trials (n° of phytoseiids/m^2)

eggplant 1999			cucumber 2000			cucumber 2001			strawberry 2006		
	fog	no fog		fog	no fog		fog	no fog		fog	no fog
27 May	10.3	10.3	8 Jun	0	13.2	6 Jun	6	6	27 Apr	23.8	23.8
17Jun	0	23.5	22 Jun	0	6.6	13 Jun	6	6	29 Aug	11.9	11.9
24 Jun	0	23.5									
1Jul	0	20.6									
8 Jul	0	17.6									
15 Jul	2.3	11.8									
total	12.6	107.3	total	0	19.8	total	12	12	total	35.7	35.7

In 1999, on eggplant, multiple releases of *P. persimilis* were done in order to restrict the growth of *T. urticae* below the economic damage threshold: this strategy allowed us to compare the costs of pest control in the presence or absence of the fogging system.

In 2000, on cucumber, no releases of *P. persimilis* were done in the "fog" sector in order to assess if *T. urticae* could be controlled by water alone; in the "no fog" sector two releases of *P. persimilis* were done.

In 2001 on cucumber and in 2006 on strawberry, two releases of *P. persimilis* were done in order to estimate the population dynamics of both the pest and the beneficial in the two sectors.

The populations dynamics were estimated counting young and adult instars of *T. urticae* and *P. persimilis* on leaves chosen from the upper, median and lower part of the plants of cucumber and on the young and old leaves of strawberry. On eggplant, instead, only the number of leaves occupied by the pest and the predator were recorded; even in this case the leaves were chosen from the upper, median and lower part of the plants. The computation was made weekly, monitoring 20% of the plants on eggplant, 40% on cucumber, 10% on strawberry.

The control of insect pests was made by multiple releases of beneficials: particularly *Aphidius colemani* and *Lysiphlebus testaceipes* (Hymenoptera, Aphidiidae) against the melon aphid *Aphis gossypii* (Hemiptera, Aphididae); furthermore their activity on pest control was monitored. Every year the yields were recorded and observations were made on the occurrence of fungal and bacterial diseases. In 2000 and 2001 trials Proc GLM, Repeated Measure Analysis of Variance was done. In 1999 and 2006 trials Analysis of variance with Tukey test was done.

Results and discussion

The results of the different trials are expressed in the figures 1, 2, 3, 4, where *T. urticae* population dynamics can bee seen.

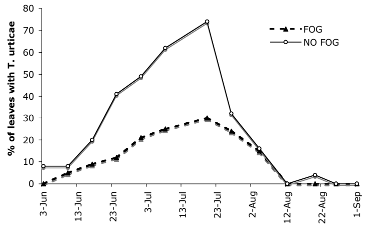

Fig. 1: population dynamics of *T. urticae* on eggplant in 1999

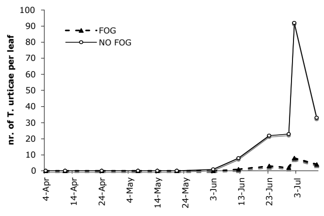

Fig. 2: population dynamics of *T. urticae* on cucumber in 2000

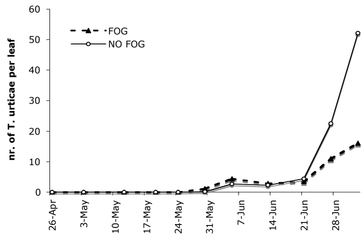

Fig. 3: population dynamics of *T. urticae* on cucumber in 2001

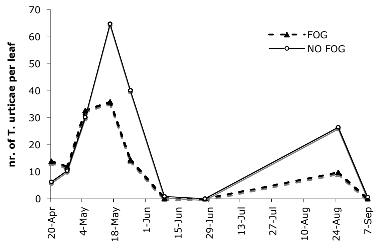

Fig. 4: population dynamics of *T. urticae* on strawberry in 2006

In all the trials the development of *T. urticae* populations in the "fog" sector was significantly lower than the level recorded in the "no fog" sector and it was always under the economic damage threshold. The development of *P. persimilis* populations always followed the one of *T. urticae* in both sectors (data not shown in this paper); as a matter of fact, the fogging system did not affect positively the growth of predator's populations as expected.

In both the sectors the yields were similar, except for the cucumber in 2001 when a higher yield was obtained in the 'fog' sector (Chiarini et al., 2002) and for the strawberry in 2006, which had 467a and 425b g/plant yield, respectively in the 'fog' and ‘no fog’ sectors (p=0.04). The fogging system did not promote the spread and development of fungal and bacterial diseases on the crops; furthermore no negative effects were also recorded on biological control of insect pests.

Conclusions

1. The use of a fogging system in greenhouses, during the summer, is an effective tool to hinder the growth of *T. urticae* populations.

2. The repeated sprinkling of water done in the hottest hours of the day, lowers the leaf temperature below a critic threshold and so rendering the net photosynthesis value positive: this means that during the summer, the crops grow better even inside the greenhouses and give either comparable or even higher yields.

3. The repeated sprinkling of water on the plant canopy does not promote the development of fungal and bacterial diseases and does not affect negatively the biological control of insect pests.

4. In the 1999 trial we estimated that the annual amortization share of the fogging system is lower than the cost of an adequate amount of *P. persimilis* to keep *T. urticae* populations under the economic damage threshold (Conte et al., 2000).

Finally, repeated observations on pest management in small farms suggest that water can be used to control *T. urticae* in greenhouses even without a fogging system: in fact a cheaper system, which consists of a web of micro-sprinklers producing water droplets on the plant canopy, can be used. The farmer should then regulate the frequency and the duration of the sprinkling. The same rule used for the fogging system can be applied: the frequency of the spraying has to be regulated in order to prevent the persistence of a layer of water on the leaves; therefore an alternation of wet and dry phases is needed on the leaf surface. This system is cheaper than the fogging system but has been tested reliable enough to be used on small farms.

Acknowledgments

Thanks to L. Dalla Montà, C. Duso, V. Bonora ed E. Berto of Padova University, Faculty of Agriculture, for having worked with us in the 2000 and 2001 tests.

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Effects of *Trichoderma* applications on vines grown in organic nursery

Di Marco, S.[1] & Osti, F.[1]

Key words: *Trichoderma*, root development, disease, organic nursery

Abstract

A two-year trial was conducted to evaluate the effects of applications of commercial formulations of the fungus Trichoderma on graftlings of grapevine (Vitis vinifera L.) in a commercial nursery where plants were grown under organic management. Treatments were carried out at callusing, rooting and callusing+rooting. Effects on the host-plant morpho-physiological characteristics were observed and depended on the type and timing of Trichoderma application. Treatment at rooting was the most effective whilst application at callusing and combination of treatments gave controversial results. The most noticeable effect of application of Trichoderma was an increase of quantitative-qualitative characteristics of the root system, with a consistent development of root hairs. Compared to untreated plants the percentage of certifiable plants treated at rooting was higher.

Introduction

Studies on the fungus *Trichoderma* demonstrated that this microorganism is able to control several fungal pathogens and can be used as biocontrol agent. The mechanism of activity of *Trichoderma* applied to the soil as inductor of plant defence responses towards pathogens far from the site of application has been recently discussed. An enhancement of crop productivity as well as beneficial effects on plant morphology and physiology were also emphasized (Harman *et al.,* 2004). The potential of nursery applications of *Trichoderma* to prevent or reduce infections of *Phaeomoniella chlamydospora* and *Phaeoacremonium* spp., fungi associated with esca, a complex wood disease of grapevine, was recently investigated. Formulations based on *T. harzianum*, applied at various nursery stages, showed a slight reduction of levels of esca pathogens, assessed on uprooted vines deriving from field nursery, and of leaf necroses due to *Botrytis cinerea* inoculated on vine leaves (Di Marco *et al*., 2004; Di Marco and Osti, 2007; Fourie and Halleen, 2006). This paper reports on results obtained in a two-years study carried out in an organic nursery on morpho-physiological effects on vines treated with *Trichoderma* formulations at various nursery vine-growth stages.

Materials and methods

Field trials were carried out in 2005-2006 growing seasons in a commercial organic nursery at Faenza, Emilia Romagna, north–central Italy. Grapevine plants cv. Trebbiano romagnolo (TR3T) grafted on K5BB or 1103P were treated with commercial formulations Rootshield® granules or Remedier® (in 2006), containing *Trichoderma harzianum* T 22 or *T. harzianum* ICC012 + *Trichoderma viride* ICC080 respectively.

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The bio-products were applied as follows: (i) “callusing”: graftlings were completely drenched for 30 min in a water suspension at 15 g l^{-1} (Rootshield) and at 50 g l^{-1} (Remedier) in PVC boxes containing 750-800 plants each, then stored for 3 weeks in boxes with wet sawdust at about 30°C and 70-80% relative humidity; (ii) “rooting”: the bottom ends of graftlings were placed for 30 min in PVC buckets with a suspension of the *Trichoderma* formulations at the same concentrations mentioned above; four or five weeks after planting, graftlings were treated by soil drenching with *Trichoderma* suspensions at 0.5 g l^{-1}(Rootshield) and at 5 g l^{-1} (Remedier); (iii) “callusing+rooting”: graftlings were submitted to the combinations of the treatments above described. For each treatment, control plants were treated with water instead of *Trichoderma.* For each year of trial, differences in the quality and development of callus around the grafting junction were visually assessed. The graftlings showing a successful callus were recorded as plantable. Two hundred cuttings per treatment with 4 replicates (each consisting of 50 cuttings) were planted in a field nursery and left in the soil for 28-29 weeks. In autumn dormant graftlings were mechanically uprooted. After uprooting, certifiable plants were selected according to the EU directive 2005/43, and recorded. Some plants were uprooted by hand taking care to preserve the entire root system. For each treatment 4 replicates each consisting of one plant were set up. The root system of plants uprooted by hand was washed and root diameter measured with a caliper in the laboratory. Roots were then collected and grouped into 3 categories: hairs (< 0.05 mm diameter); secondary (0.05–0.2 mm); primary (> 0.2 mm). For each category the projected root area (cm^2) was evaluated by video-image analysis as described in Di Marco *et al*. (2004). The root development was examined only in the TR3T/K5BB scion/rootstock combination. In 2005, the examination was carried out with Rootshield both on potted plants and on plants collected from the nursery field; in 2006, trials were conducted only in the nursery field with both Rootshield and Remedier. Results were subjected to statistical analysis using Duncan’s multiple range test, P=0.05.

Results

At the end of the callusing period, treatment with Trichodex provided a percentage of plantable plants 5% lower than untreated, only in 2005 trial and for the TR3T/K5BB scion-rootstock combination. No significant differences in the formation of grafting callus between treated and untreated graftlings were observed. At the end of the growing season, effects of *Trichoderma* treatments on the percentage of uprooted plants was not assessed, except for, in a few cases, a certain decrease in plants treated at callusing or at callusing+rooting (Tab. 1).

Tab. 1: Percentage of plants uprooted at the end of the growing season.

Treatment	2005		2006			
	Rootshield		Rootshield		Remedier	
	K5BB*	1103P*	K5BB	1103P	K5BB	1103P
Callusing	42.0a	51.5b	46.5a	58.5a	30.0b	59.5a
Rooting	46.8a	57.0a	52.0a	73.0a	54.0a	67.3a
Callusing + rooting	47.2a	60.3a	13.0b	72.0a	39.0b	56.6a
Untreated control	47.8a	67.3a	53.6a	64.0a	53.6a	64,0a

* Type of rootstock.

A significantly higher percentage of certifiable plants was noticed for plants treated at rooting with Remedier compared to the other treatments. Rootshield applied at rooting showed a significant increase of certifiable plants compared to callusing and, in some cases, to the control or to the callusing+rooting (Tab. 2).

Tab. 2: Percentage of certifiable plants after uprooting selected according to the EU directive 2005/43.

Treatment	2005		2006			
	Rootshield		Rootshield		Remedier	
	K5BB*	1103P*	K5BB	1103P	K5BB	1103P
Callusing	25.8b**	30.0c	22.0b	22.5c	6.8d	27.3b
Rooting	32.8a	42.0a	29.8a	37.3a	31.3a	35.0a
Callusing + rooting	29.8ab	37.0ab	6.5c	32.0ab	15.8c	25.3b
Untreated control	28.0ab	35.3b	25.0ab	28.5b	25.0b	28.5b

* See table 1.

** See table 1.

An enhancement of root hairs development on vines treated with *Trichoderma* was observed (Tab. 3).

Tab. 3: Development of the root type (cm2) of potted plants and plants grown in nursery field assessed by Video Image Analysis.

2005 trials

Treatment	Root system					
	Potted plants			Field nursery plants		
	Hairs*	Secondary	Primary	Hairs	Secondary	Primary
Untreated control	62.4a**	32.3a	15.4a	34.5a	38.5a	26.0a
Callusing	106.5b	32.7a	16.5a	-	-	-
Rooting	125.7b	33.9a	15.2a	107.4b	53.8a	24.0a
Callusing + Rooting	116.5b	32.0a	16.8a	-	-	-

2006 trials

Treatment at the rooting in field nursery trial

Treatment	Root system		
	Hairs*	Secondary	Primary
Untreated control	34.5a**	38.5a	26.0a
Rootshield	107.4b	53.8a	24.0a
Remedier	135.0b	55.1a	23.5a

* Root diameter: hairy (< 0.05 mm); secondary (0.05–0.2 mm); primary (> 0.2 mm).

** See Table 1.

Discussion

Results obtained in this study on the morpho-physiological characteristics of the host-plant after the application of *Trichoderma* at different nursery vine-growth stages, confirmed the complexity of the mechanism of action of the bio-control agent and its potential in enhancing crop productivity and quality. Treatments can affect the percentage of growing graftlings, suggesting the possibility of a kind of selection caused by the action of *Trichoderma*. Callusing, rooting or callusing+rooting treatments gave different results. On the whole, the two *Trichoderma* applications scheduled in the "rooting" treatment showed the most interesting activity reducing as well the variability of results obtained. Beneficial effects may be related with the choice of nursery stage and the localization of the application. In this trial Remedier was used at high dosage; ongoing studies showed that a reduction of dosage does not lead to a decrease of its activity. So, the activity seems not strictly associated with the amount of *Trichoderma* used. Generally all types of *Trichoderma* applications caused a proliferation of root system, consistent for root hairs. So, vines are better equipped to withstand stress conditions, including stress-related pathogens like those associated with esca.

Conclusions

The application of *Trichoderma* formulations in the nursery generally caused beneficial effects on plants which showed an enhancement of quality characteristics, especially for root development and, in some cases, percentage of certifiable plants. The type and timing of application demonstrated to be important for the activity of *Trichoderma*.

Acknowledgments

The research was carried out within the project co-ordinated by CRPV (Vegetal Production Research Center) in collaboration with ProBER (Organic Producers of E.R.), funded by Emilia-Romagna Region (L.R. 28/98). The authors also thank the nursery Dalmonte Guido e Vittorio s.s. Società Agricola, and Dr. Gianluca Mordenti for much help and assistance given during this study.

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Efficacy evaluation of copper formulations for the control of lettuce downy mildew (*Bremia lactucae*)

Gengotti, S.[1], Tommasini, M.G.[2], Antoniacci, L.[3] & Bugiani, R.[4]

Key words: Copper; Downy mildew (*Bremia lactucae*); Lettuce (*Lactuca sativa*)

Abstract

*A four-year field trial was run to determine the effectiveness of copper fungicides and foliar fertilizers in controlling lettuce downy mildew (*Bremia lactucae *Regel) in Italy's Emilia-Romagna Region. The experimental design was randomized blocks with 4 replicates using the highly susceptible Camaro cultivar. Eleven different fungicide formulae and foliar fertilizers with low copper concentration were compared. Tribasic copper sulphate (Cuproxat S.D.I.), copper sulphate (Poltiglia Caffaro 20) and copper oxychloride (Pasta Caffaro Nc) exhibited the best control; the effects of pentahydrate sulphate (Kay Tee) and hydroxyde (Kocide 2000) were less consistent. Hydroxide sulphate (Poltiglia disperses), tribasic sulphate (Cuproxat liquido) and the Special Kopper were less effective. The action of the foliar dressings Kendal TE, Fertileader rame and Labicuper showed the most promising results. The only non-copper-based alternative product, grapefruit seed extract, or DF 100 V, proved to be ineffective. Some of the tested foliar sprays were thus as effective as some copper-based fungicides and released less copper into the environment.*

Introduction

Downy mildew, caused by *Bremia lactucae* Regel, is one of the major lettuce (*Lactuca sativa* L.) diseases worldwide because the fungus attacks the leaves and leads to high crop losses. The control of downy mildew in organic lettuce farming is based on both, the use of resistant varieties and preventive copper-based sprays (Crute, 1992; Malezieux *et al*., 1993). The use of resistant varieties is not sufficient *per se* to prevent *B. lactucae* infections because of the pathogen's ability to breach genetic barriers, hence the need for copper-based compounds (Gengotti, 2003). The alternative fungicides allowed under EU protocols for organic agriculture are less effective in controlling downy mildew, especially when disease pressure is high (Pertot *et al*., 2002). However, since the long-term inputs of copper may have health and environmental consequences due to soil accumulation, Commission Regulation (EC) No. 473/2002 limits the amount of copper used to 6 kg ha^{-1} $year^{-1}$. Given that further studies of low-copper fungicides are needed, our aim was to test the effectiveness of several copper-based compounds at low dressing rates, including foliar fertilizers widely used in Italy.

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Materials and methods

Tab. 1: Main trial data

	Trial 1	Trial 2	Trial 3	Trial 4
Year	2003	2004	2005	2006
Transplant date	15-Sep	22-Sep	16-Sep	15-Sep
Plot size (m^2)	12	12	14	14
No. of sprayings	7	5	7	6
Application date	25-Sept, 3, 10, 18, 25, 31-Oct, 10-Nov	6, 13, 20, 22, 26-Oct	26-Sept, 6, 12, 18, 24, 31-Oct, 9-Nov	19, 27-Sept, 4, 11, 17, 23-Oct
Spray volume (l ha^{-1})	600-1000	800-1000	1000	1000
Harvest date	20-Nov	15-Nov	16-Nov	30-Oct

Tab. 2: Tested compounds and application rates

Product	Type of copper	Copper content (g l^{-1})	Rate	
			Product (g or ml hl^{-1})	Copper (g hl^{-1})
Cuproxat S.D.I.	tribasic sulphate	195.0	350	68.25
Kay Tee	pentahydrate sulphate	60.0	150	9.00
Kocide 2000	hydroxide	35.0 %	150	52.50
Pasta Caffaro Nc	oxychloride	377.5	375	141.56
Poltiglia Caffaro 20	sulphate	20.2 %	700	141.40
Special Kopper (1)	unlisted	42.8	225	9.63
Cuproxat liquido	tribasic sulphate	195	400	78
Poltiglia disperss	hydroxide sulphate	20 %	400	80
Fertileader rame (1)	sulphate	72.0	150	10.8
Labicuper (1)	gluconate	67.8	400	27.12
Kendal TE (1)	oxychloride	23.0 %	300	69

(1) foliar dressing

The highly susceptible cv. Camaro lettuce was tested in four randomized blocks with 4 replicates at plots in Cesena, Italy, from 2003-2006; the main trial features are reported in Table 1. Table 2 shows the products tested and their formulae. Trials 3 and 4 tested also an alternative natural product based on 2% grapefruit seed extract (DF 100 V, marketed by Agritalia Ltd) at the rate of 200 ml hl^{-1}. The sprayer was a power Fox F320 knapsack with Teejet TX 8002 VS nozzles. Whenever possible, sprays were preventively applied 4-14 days after transplants at intervals of 3-10 days depending on weather conditions. The commercial crop and the percentage of infected leaves were assessed at harvest on 10-20 plants/plot and 10-15 leaves/plant. Data were transformed and processed by one-way ANOVA followed by LSD test ($p \leq 0.05$).

Results

Tab. 3: Trials 1 and 2

Treatment	Infected leaves (%)				Commercial yield (g/plant)				Cu^{++} amount (g ha^{-1})*
	Trial 1		Trial 2		Trial 1		Trial 2		
Untreated control	52.8	a	87.8	a	147.3	c	146.1	c	0
Cuproxat S.D.I.	12.0	cd	79.3	b	210.3	a	203.8	a	3554
Kay Tee	23.0	bc	77.5	b	200.1	ab	182.6	ab	469
Kocide 2000	36.5	ab	80.3	b	176.3	bc	190.0	ab	2734
Pasta Caffaro Nc	16.8	cd	77.5	b	197.8	ab	192.0	ab	7371
Poltiglia Caffaro 20	3.6	d	79.0	b	218.1	a	202.5	a	7363
Special Kopper	-	-	79.3	b	-	-	165.6	bc	430

Different letters in the same column indicate statistical differences (LSD test, $p < 0.05$).
*Amount of Cu^{++} distributed (means of Trials 1 and 2)

Tab. 4: Trials 3 and 4

Treatment	Infected leaves (%)				Commercial yield (g/plant)				Cu^{++} amount (g ha^{-1}) *
	Trial 3		Trial 4		Trial 3		Trial 4		
Untreated control	52.4	ab	79.9	ab	112.4	d	344.8	b	0
Cuproxat liquido	48.9	abc	68.3	d	117.9	cd	471.0	a	5070
Poltiglia disperss	44.7	bc	75.9	bc	136.8	ab	454.4	a	5200
Fertileader rame	45.4	abc	71.3	cd	137.2	ab	442.1	a	702
Labicuper	49.2	abc	68.1	d	131.0	abc	446.5	a	1763
Kendal TE	42.5	c	68.1	d	149.4	a	453.3	a	4485
DF 100 V	54.5	a	83.8	a	119.3	bcd	354.8	b	0

Different letters in the same column indicate statistical differences (LSD test, $p < 0.05$).
*Amount of Cu^{++} distributed (means of Trials 3 and 4)

Trial 1. While weather conditions were not conducive to pathogen outbreak, end-of-season rains made it possible to evaluate the efficacy of the products. Except for

Kocide 2000, all the compounds differed from untreated control. Poltiglia Caffaro 20, Pasta Caffaro Nc and Cuproxat S.D.I. were the most effective (Table 3).

Trial 2. The weather was very favourable for the disease. The first symptoms were observed 10 days after transplant (before the first spraying). The early outbreak may explain the generally poor effectiveness registered in this trial. All the fungicides reduced the disease to some extent compared to the control; Special Kopper was the least effective (Table 3).

Trial 3. Weather conditions were disease-favourable. The first symptoms appeared early in the season, soon after the transplant. Kendal TE provided the best protection and, along with Poltiglia disperss, Fertileader rame and Labicuper, resulted in the highest yields (Table 4).

Trial 4. Weather conditions were conducive to mildew. The overall results showed relatively poor disease control; Kendal TE, Labicuper, Cuproxat liquido and Fertileader rame proved the most effective (Table 4).

Conclusions

The tested products adequately controlled the disease in 2003, when mildew incidence was low, but proved unsatisfactory from 2004-2006 despite the high number of sprayings. These results show that pronounced disease pressure makes it extremely hard to control downy mildew infections on lettuce using only copper-based sprays, although the latter proved to be the most effective among the fungicides allowed in organic farming (Pertot *et al*., 2002). The best mildew control was provided by the fungicides Cuproxat S.D.I., Poltiglia Caffaro 20 and Pasta Caffaro Nc; effectiveness of Kocide 2000 and Kay Tee was inconsistent. The foliar dressings Kendal TE, Fertileader rame and Labicuper protected the crop as effectively as, and sometimes better than, the best copper fungicides. Except Special Kopper, the amounts of copper released by the foliar dressings were lower than those from the most effective copper-based products, *i.e*. 2317 g ha^{-1} compared to 6096 g ha^{-1} (average of all trials) (Tables 3, 4). DF 100 V, the only natural compound tested, proved to be ineffective against *B. lactucae*. Thus, the foliar sprays Kendal TE, Fertileader rame and Labicuper effectively controlled the disease with low environmental impact because of their limited copper input.

Acknowledgements

Trials carried out under a project co-ordinated by CRPV and ProBER with funding by Emilia-Romagna Region (L.R. 28/98) (Italy).

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Evaluation of natural active ingredients and agronomical techniques against flea beetle (*Phyllotreta* spp.) on open field organic garden rocket (*Eruca sativa*)

Gengotti, S.[1] & Tommasini, M.G. [2]

Key words: Crop cover, Flea beetle (*Phyllotreta* spp.), Garden rocket, Rotenone

Abstract

*Natural pesticides and crop covering proved to be effective in containing flea beetle (*Phyllotreta *spp.) in a three-year trial of open-field organic garden rocket (*Eruca sativa *Miller) in Italy's Emilia-Romagna Region. Although rotenone proved to be more effective than pyrethrins, it was still unsatisfactory. Crop cover with non-woven polypropylene sheets produced encouraging results in pest control.*

Introduction

Flea beetles of the genus *Phyllotreta* (Coleoptera: Chrysomelidae) are a serious pest of many crops in the *Brassicaceae* family, including cabbage and garden rocket (Subedi and Vaidya, 2003; Andersen et al., 2006). This plant family's variability in susceptibility to attack by the flea beetle has often made chemical pesticides the only solution (Hiiesaar *et al*., 2003; 2006). While conventional farming uses systematic or contact insecticides, the organic farmer has had little to fall back on. Garden rocket (*Eruca sativa* Miller), also known as arugula or rocket salad, is a good case in point. Its short natural growing cycle and the demand for a high-quality and residue-free crop have made it difficult to treat with chemical deterrents alone (Subedi and Vaidya, 2003). The aim of our study was to determine the effectiveness of different natural active ingredients and crop covering in controlling flea beetle in garden rocket.

Materials and methods

A three-year (2005-2007) trial was set up in randomized blocks at an organic farm at Sala di Cesenatico, Forli'-Cesena Province, Emilia-Romagna Region. The main trial features are shown in Table 1, and Table 2 displays the types and amounts of pesticides used. Besides comparing the results of natural active ingredients, Trials 1 and 2 also tested whether certain management techniques could be used for pest control instead of repeated chemical treatment. In these trials, the garden rocket was covered immediately after transplant with non-woven polypropylene sheets stretched over hoops to form tunnels. Trial 3 compared two cover techniques using non-woven polypropylene sheets: one laid the sheeting directly on top of the plants and the other stretched it over hoops to form a tunnel. A third treatment contained plants that were sprayed with Tanacide 5 times, a standard organic pesticide. *Diplotaxis tenuifolia* (L.) DC, a widely grown species commonly called wild rocket, was included as untreated random control, to compare its susceptibility to that of the untreated garden rocket.

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Each trial was carried out when field plants were 2 cm in height. Given the small size of the plants and the early onset of flea beetle in many of the trials, all plots were treated with pyrethrins (Piresan Plus) pre-trial, *i.e.* one treatment was applied before Trials 1 and 3 and three before Trial 2. The plots with non-woven polypropylene sheets were covered immediately after the last pre-trial treatment to ensure no flea beetles would be inside; samples were taken two days after removal of the sheeting. At harvest, a sample of 50-100 leaves was taken from each plot to measure the extent (% of damaged leaves) and severity (% eaten leaf or number of holes/leaf) of damage. The data were processed by analysis of variance (ANOVA) and LSD test ($P<0.05$).

Tab. 1: Main trial features

	Trial 1	Trial 2	Trial 3
Year	2005	2006	2007
Transplant date	4-Aug	4-Aug	12-Jun
Plot size (m^2)	12	12	12
Crop cover date	6-Aug	13-Aug	14-Aug
Application equipment	power knapsack sprayer ECHO SHR 150 SI		
Spray volume ($l\ ha^{-1}$)	600-1000		
Number of applications	7	5	5
Application dates	8-10-12-14-16 18-20-Aug	16-18-19 22-23-Aug	15-18-20 22-25-Jun

Tab. 2: Compound details

Compound	Active ingredient (A.i.)	A.i. content (% or $g\ l^{-1}$)	Dose		Applied in trial
			compound (g or ml hl^{-1})	A.i. (g hl^{-1})	
Diractin	azadirachtin	32	112.5	3.60	1
Piresan Plus	pyrethrins + piperonyl butoxide	150 120	100	12 + 9.6	1 and 2
Rotena 43	rotenone	43	450	193.5	2
Rotena	rotenone	62.4	275	17.16	1
Show	pyrethrins + rotenone	5 + 20	700	35 + 140	2
Tanacid	pyrethrins	36.6	100	36.3	3

Results

Trial 1. The results are shown in Table 3. The leaves of the untreated control were completely riddled by the pest, the eaten leaf area being high. The leaves of plants treated with Diractin did not differ significantly from those of the control, and the protection afforded by Piresan Plus and Rotena, though reducing leaf damage, was not very effective. Plant cover proved to be the most effective measure with slight damage being found on 54% leaves.

Trial 2. The results are shown in Table 4. As in Trial 1, control leaves showed the most, but not very severe, damage. Piresan Plus reduced hole number per leaf but not the number of damaged leaves. Rotena 43 and Show proved to be more effective than Piresan Plus. Crop cover showed significantly lower damage than all the other treatments.

Trial 3. The results are shown in Table 5. The leaves of all the non-treated controls, whether garden or wild rocket, were similarly and heavily damaged. Tanacid spraying reduced the number of holes per leaf but not the percentage of damaged leaves. Crop cover, whether in direct contact or stretched over hoops, proved the most effective means of controlling the pest.

Tab. 3: Average results of trial 1 (22 August 2005)

Treatment		Damaged leaves (%)		Eroded leaf area (%)	
1	untreated control	100	a	63.2	a
2	Diractin	100	a	62.8	a
3	Piresan Plus	98.0	a	25.5	b
4	Rotena	100	a	19.4	b
5	Cover	54.0	b	0.6	c

Different letters in the same column show statistical differences (LSD test, P<0.05)

Tab. 4: Average results of Trial 2 (25 August 2006)

Treatment		Damaged leaves (%)		Number of holes/leaf	
1	untreated control	96.8	a	6.4	a
2	Piresan Plus	71.8	ab	2.3	b
3	Rotena 43	52.0	bc	0.7	c
4	Show	37.8	c	0.4	c
5	Cover	8.8	d	0.0	c

Different letters in the same column show statistical differences (LSD test, P<0.05)

Tab. 5: Average results of Trial 3 (29 June 2007)

Treatment		Damaged leaves (%)		Number of holes/leaf	
1	untreated control (wild rocket)	100	a	144.0	a
2	untreated control (garden rocket)	100	a	131.5	a
3	cover on hoops (garden rocket)	29.0	b	0.2	c
4	cover directly on crop (garden rocket)	30.0	b	0.5	c
5	Tanacid (garden rocket)	100	a	63.0	b

Different letters in the same column show statistical differences (LSD test, P<0.05)

Discussion

Despite the high number of sprayings and the short interval between them the chemicals never provided adequate protection over the three trial years. While our findings appear to be in contrast with those reported by Hiiesaar *et al*. (2003), who tested synthetic, not natural compounds, they are in line with those reported by Andersen *et al*. (2006), who tested the natural azadirachtin on *Brassica rapa* L. It is worth reiterating that Piresan Plus, Rotena, Rotena 43 and Show did reduce, albeit slightly, damage severity, the latter three showing the best results. By contrast, the most effective pest control agent proved to be the row cover, whether laid directly on or stretched over the crop, as also reported by Andersen *et al*. (2006). It is worth noting that the poor scores registered by the natural pesticides may in part be attributed to the small size of the test plots and the pronounced mobility of the flea beetle. Further tests are needed to clarify this point. Note too that both rocket species used in the trials are highly susceptible to flea beetle attack.

Conclusions

No natural pesticide tested proved as effective in controlling flea beetle as non-woven sheeting. Placing the sheeting directly on the crop is obviously more practical than stretching it on hoops to form a tunnel. While removing the cover a couple of days before harvest prevented mechanical damage to leaves, questions remain with regard to both cover-induced alterations in crop flavour traits and economics. Further tests are thus required to address these questions so as to upgrade cover use in organic farming.

Acknowledgements

Activity carried out within the project co-ordinated by CRPV (I) in collaboration with ProBER, funded by Emilia-Romagna Region (L.R. 28/98).

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The use of copper seed treatments to control potato late blight in organic farming

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Key words: *Phytophthora infestans*, primary infections, stem blight, Öko-Simphyt

Abstract

In organic farming, potato late blight still is an unsolved problem. Up to now copper fungicides have been the most effective way to control this disease. In order to postpone the beginning of the blight epidemic, as well as the start of spraying, primary stem infections (stem blight) should be reduced by copper seed treatment. In field trials, copper fungicide treatments not only reduced stem blight and the spreading of the pathogen from infected seed tubers, but also decreased the number of infected daughter tubers.

Introduction

Potato late blight caused by the oomycete *Phytophthora infestans* is one of the most important yield-limiting factors in organic potato farming. In most countries the pathogen is controlled by the protective application of copper fungicides. However, the use of copper in Germany is limited to 3kg/ha throughout a growing season. While secondary infections of the leaves can be prevented by the protective application of copper, primary infections (stem blight) can not be prevented. Secondary infections are caused by sporangia blown in from inoculum sources outside the field. Possible sources, especially after a mild winter, are volunteers and/or infected cull piles (HOFFMANN and SCHMUTTERER, 1999). However, the main inoculum source is latent infected tubers in storage (ANDRIVON, 1997). Favourable conditions during storage prevent these tubers from showing symptoms or rotting (ADLER, 2000). The infection remains undetected, and the infected tubers are used as seed tubers, bringing the inoculum direct into the field. The resulting primary infections from this latent infected seed tubers cause an early start of an epidemic. Under favourable conditions (20 mm rain, high soil moisture) the pathogen is able to extend its growth to the stem of the infected tuber, causing stem blight (ZELLNER, 2006). This takes place either by direct intercellular growth from the tuber into the stem (ADLER, 2000; APPEL et al., 2001), or by reinfection of the stem after sporulation on the surface of the tuber. The produced sporangia are also spread via soil water to neighbouring plants (BAIN and MÖLLER, 1998), causing stem blight on them as well. This way of infection cannot be prevented by the foliar application of copper. As a new approach, seed treatments with low volumes of copper should prevent healthy tubers from being infected by inoculum in the soil and also directly inhibit latent infected tubers from producing sporangia (BENKER et al., 2006). In conventional farming the use of fungicide seed treatments can postpone primary infections for 8-20 days and slow down the course of the blight epidemic (BÄßLER et al., 2002). In this project these promising findings will be transferred to organic farming by the application of copper seed treatments within the project Öko-Simphyt.

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Materials and methods

Field trials where conducted in 2005 –2007 at two sites in Bavaria on heavy and light soils. To ensure the appearance of primary stem infections (stem blight), seed tubers were artificially inoculated by injection of zoospores of *P. infestans*. In accordance with the aim of the experiments, the tubers were treated with copper fungicides (copper hydroxide, trade name: Cuprozin flüssig; 120g Cu/ha) before planting.

In one approach the transmission of infections from seed tubers to their daughter tubers was tested with artificially infected (50 zoospores) tubers of the variety Agria. A copper seed treatment should reduce the number of infected daughter tubers by preventing the pathogen from spreading from the infected seed tuber. A sample of more than 45 daughter tubers per approach was analysed for tuber blight by PCR (JUDELSON and TOOLEY, 2000).

In the second approach two seed tubers were planted close to each other. One of them (variety Quarta) was inoculated with 200 zoospores and the other one (variety Agria) remained healthy. Copper seed treatment was applied either to the infected tuber or the healthy one. For control both tubers remained untreated. After emergence the frequency of stem blight was measured weekly and confirmed by PCR detection. In this way the effect of the copper seed treatment on the spreading of inoculum from diseased to healthy plants was tested.

Results

When a copper seed treatment was applied, less than 5% of the corresponding daughter tubers were infected. That is a significant difference ($p<0.05$) compared with untreated seed tubers, which had an average of 72% infected daughter tubers.

In the second approach infected seed tubers of the variety Quarta were able to infect the neighbouring plants (Agria) with a frequency of 45%, if neither of the tubers was treated with copper. A copper seed treatment of the latent infected tubers slightly prevented the pathogen from spreading, reducing the frequency of stem blight to 35% on the adjacent plants. The best effect was achieved by a treatment of the healthy Agria seed tubers with copper. This significantly protected them from being infected by released sporangia (25% frequency of stem blight).

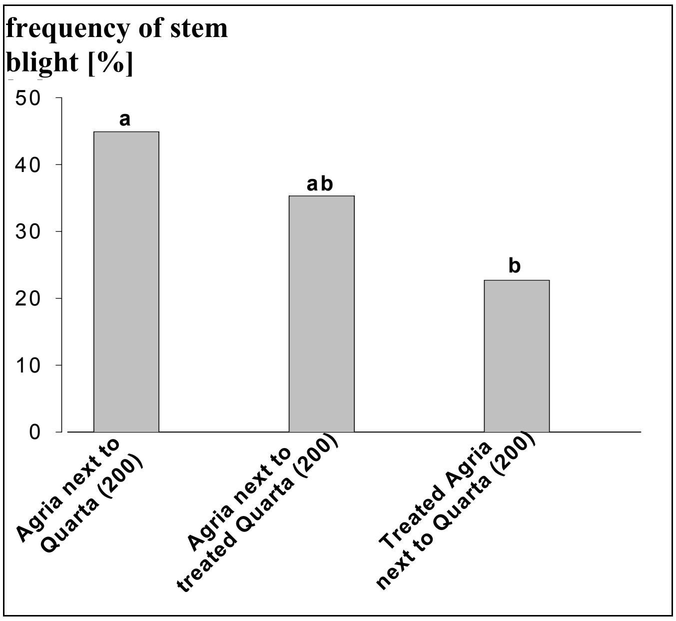

Figure 1: Effect of copper seed treatment (120g Cu/ha) on stem blight; different letters indicate significant ($p<0.05$) differences; variety Quarta was artificially inoculated with 200 zoospores.

Discussion

Primary infections caused by latent infected seed tubers cannot be prevented by crop rotation, since the inoculum is brought into the field by the farmer. The findings show that copper seed treatments are a promising way of reducing stem blight and the spread of the disease. Since the dosage of the copper used to cover the seed tubers is as low as 48g/t (120g/ha), this way of protecting the plants can be deployed in addition to the normal sprayings without exceeding the maximum allowed amount of copper.

Conclusions

Copper seed treatments reduce primary stem infections (stem blight) and decrease the spread of inoculum to neighbouring plants. Thus an early outbreak of the epidemic can be prevented. Also the number of infected daughter tubers is reduced.

Acknowledgments

This project was funded by the Federal Agency for Agriculture and Food (BLE) within the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) under the Federal Organic Farming Scheme (BÖL)

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Efficacy of biological insecticides to control the Colorado potato beetle (*Leptinotasara decemlineata*) in organic farming

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Key words: Plant protection, insecticides, Colorado potato beetle, forecast model

Abstract

The Colorado potato beetle (Leptinotasara decemlineata Say) is one of the most important pests on potatoes (Solanum tuberosum). In the present study, we compared the efficacy of three biological insecticides – Neem (NeemAzal-T/S), pyrethrum/rapeseed oil (Spruzit Neu) and Bacillus thuringiensis var. tenebrionis (Novodor FC) – against this pest in field trials conducted from 2005 to 2007. The combined and temporarily shifted application of neem and B.t.t. reduced significantly the number of beetle larvae and the percentage of defoliation due to larval feeding, and increased the potato yield considerably. The SIMLEP3 forecasting model is useful for determining the optimal timing of the treatment. Pyrethrum/rapeseed oil did not lead to a significant reduction of Colorado potato beetle larvae.

Introduction

The Colorado potato beetle (*Leptinotarsa decemlineata* Say) is one of the most important pests on potatoes. In organic agriculture, the application of insecticides of biological and mineral origin is accepted as a last option to control pests only after all other preventive methods have failed. The selection of early-maturing varieties and creating conditions to make them emerge quickly ensure the yield development to occur earlier than the infestation by the beetle. Other preventive steps to be taken are both avoiding volunteers to emerge and selecting fields, neighbouring areas of which had seen potato cropping in the previous year, as the pest always spreads from there. (Kühne et al. 2006). Considering crop rotation, the cultivation of potato in immediately neighbouring fields may be regarded as a monoculture for the Colorado potato beetle. In many areas, preventive measures do not appear to be sufficient to avoid damage caused by the Colorado potato beetle.

Materials and Methods

The insecticides approved for potato beetle control in organic farming were comparatively tested from 2005 to 2007 on a test site of the Federal Biological Research Centre for Agriculture and Forestry (BBA) in Dahnsdorf (Brandenburg), Germany. The test site was certified for organic farming according to EU guidelines (control no.: D-BB-043-4143 A; soil type: sandy loess sL, mean annual precipitation: 526 mm). Relevant experience data were available for the neem-based product "NeemAzal-T/S" and for the *Bacillus thuringiensis* var. *tenebrionis* (*B.t.t.*)-based

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product “Novodor FC” (Zehnder et. al. 2007); however, this was the first time that the efficacy of the pyrethrum/rapeseed oil-based product "Spruzit Neu” was investigated in the context of an organic potato farming comparative study. These efficacy studies were performed in accordance with the specifications in EPPO guideline PP 1/12 (3) (see also www.bba.de/eppo/i_12.pdf). The trials were conducted as a randomised, single-factor experiment with block design and four repetitions. Seven treatments were investigated in 2006 (plot size: 6 m x 17 m per treatment), and three treatments in 2005 and 2007 (plot size: 6 m x 34 m per treatment) (Table 1). They were compared with an untreated control every year. Both the number of potato beetles and the percentage of defoliation due to feeding damage (defoliaton index, Boiteau 1994) were determined at weekly intervals on the same ten randomly-selected and marked potato plants per treatment variant. Since the larvae may be counted on the plants for a comparatively long period of time following the application of Neem, the calculation of its efficacy was performed according to the defoliation index by the Abbott-formula: degree of effectiveness = (X – Y) / X x 100 with X = value of the control and Y = value of the test item. For timing the treatment, the SIMLEP3 forecast model was used in 2006 and 2007 to determine the maximum number of young larvae, thus finding the optimum time of pesticide application. The SIMLEP3 model uses a temperature-sum method to calculate the population dynamics of the potato beetle (Roßberg 1999). The date of first egg-laying in the field and weather data from the nearest weather station were used as input parameters for the model calculations. The respective insecticide treatments were conducted under optimal weather conditions, i.e. with no direct sunlight, wind speed < 1 m/s, and temperature < 20 °C. Pyrethrum was applied with 1000 l/ha of water. Neem and *B.t.t.* were mixed with 400 l/ha and 500 l/ha of water. In 2006, the potato blight (*Phytophthora infestans*) was controlled by a five-time application of copper-products (CUPROZIN flüssig, 750 g copper per application) throughout all treatments.

Results

The results of the field counts made on the respective scoring days were in harmony with the forecast model calculations; the insecticide treatments were therefore performed within the predicted time frame.

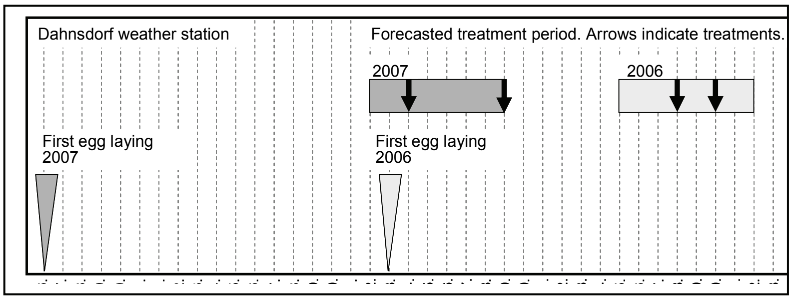

Figure 1: Results achieved with the SIMLEP3 forecast model in terms of predicting the optimal time of treatment for the two years of the trial.

In 2007, treatment was necessary two weeks earlier than in 2006 and 2005. The average number of larvae per plant before treatment were 49 in 2005, 17 in 2006, and 38 in 2007 (n=160). Table 1 shows the treatments for the applications of the plant protection products used to control potato beetles between 2005 and 2007. In addition to that, the degree of effectiveness related to the reduction of leaf consumption (24 days after treatment) and the increase in yield in dt/ha compared with the untreated control are stated.

Tab. 1: Treatments for application of the plant protection products used to control potato beetles between 2005 to 2007, degree of effectiveness in % regarding defoliation 25 days after treatment and increment (dt/ha) in comparison to untreated control. * Significant relates to untreated control (Tukey's test; P<0.05)

year of exp.	First trt	Product (L)/ha	Second trt	Product (L)/ha	Timing of second trt	Degree of effectiv-eness %	increment to untreated control dt/ha
2005	Pyreth.	8	None	None	None	9	16
2006	Pyreth.	8	Pyreth.	8	+12dd	16	17
2005	B.t.t.	5	None	None	None	30	25
2006	B.t.t.	5	None	None	None	45	17
2006	B.t.t.	5	Pyreth.	8	+2dd	43	9
2005	Neem	2.5	None	None	None	44*	54*
2006	Neem	2.5	None	None	None	57*	19
2006	Neem	2.5	Pyreth.	8	+2dd	71	0
2006	Neem	1.5	B.t.t.	5	+2dd	80*	42*
2007	Neem	2.5	B.t.t.	5	+5dd	87*	62*
2007	Neem	2.5	B.t.t.	3	+5dd	82*	70*
2006	Neem	2.5	B.t.t.	1,7	Tank mix with first trt	77*	18
2007	Neem	2.5	B.t.t.	1,7	Tank mix with first trt	68*	16*

The control results with Pyrethrum were unsatisfactory throughout the entire period. Feeding damage rates were high, and even a second insecticide treatment in 2006 could not improve the result essentially. A single *B.t.t.*-treatment was also unsatisfactory and could not increase the yield significantly in terms of statistics. Only one single neem treatment could increase both the degree of effectiveness and the yield significantly. The best potato beetle control results were achieved when using the combination of Neem + *B.t.t.*. In 2007, the degree of effectiveness was increased to 87 % by raising the dose of *B.t.t.* and prolonging the time between treatments in comparison to the tank mix.

Discussion

The explanation for the advantageous effects of neem and *B.t.t.* when combined to control the potato beetle lies in the different mechanisms of action of the two substances. Neem must be consumed by the potato beetle larvae over a long period of time in order to develop its inhibitory effect on moulting whereas *B.t.t. (Bacillus thuringiensis var. tenebrionis*) is a bacteriotoxin that rapidly leads to the cessation of feeding following ingestion. It is also much cheaper than neem. For this reason, the two insecticides should be applied at different times using a temporal displacement strategy with neem always being applied first. When applied 5 days apart, neem has time to weaken the larvae so that the bacteriotoxin *B.t.t.* can kill them faster with the effect that larvae that hatch later will also be killed. Since these biological insecticides remain active for only a few days after application, optimal timing of their application is of utmost importance. The SIMLEP3 forecast model proved to be suitable for this task as the scoring data collecting in the field showed excellent correlation with the forecasts calculated according to the simulation model. The pyrethrum-rapeseed oil-based product (Spruzit Neu) did not exhibit potato beetle control satisfactorily, not even after repeated application. In light of the reports of resistance development to pyrethroid insecticides, the limited efficacy of this plant protection product can presumably be attributed to reduced sensitivity of the Colorado potato beetle population (Nauen 2005).

Conclusions

In many areas, preventive strategies do not suffice to prevent potato beetle damage (Reelfs et al. 2007). In this event, insecticides may and should be used to prevent economic losses—even in organic farming. The SIMLEP3 forecasting model can be used to determine the optimal timing of treatment. The combination of neem (NeemAzal-T/S) + *B.t.t.* (Novodor FC) achieved good control of young larvae. The two insecticides should ideally be applied in a temporally displaced manner; neem should be applied first, followed by *B.t.t.*. At the same time, this dual strategy minimises the risk of the development of resistance to the insecticides.

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Effects of *Trichoderma harzianum* applications on fresh pruning wounds in *Actinidia deliciosa* for the protection against pathogens associated with the "wood decay" of kiwifruit

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Key words: kiwifruit, "wood decay", pruning, *Trichoderma harzianum*

Abstract

A chronic wood wasting disease of kiwifruit (Actinidia deliciosa) has recently been identified in Italian kiwifruit vineyards. This disease is principally caused by Phaeoacremonium aleophilum and Fomitiporia mediterranea. The "wood decay" causes a reduced productivity and longevity in the vineyards and influences the quality of the final product. "Wood decay" has a high incidence throughout the vineyards, and is difficult to eradicate once present, leaving prevention as the best defence strategy. The different pathogens causing the disease infect the plant mainly through pruning wounds. We studied a commercial formulation of Trichoderma harzianum T22 for the protection of pruning wounds, and thus for the prevention and reduction of the infection. The studies were carried out on potted plants, on shoots of the year that were cut, simulating a summer pruning, and treated with a T. harzianum commercial suspension. A different morphologic reaction was observed on treated and control shoots; physiological processes connected to the reaction, such as the variation in the levels of a growth-promoting hormone (auxin) and the content of total phenols were investigated through biochemical and histological analyses. The higher levels of auxin and phenols recorded in treated shoots suggested a stimulation of T. harzianum on the wound healing processes.

Introduction

A chronic wood wasting disease of kiwifruit (*Actinidia deliciosa*) has recently been identified in Italian kiwifruit vineyards. Principally caused by *Phaeoacremonium aleophilum* and *Fomitiporia mediterranea,* it has been named "wood decay" (Di Marco *et al*., 2000). The disease was also described in different forms in Greece and France, and affects the quality of the final product, as well as reducing the productivity and longevity of the vineyards. Wood decay is a form of wood deterioration similar to "esca" as found in grapevines, identifiable on the trunks and cordons of infected plants by wide decayed areas with a spongy texture, together with dark and hard necrotic streaks. The disease is caused by different fungi, particularly *Phaeoacremonium aleophilum* and *Fomitiporia mediterranea*, pathogens already associated with grapevine esca (Crous *et al.*,1996; Di Marco *et al.*, 2004; Di Marco and Osti, 2008). The decay starts from pruning wounds, the main portal for pathogens infection (Di Marco *et al.*, 2004). Spores deposit on the wound surface and can diffuse through the open vascular system; wounds remain susceptible to infection for several time, up to 4 months in grapevine (Eskalen *et al.*, 2007), and susceptibility varies according to the pathogen involved and the pruning season (Van Niekerk *et al.*, 2007; Serra *et al.*,

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2007); spraying pruning wounds with products providing long-term protection of xylem and pith tissue is thus recommended as a preventive control measure.

Trichoderma spp. is a well known biocontrol fungal agent. The aim of this study was to test the effect of commercial *Trichoderma harzianum* on the healing process of summer pruning wounds in kiwifruit plants (*Actinidia deliciosa*), by applications to the foliar apparatus. We also investigated the influence of *T. harzianum* on different physiological processes such as the concentration of the auxin indole-3-acetic acid (IAA), a plant growth regulator that enhanced callus formation, and the production of total phenols, compounds involved in plant defence against pathogens.

Materials and methods

The analyses were carried out on kiwifruit potted plants, grown in an open frame. Shoots of the year were pruned during the month of July, and the wounds were immediately treated by nebulization either with a commercial formulate of *T. harzianum* T22 (Rootshield®) at 0.5 g l^{-1} or with water alone (control). The wound closing process was observed on plant, on treated and control shoots, for up to 3 months after pruning. Additionally, the wound closing process was monitored at different times after pruning (6 hours, 2, 4, 8 and 11 days) by sectioning the shoots longitudinally and observing them under a stereo microscope. The quantification of total phenols and starch was carried out through histological analyses on shoot sections pruned and treated with *T. harzianum* and on control shoots. The sections were included in GMA resin (O'Brien and McCully, 1981), stained with PAS and toluidine blue, and analysed under a light microscope. Identification and quantification of indole-3-acetic acid were performed on the shoot sections adjacent to the wound collected at different times after pruning (0, 6, 24, 48 and 192 hours). The IAA concentrations in the tissues were analysed by GC-MS according to Baraldi *et al.* (1988). Re-isolations of *T. harzianum* were carried out placing pruned shoot fragments on PDA, 9 months after inoculation. All the investigations were carried out on 3 plants for each treatment. Means and standard errors are presented.

Results

From in vivo observations, the healing callus on the treated shoots was more developed and organized than in the control ones, on which callus was either not present or not well developed up to 3 months after pruning. Microscope observations on control shoots showed the formation of a lignified layer of closure 11 days after pruning, while in treated shoots lignification was already visible 8 days after pruning and was preceded by the formation of a wide necrotic area and of a lateral callus, both of which were absent in the control.

The histological analyses highlighted a higher accumulation of phenols in treated shoots than in control shoots. This phenomenon was particularly prevalent in the phloem, where it was usually accompanied by the presence of an organized closing callus. Conversely, the presence of starch was higher in the phloem of control than treated shoots (data not shown).

The variation of auxin levels in the tissues adjacent to the wound was followed in treated and control shoots (Table 1). While in treated shoots free IAA concentrations remained substantially unchanged, ranging from 47.5 to 35.8 ng g^{-1} FW, in control shoots a decrease in hormone levels occurred from the first day after pruning. In fact, at 24 and 48 hours IAA concentrations were 26.3 and 25.5 ng g^{-1} FW, respectively, while at 192 hours the concentration raised again, reaching a value similar to the initial one (31.1 ng g^{-1} FW).

Re-isolation of *T. harzianum* from the cortex of treated plants 9 months after treatment was successful.

Tab. 1: IAA concentration (ng^{-1} fresh weight) in control and pruned shoots treated with *T. harzianum* at different times after pruning.

	Time of collection (hours)				
	0	6	24	48	192
Control	47.5 ± 9.0	33.8±13.4	26.3± 0.6	25.5	31.1±7.9
Treated	47.5 ± 9.0	35.8±13.0	42.1±13.6	43.6±3.6	43.9±17.0

Values are means ± standard error (SE)

Discussion

The treatment with *Trichoderma harzianum* accelerated the closing processes of summer pruning wounds by speeding up the formation of a lignified layer of closure; moreover, the presence of a wide necrotic area, a possible obstruction to the entrance of the pathogens, suggested a more pronounced reaction by the treated plants. The hypothesis of an effect of *T. harzianum* on plant defence mechanisms was also supported by the stimulation of an extended closing callus.

The hypothesis of a stimulation of the plant defence reactions by *T. harzianum* was also reinforced by the observed fast and high accumulation of total phenols in the phloem tissue adjacent to the wound, together with a more organized callus and reduced starch levels. It is well known that wound-related defence responses include synthesis and accumulation of phenols to reinforce the cell wall and act as anti-microbic compounds (Moriondo, 1999). The energy required for defence responses is usually obtained by the degradation of carbohydrate reserves such as starch. In the present study, the treated shoots were subjected to stresses caused both by wounding and by interaction with *Trichoderma*. The faster defence reaction recorded on treated shoots could be interpreted as a response to this “double stimulus”. In other studies, *T. harzianum* T22 was reported to act as an elicitor on the plant, through the production of proteins such as Hytra1 (Ruocco *et al.*, 2007).

The pattern of auxin evolution suggested the hypothesis of an involvement of *Trichoderma* in the signalling pathway that finally lead to wound closing and cicatrisation; the constant levels of free IAA measured in treated shoots in fact indicated a possible way of behaviour on the part of the fungus, which protected the biological active form of this hormone from the oxidative degradation normally occurring in wounded tissues. The persisting activity of this hormone could lead to a faster wound closing and to the production, via cell division and elongation, of the more developed callus that was visible on treated shoots.

Finally, *T. harzianum* survived for up to 9 months on treated plants. The prolonged activity of *T. harzianum* on the plant is very important because wounds remain susceptible to pathogens attack for several months (Eskalen *et al.*, 2007). Further trials are underway in order to assess the viability and persistence of this biocontrol agent at lower temperatures than the ones recorded during the winter season 2006-2007.

Conclusions

Trichoderma harzianum, sprayed on summer pruning wounds, appeared to contribute to the physiological processes of wound healing, by accelerating callus formation and influencing the accumulation of total defence phenols, with a concurrent decrease in starch content. This role was supported by the concentrations of auxin, a plant growth regulator involved in the formation of closing callus, whose levels remained higher in treated shoots compared to the control. Further studies focused on the activity of *Trichoderma* towards wood decay associated pathogens, both under greenhouse and field conditions, are ongoing at the moment.

Acknowledgments

The research was carried out within the project co-ordinated by CRPV (Vegetal Production Research Center) and funded by Emilia-Romagna Region (L.R. 28/98). Authors thank Dr. Annalisa Rotondi for her help in the development of histological techniques.

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Weed Control in Organic Onion

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Key words: onion, weed control, flaming, transplanting.

Abstract

Weed control is a major management concern in extensive plantings of organic vegetables. We tested organic onion under conventional sowing with mechanical and flaming weed control against transplants. The parameters logged included weed number and species and bulb yield, size and storability. We found fewer weeds and higher yields in the transplanted than in the sown treatments.

Introduction

Weeding is a chief management priority in extensive plots of organically grown vegetables, and the results are seldom comparable to chemical sprays (Casini P, 1994). In effect, it is often the case that field practices like rotation and planting date are more effective than direct control techniques (Barberi P. Frondoni U., 1999). Complicating matters is the fact onion has a low market profile and even relatively effective approaches like flaming can often be too expensive for small-to-mid-sized farms and are not always as selective as possible (Dal Re L., Innocenti A., 2001). We thus tested the viability of two organic approaches by comparing a traditionally sown crop managed under both mechanical control and flaming and a transplant crop (Leskovar D. et al, 2004; Koller M. et al, 2005).

Materials and methods

The trials were run from 2002-2005 at an organic farm in Parma Province of northern Italy's Emilia Romagna Region. The experimental layout consisted of randomised blocks with four replicates. The collected data were processed by analysis of variance and the means separated by Scott-Knott test. Three treatments were tested in 2002: (I) T1 - 76 plants/m² sown under flaming and mechanical control; (II) T2 - 76 p/m ² sown under mechanical control; and (III) T3 - 3 plants/plot, or 57 p/m², under mechanical control. Over the next three years (2003-2005), in addition to the above trial, a new one tested plant density per bulb bed to determine if overhead costs could be reduced and yield increased. The treatments consisted of: (I) T1 - 76 p/m² sown under flaming and mechanical control; (II) T2 - 76 p/m² sown under mechanical control; (III) T3 - 3 plants/plot, or 57 p/m², transplanted under mechanical control; (IV) T4 – 2 p/plot, or 38 p/m², transplanted under mechanical control; and (V) T5 - 4 p/plot, or 76 p/m², under mechanical control. The onion crop in all four trial years followed a wheat crop of cvs. Density in 2002 and Densidor in the subsequent years in rotation. Just prior to sowing and transplant the soil was always thoroughly turned over and tilled to eliminate clods and debris. The units employed for machine weeding were an inter-row adjustable Kress cultivator, which can be fitted with hoe blades or used as

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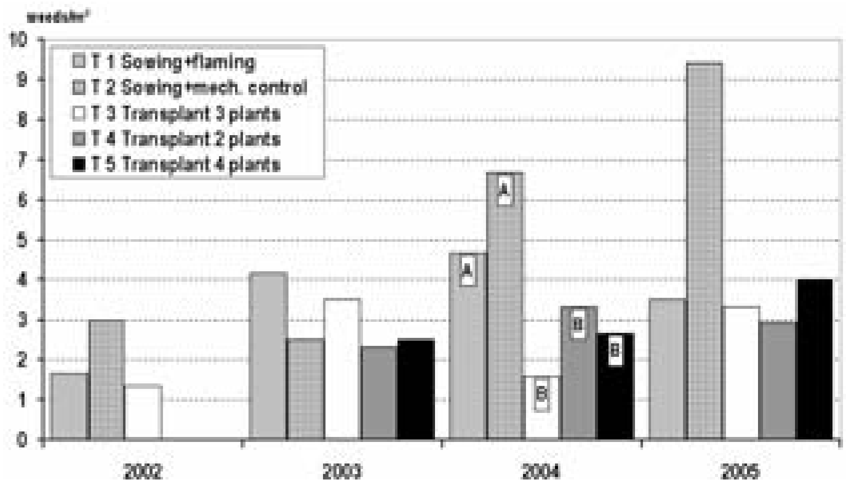
ridger or weeder with rotating tines depending on need, a tool-bar-mounted PTR 1600 flamer made by the Rovigo-based Tecnoecologica company and a tool-bar-mounted Lely harrower with 7-mm tines; the tool-bar-mounted Ferrari transplanter was manufactured by the Guidizzolo firm based in Mantua Province. Inter-row spacing in all treatments was 33 cm so as to be compatible with the cultivator units; intra-row spacing varied depending on unit since the transplanter could not go below 16-17 cm between plants. Treatments T1 and T2 were directly sown in week three-four of March with enough seed for 76 plants/m², or an intra-row spacing of 4 cm, which is the norm in conventional onion plots. Treatments T3, T4 and T5 were seeded at the same time in trays for subsequent transplanting, which took place about a month after direct sowing except in 2003, when the date was 9 May. Flaming of treatment T2 was carried out just before bolting so as to kill most of the emerging and germinating weeds without damaging the crop. Cultivator weeding and hoeing began at the 2-leaf stage for the sown and at leaf 4-5 for the transplant treatments. The cultivator was also used at leaf 2-3 in 2002. The average number of weeding runs was 4-5 for the sown plots and 2-3 for the transplanted ones. The parameters logged were the number and type of weed and bulb yield, size and storability.

Figure 1: Residual weeds at harvest (no./m²). Significant at $P<0.05$. The same class is marked by the same letter.



Results and discussion

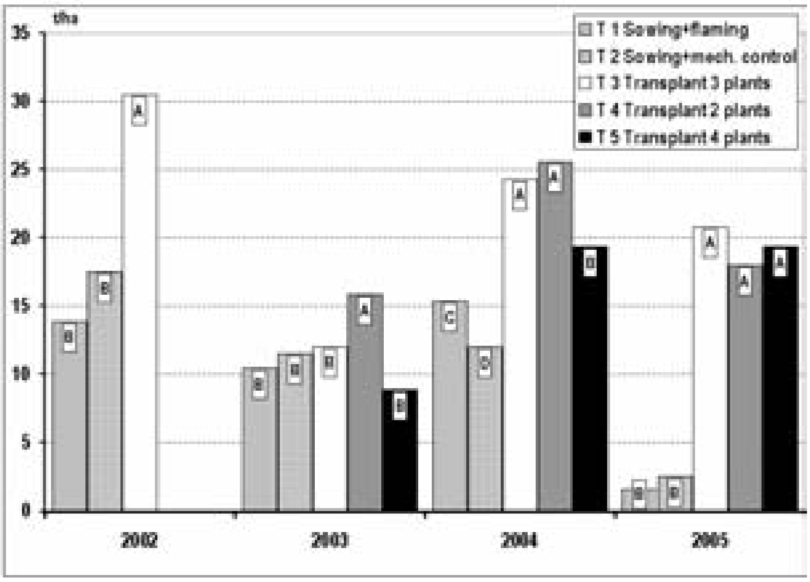
Only a limited number of weeds were found at the beginning of post-emergence operations in all trial years except 2003. The most frequently occurring species were *Amaranthus spp., Capsella bursa pastoris, Fallopia convolvolus, Polygonum aviculare, Polygonum persicaria, Portulaca oleracea, Solanum nigrum* and *Veronica persica*. Flaming proved particularly effective against all weeds except *Alopecurus myusuroides*. Indeed, the number detected in these plots just prior to initial weeding was comparable to that in the transplants and noticeably lower than that in the as yet unweeded sown treatment T1.

The mechanical units effectively controlled inter-row weeds in post-emergence, the only exception being 2003 when high temperatures and drought conditions compacted the soil to such an extent that weeder tines and blades broke and removal operations were severely hampered. By contrast, the effectiveness of cultivator units on intra-row weeds was all but nil.

Figure 2: Marketable crop (MT/ha). Significant at P<0.05. The same yield class is marked by the same letter

Almost all the weeds left at the end of the crop cycle were in the intrarow area and, though not numerous, were of notably large size. The transplant treatments had fewer and smaller weeds than the sown ones, although the difference was significant only in 2004 (Fig. 1). Neither mechanical weeding nor flaming caused crop damage. There was, though, a particularly evident drop in post-bolting bulb number in the sown treatments in 2002 and 2005 because of *Pythium spp*. infections.

Yields were lower on average than the usual 30 MT/ha for onion grown under conventional or integrated management regimes. Treatments with 2-3 transplants per bed registered the highest marketable yields, i.e. bigger than 40 mm, over the four trial



years and, in some case, even higher than under conventional management (Fig. 2). The sown treatments, by contrast, always had lower marketable yields and the T5 treatments with 4-5 transplants per bed had uneven yields. Bulb size in the plots of T5 and in those of the treatments with 2-3 transplants per bed were respectively 30% and 16% smaller. No differences were found in rot affected crop, very little, and post-harvest storability.

Conclusions

Our overall findings show that while cultivator units provided satisfactory inter-row weed control, their intra-row control was decidedly poor even with very small weeds, thus underscoring yet again how difficult weed control is in onion using only mechanical means. Weeds of notable size exerted a marked competitive effect even when their number was relatively low. The treatment with 2/3 transplants per bed showed the best results: (i) it allows more time for pre-planting soil tilling and the use of dummy-seed beds if needed; (ii) its later planting date with respect to direct sowing means weeds have less time to sprout and grow; (iii) it makes possible mechanical control shortly after transplant when weeds are smaller, thus resulting in better removal rates; (iv) it enables a plant number comparable to that planned under direct sowing, where the use of chemically uncoated seed, which is obligatory for organic growers, often falls short of the objective; and (v) it delivers yields very close to those of conventionally grown crop in terms of bulb number, size and storability.

Acknowledgments

Activity carried out within project co-ordinated by CRPV (Vegetal Production Research Center, Italy) in collaboration with ProBER (Organic Producers of E. R.), funded by Emilia-Romagna Region (L.R. 28/98).

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The use of organic certified compost to control soilborne diseases caused by *Phytophthora* spp.

Pugliese, M.[1], Gullino, M.L.[2] & Garibaldi, A.[3]

Key words: wastes, suppressiveness, soil biodiversity, *Phytophthora nicotianae, Trichoderma* spp.

Abstract

Soilborne pathogens can cause serious damages to economically important crops. Control of these diseases has traditionally depended upon rotations and soil quality improvement strategies. Compost has shown a suppressive activity against soilborne pathogens, and its use may decrease the severity of root rot diseases, optimize waste recycling and increase yields in organic farming. An organic certified compost produced from biowaste, green and yard wastes in a composting plant in the North-West of Italy, has been analysed for its suppressiveness against Phytophthora disease. The organic certified compost has been compared with a conventional compost produced in the same composting plant and with a peat substrate. In the first group of trials, composts maturity and quality have been estimated using Wood's End Lab's "Solvita" Compost Maturity Test Kit, and germination and plant grown bioassays. In a second group of trials, the organic certified compost, has been assessed for its suppressive activity in greenhouse against Phytophthora nicotianae on tomato and Phytophthora capsici on zucchini. In a third group of trials, compost was used alone or enriched with microorganism of the fungal genus Trichoderma and the suppressiveness in open field towards Phytophthora capsici on pepper has been evaluated. Organic certified compost quality was comparable to peat quality. Organic certified compost showed to have a disease suppressive activity in greenhouse, compared to peat amendment, against Phytophthora spp.. The disease suppresiveness of certified compost reached 76% in the case of tomato. The results were not confirmed in open field, even when compost was enriched with Trichoderma spp.

Introduction

Organic farmers use on-farm resources whenever possible to increase organic matter in soil and to manage soil fertility, through the use of compost, cover crops and crop rotations. Some composts have been found to be suppressive against several soil-borne pathogens in various cropping systems (Noble and Coventry, 2005). The use of compost as a peat substitute to control root pathogens in Italy was first suggested in 1988 (Garibaldi, 1988). An increase of some diseases due to compost usage has also been demonstrated, since compost is a product that varies considerably in chemical, physical and biotic composition, and, consequently, also in ability to suppress soilborne diseases (Termorshuizen *et al.,* 2006). The level and reproducibility of

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[3] As Above

suppressive properties of compost can be increased upon antagonist enrichment (Postma *et al.,* 2006).

In the present study, a certified organic compost has been analysed for its suppressive activity against soil-borne diseases and compared to a not certified compost and to peat.

Materials and methods

The composting plant "ACEA Pinerolese S.p.A." located in Pinerolo, near Torino (Italy), was selected, according to previous trials (Pugliese *et al.,* 2007), for producing high suppressive compost. One organic certified compost and one not certified compost produced by the composting plant in three different periods (autumn, spring and summer) were selected for experiments. Organic certified compost was produced according to EC Reg. 2092/91 from biowaste, green and yard wastes, while non certified compost was produced from sludge obtained from urban waste water treatment, organic domestic waste and green waste.

Compost maturity was estimated using Wood's End Lab's "Solvita" Compost Maturity Test Kit, which estimates maturity based on respiration rate. Germination and plant growth bioassays were used to test the quality of composts, according to Warman, 1999. The germination index (Gi) was calculated according to the formula Gi = G/G0 x L/L0 x 100, where G0 and L0 are respectively the germination percentage and radicle growth of the 100% H2O control. For the plant growth assays, compost was mixed with sphagnum peat at 20, 40 and 100% v/v. Sphagnum peat was also used as control medium and the potting mixes were sowed with 100 seeds of *Lepidium sativum.* The plant growth index (Pi) was calculated according to the formula Pi = (PSc/PSp) x 100, where PSc is the average dry weight of plants grown on compost-amended potting mixes, while PSp is the average dry weight of plants grown on peat. The global plant growth index (Pi) was the Pi average of the 20, 40 and 100% mixes treatments.

A second run of trials was carried out in greenhouse to test the suppressiveness of composts. A randomized block design was used. All assays were repeated at least twice. Five pots of 1 l of volume were prepared for each treatment and 7 seeds of tomato were sown in each pot. Seven days before sowing, pots were inoculated with *Phytophthora nicotianae*, previously propagated in flasks on wheat plus hemp and added to the pots at 2 g/l of mycelium plus substrate. Other pots were also prepared and 5 seeds of zucchini (*Cucurbita pepo*) were sown in each. Seven days before sowing, pots were inoculated with *Phytophthora capsici* at 2 g/l dosage. A sphagnum peat amendment was used as control mean. The disease levels were related to that of the peat control in order to be able to compare suppression levels among the different trials, based on percentage of disease suppression (according to Termorshuizen *et al.,* 2006).

A third run of trials was carried out on an open field of bell pepper (*Capsicum annuum*) strongly infested in the previous years by *Phytophthora capsici*. Compost was inoculated 7 day before rototilling with several biological control agents at 4g/l dosages: *Trichoderma harzianum* T-22 (Rootshield®, 108 CFU/g, Intrachem Bio Italia), *Trichoderma viride* TV1 (TV1®, 108 CFU/g, Agribiotec) and *T. harzianum* (strain ICC012) in mixture with *T. viride* (strain ICC080) (Remedier®, 108 CFU/g, Isagro). Pepper plants were transplanted 2 days after organic certified compost (enriched or not with *Trichoderma* spp.) was rototilled into soil at 2 kg/m^2 dosage. After transplanting diseased plants affected by *P. capsici* were counted every 7-10 days. The effect of micro-organisms added to compost on percentage of disease suppression (according to Termorshuizen et al., 2006) was assessed compared to control.

Analyses of variance (ANOVA) were carried out with the statistical programme SPSS 12.0 (SPSS Inc., Chicago, IL). Tukey's HSD test was applied when one-way ANOVA revealed significant differences ($P<0.05$).

Results

Regarding compost maturity test, organic certified compost showed an higher level of CO_2 in the compost maturity test, that means a lower maturity (Tab. 1). The germination assay showed that organic certified compost has a lower germinability compared to conventional compost (Tab. 1). *L. sativum* growth was not statistically different compared to peat control (Tab. 1).

Tab. 1: Compost maturity and quality

Amendment	Maturity*	Germination index (Gi)**	Plant Growth index (Pi)
Organic certified compost	6	124.9 b	102.3 a
Conventional compost	7	211.5 a	111.8 a
Peat	-	179.7 ab	100.0 a

* 7= very mature; 6 = mature; <6 = not mature.

** Gi lower than 71 indicates low germinability and high phytotoxicity

°significant for P<0.05

In greenhouse trials, composts showed a good disease suppressive activity against *P. nicotianae* on tomato (Tab. 2). No differences in disease suppression were showed between organic certified compost and conventional compost.

In open field trial no statistical differences were showed by the use of compost on the disease suppressiveness of *P. capsici* on bell pepper, even when enriched with *Trichoderma* spp.

Discussion

Quality and disease suppressiveness of organic certified compost was assessed. Compost quality showed to be comparable to peat, but with a lower germinability than conventional compost. This difference could be due to an higher nutrient content of the conventional compost. Composts showed to be suppressive against some soilborne pathogens (*Phytophthora* spp.), as already suggested by Noble and Coventry (2005). The suppressive activity was not statistically significant when compost was used in open field, even when enriched with biological control agents like *Trichoderma* spp.

Tab. 2: Effect of compost on disease suppressiveness on *Phytophthora capsici* of zucchino (courgette) and *Phytophthora nicotianae* of tomato in greenhouse.

Treatment	% disease suppressiveness	
	Phytophthora capsici / zucchini	Phytophthora nicotianae / tomato
Organic certified compost	40 b*	76 b
Conventional compost	55 ab	79 b
Peat (inoculated)	5 c	0 c
Peat (not inoculated)	100 a	100 a

* significant for P<0.05

Conclusions

In conclusion, our results indicate that organic certified compost can be used as a mean to control some soilborne diseases at least in greenhouse conditions. Organic certified compost quality is comparable to peat and its adoption is foreseen as a peat substitute. The combination of biological control agents with compost could lead to a more stable suppressive substrate, but *Trichoderma* spp. didn’t showed to increase compost suppressiveness against *Phytophthora* spp. This study represents an initial step toward the development of a new substrate able to control a wide range of soil-borne pathogens.

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Investigations on the efficacy of different products for the control of *Stephanitis pyri* in an organic pear orchard during the two-year period 2004-'05

Vergnani, S.[1] & Caruso, S.[2]

Key words: *Stephanitis pyri*, organic pear orchard, control.

Abstract

The results of two trials, carried out respectively in 2004 and 2005, against Stephanitis pyri in an organic pear orchard are reported. Different formulations of the following active substances were tested: pyrethrum + PPBO, rotenone, rotenone + pyrethrum + PPBO, azadirachtin, Beauveria bassiana strain ATCC 74040, Marsiglia and potassium soap; and quassia wood. The pyrethrum + PPBO- and rotenone-based formulated products showed good efficacy, when applied against neonate larvae. A good efficacy was also observed with the azadirachtin-based formulation, but the product may have phytotoxic effects on pear, and therefore its use is not recommended. The B. bassiana-based product showed partial efficacy in controlling the target pest, while the efficacy of the formulations based on Marsiglia soap, Potassium soap and Quassia wood was not satisfactory.

Introduction

The pear lace bug (*Stephanitis pyri*) is an insect that can cause extensive damage in organic pear (*Pyrus communis*) orchards. Widespread infestations, affecting entire plots, can occur in orchards where this pest is not adequately treated (Protic, 1994; Forti, 1992). The major effects of *S. pyri* on pear plants and production are decolorisation of leaves, reduction in photosynthetic activity, early leaf-drop, decrease in fruit size and, finally, loss of production (sometimes on a drastic scale), either in the current year or in successive years. Due to the lack of information available in literature on the use and positioning of insecticides against this pest and the rather limited persistence of the insecticides allowed in organic farming and listed in Annex IIB of Reg. EEC 2092/91, we decided to evaluate the efficacy and application strategies of different formulated products. The results of two trials, carried out in 2004 and 2005 in the province of Modena, are reported.

Materials and methods

The trials were carried out in an organic pear cv. Abate Fetel orchard in Ravarino (Modena, Italy). The tested products are reported in table 1. The different products were tested on large, not replicated plots of 40-48 plants each. We decided to use a large-plot design to avoid biasing of data due to non-homogeneous distribution of the target pest which is very likely to occur on small plots. All treatments were applied during evening hours in order to optimise the efficiency of the products, and directed

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against neonate *S. pyri* larvae. Treatments were applied with a motorized barrow sprayer, equipped with a manual Comet MC 20/20 pump nozzle using normal spray volumes (1500 l/ha). Treatments were applied at regular time intervals according to the presence of living immature stages of the target pest. Due to operational difficulties and the heterogeneity of the infestation, in 2004 the treatments were applied against neonates of the second generation (in July and August), while in 2005 they were directed against neonates of the first generation (in June). To assess for leaf damage caused by *S. pyri*, in each trial and for each treatment, the number of leaves showing symptoms of *S. pyri* damage was counted on a total of 300 leaves (upper 10 leaves of 30 randomly selected shoots) per plot/treatment. Three classes of evaluation were identified: no symptoms (class 0); up to 50% of leaf surface showing symptoms (class 1); syptoms occupying more than 50% of leaf surface (class 2). Furthermore, for each treatment, we evaluated the presence of both living and dead insects on the leaves following the sprays.

Tab. 1: Products tested in 2004 and 2005

Active substance	Formulation	Applied rate (g-ml/hl)	No. applications 2004	No. applications 2005
Pyrethrum+PPBO	Piresan Plus	100	3	2
Rotenone	Rotena 43	600	3	2
Beauveria bassiana strain ATCC 74040	Boveral OF	200	3	2
Soap	Marsiglia soap	600	3	-
Soap of potassium	SBS 200 K PLUS	600	-	2
Rotenone +Pyrethrum+PPBO	Show	700	3	-
quassia wood	quassia wood	500	3	-
Azadirachtin	Oikos	150	3	-

Results and discussion

Year 2004

The year 2004 was characterised by a limited initial development of the lace bug population. The risk that assessments on the first generation would not provide conclusive results due to low pest pressure existed, and therefore the treatments were directed against the second generation. On the final assessment date (11 August) clear differences among the tested products in reducing leaf damage caused by *S. pyri* emerged (figure 1). Leaf damage was considerably reduced only in the plots treated with the products containing pyrethrum+PPBO, rotenone and azadirachtin as active ingredients. We furthermore observed that in these plots, the neonates were all dead and no living adults were present, while in the plots exposed to the other treatments and in the untreated control plot both living adults and neonate larvae were present. The azadirachtin-based product, when applied in July and August, did not show symptoms of phytotoxicity. Azadirachtin-based products are generally indicated as being phytotoxic to most varieties of pears. Since phytotoxicity of a product the a crop is related the phenological phase, we can deduce that the risk of adverse effects of azadirachtin on pear decreases in the summer months. The *B. bassiana*-based product, Quassia wood, and marsiglia soap did not provide satisfactory control.

Year 2005

In the second study year, a heavy infestation occurred already during the first generation of the target pest, thus treatments were applied against the first generation. On the final assessment (16 June), the pyrethrum+PPBO- and rotenone-based treatments again showed highest efficacy in reducing leaf damage caused by *S. pyri*, while the efficacy of potassium soap and *B. bassiana* was only partial and considerably lower than that of the other products (Figure 2). Our observations on the percentage of living individuals confirm the results on leaf damage (table 4): survival was lowest for the pyrethrum+PPBO- and rotenone-based treatments.

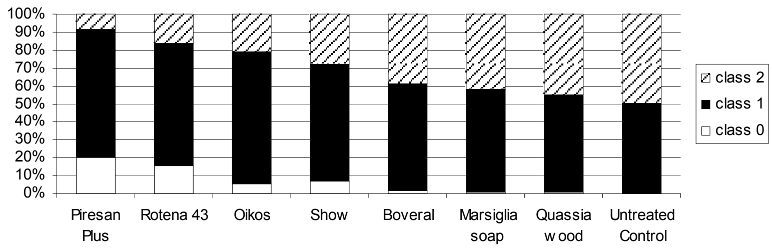

Figure 1: 2004: percentage of leaves in the three leaf damage classes recorded for the different treatments on the final assessment date (11 August 2004).

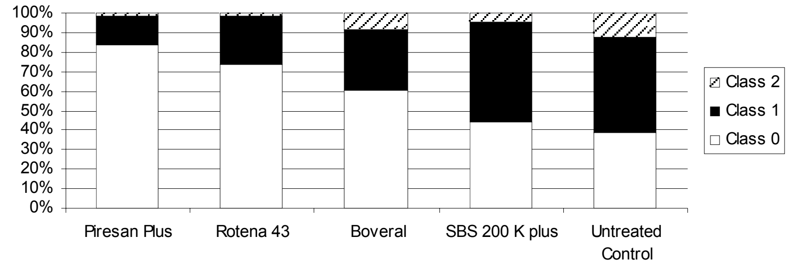

Figure 2: 2005: percentage of leaves in the three leaf damage classes recorded for the different treatments on the final assessment date (16 June 2005).

Tab. 4: 2005: percentage of leaves with living *S. pyri* individuals in the different treatments.

Treatment	% of leaves with living *S. pyri* individuals	Efficacy (Abbott)
Untreated Control	70	-
Pyrethrum + PPBO	5	93
Rotenone	5	93
Beauveria bassiana strain ATCC 74040	40	43
Potassium soap	25	64

Conclusions

Among the products tested in our trials, the pyrethrum+PPBO- and rotenone-based products always showed highest efficacy in controlling lace bug infestations on pear. Products with these two substances as active ingredients may therefore be considered valuable tools for the control of this pest, provided that they are applied against neonate individuals as in our trials. In fact, in additional trials we observed that the efficacy of both insecticides is unsatisfactory when they are applied against adults (data not reported). Also the azadirachtin-based product, tested only in 2004, showed good efficacy in reducing *S. pyri* leaf damage without showing any phytotoxic effect. It is well-known that the phytotoxicity of a product to a certain crop can vary both according to the formulation and the phenological stage of the crop during spraying. Therefore, special care should be taken, when azadirachtin-based products are used on pear, and preliminary testing of possible negative side effects is recommended. Under our trial conditions, the *B. bassiana*- based product showed poor efficacy in 2004 and only partial efficacy in 2005, even though the application instructions reported on the label were followed and application rates were almost doubled. Unacceptable efficacy values were recorded for Marsiglia soap, the quassia wood-based product (not yet included in Annex I), and Potassium soap, the former two tested in 2004 and the latter in 2005. However, the results of one single trial can not be considered conclusive, and further research is needed. In conclusion, given the results of our trials, pyrethrum+PPBO- and rotenone-based products seem to be the best options for an efficient control of lace bugs in organic farming.

Acknowledgements

Activity carried out within the project co-ordinated by CRPV (Vegetal Production Research Center) in collaboration with ProBER (Organic Producers of E.R.), funded by Emilia-Romagna Region (L.R. 28/98).

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Efficacy of *Cydia Pomonella* granulosis virus (cpgv) in controlling codling moth in the Emilia-Romagna region

Vergnani, S.1, Caruso, S.2, Boselli, M.3 & Pasqualini, E.4

Key words: Apple orchard, Pear orchard, *Cydia pomonella*, Granulosis virus, Efficacy

Abstract

During the period 1999 to 2007, numerous field trials were carried out in the Emilia Romagna region in order to test the efficacy of Cydia pomonella *Granulosis Virus-based (CpGV) products in controlling codling moth, Cydia pomonella (L.). The trial results demonstrate that CpGV-based products can be considered among the best larvicides currently available on the market. Good results were achieved against I generation larvae, while applications against successive generations did not always provide satisfactory control.*

Introduction

The introduction of *Cydia pomonella* Granulosis Virus-based (CpGV) products in the Emilia Romagna region, often complemented by the method of mating disruption, has favoured the development of organic apple (*Malus* communis) and pear *(Pyrus communis*) orchards, even in areas with high codling moth, C*ydia pomonella* L. (henceforth CM), pressure, and has suppressed CM damage to fruit. CM control is becoming increasingly challenging not only in organic farming, but also in integrated and conventional production due to ecotoxicological, residue, and resistance issues (Riedl and Zelger, 1994; Sauphanor et al., 1998; Ioriatti et al., 2000). CpGV-based products could be valuable tools to be included in resistance management strategies, could help to avoid the presence of undesired residues in the final production, and to meet the requirements of the most stringent production regulations.

Materials and methods

During the study period (1999-2007), the efficacy of different CpGV-based products in comparison to chemical reference insecticides and an untreated control was tested in a total of 14 trials conducted in both organic and integrated pear orchards. Ten trials (henceforth Trial Group 1) aimed at evaluating the efficacy of a CpGV-based product (formulated product: Carpovirusine; applied rate: 100 ml/100 l; no. applications: 3 at 7-10-day time intervals) in comparison to that of chemical insecticides and an untreated control. Out of these 10 trials, 7 were targeted against I generation CM larvae, while other 3 trials were directed against II generation CM larvae. Four additional trials (henceforth Trial Group 2), instead, aimed at comparing the efficacy of different

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CpGV-based products (tested products: Madex, Virgo/Carpostop, Carpovirusine), and an untreated control against I generation CM larvae.

In each trial, a randomised block design with four replicates per treatment, and with a mean number of 5 trees per plot was used. Since we decided to assess fruit damage on 100 fruits per plot (see below), the number of trees per plot differed among trials according to the number of fruitlets present on the trees. In all trials, treatments were applied according to label instructions with a motorised barrow sprayer (spray volume: 1200-1500 l/ha, depending on vegetative growth and tree height). Indications provided by climate/insect development models (MRV- codling moth) of the Emilia-Romagna region and by CM monitoring traps (threshold: 2 adults per trap per week) were used to choose the correct timing of the applications. In each trial, fruit damage was assessed by counting the number of fruits damaged by CM larvae (fruits with deep entries) on 100 randomly selected fruits per plot at the end of the CM target generation, and percent fruit damage was calculated.

Results

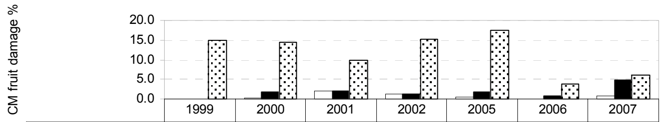
In several trials of Trial Group 1, the CpGV-based product was compared to more than one chemical reference insecticide. In order to provide a clear and concise description of the results concerning CpGV efficacy, for each trial, we decided to report observed percent fruit damage values only for the CpGV-based treatment, the chemical reference treatment that showed highest efficacy (see Table 1 for details), and the untreated control, and to omit the results obtained with the other chemical treatments tested within the same trial that showed intermediate efficacy.

In the 7 trials of Trial Group 1 carried out against I generation CM larvae, percent CM fruit damage in the CpGV-based treatment was always comparable to or lower than that recorded for the chemical reference treatment, and considerably lower than in the untreated control (Figure 1). In the 3 trials of Trial Group 1, conducted against II generation CM larvae, percent CM fruit damage recorded for the CpGV-based treatment was again always lower than in the untreated control, but comparable to that registered for the chemical reference treatment in one trial, and higher in the other two trials (Figure 2). No significant differences among the different CpGV-based products emerged in the trials of Trial Group 2: all products considerably reduced percent fruit damage compared to the untreated control, with efficacy values being comparable among products (Figure 3).

Tab. 1: Active substance, applied rate and number of applications of the chemical reference insecticides in the different trials of Trial Group 1.

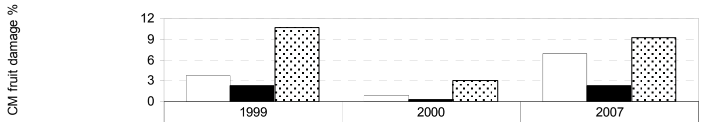
Year	Active substance	Conc. a.s. (%)	Applied rate (g or ml/hl)	No. Applic.
Trials against I generation CM larvae				
1999	Chlorpyriphos	75,0	70	3
2000	Azinphos methyl	19,0	200	3
2001	Chlorpyriphos	75,0	70	3
2002	Chlorpyriphos	75,0	70	3
2005	Azinphos methyl	19,0	200	3
2006	Azinphos methyl	19,0	200	3
2007	Chlorpyriphos	75,0	70	3

Year	Active substance	Conc. a.s. (%)	Applied rate (g or ml/hl)	No. Applic.
Trials against II generation CM larvae				
1999	Chlorpyriphos	75,0	70	3
2000	Methoxifenozide	22,5	40	2
2007	Spinosad	44,2	30	3



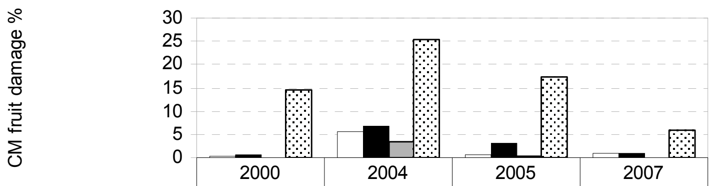
	1999	2000	2001	2002	2005	2006	2007
□ CpGV	0.0	0.3	2.0	1.3	0.5	0.0	0.8
■ chemical insecticide	0.0	1.8	1.9	1.3	1.7	0.8	4.8
⊡ Untreated Control	15.0	14.5	10.0	15.3	17.4	3.8	6.0

Figure 1: percentage of fruits damaged by I generation CM larvae in the different treatments and trials.



	1999	2000	2007
□ CpGV	3.75	0.8	7
■ chemical insecticide	2.25	0.3	2.3
⊡ Untreated Control	10.75	3	9.3

Figure 2: percentage of fruits damaged by II generation CM larvae in the different treatments and trials.



	2000	2004	2005	2007
□ Carpovirusine	0.3	5.7	0.5	0.8
■ Madex	0.5	6.7	3.1	1.0
▣ Virgo/Carpostop		3.5	0.3	
⊡ Control	14.5	25.5	17.4	6.0

Figure 3: Percentage of fruits damaged by CM larvae in the different CpGV-based treatments and in the untreated control in four trials.

Conclusions

The results of our trials are evidence of the excellent larvicidal activity of CpGV-based products: irrespective of the formulation tested, CpGV-based products were able to considerably reduce percent CM fruit damage, with efficacy values being comparable to those of the chemical reference insecticides, especially when the treatments were applied against I generation larvae (Boselli *et. al.*, 2001). CpGV-based products can therefore be considered valuable tools for the control of *C. pomonella* not only in organic farming but also in any other plant protection strategy.

However, there are also some negative aspects related to CpGV-based products: they may show reduced efficacy against II and III generation CM larvae; they have short shelf life at room temperature (CpGV-based products should be stored in the refrigerator or in the freezer; because of the mode of action of CpGV, superficial damage, depreciating the commercial value of fruit especially on apple, is more likely to occur in CpGV-treated orchards than in orchards treated with chemical insecticides. In organic farming, where CM populations are repeatedly exposed to CpGV treatments over years, because at the moment CpGV is the only efficient active substance available for the control of CM, resistance to the microbial control agent may develop. In fact, cases of CM populations resistant to the Mexican isolate, the active ingredient of the CpGV-products currently available on the market, have already been reported in several European countries (Fritsch *et. al.*, 2004). Different new CpGV isolates are now being studied to overcome resistance (Jehle, 2008). In our opinion, the inclusion of additional natural plant protection substances, such as Ryania and Spinosad into Annex II B of Reg. EEC 2092/91, could be useful for the development of efficient resistance management programs also in organic farming.

Acknowledgements

These studies are part of an experimental programme of the Emilia-Romagna region that involved numerous organisations: the University of Bologna, the Phytosanitary Service of Emilia-Romagna, the Consorzio Fitosanitario of Modena, and CRPV (Crop Production Research Centre). Activity carried out within the project co-ordinated by CRPV (Vegetal Production Research Center) in collaboration with ProBER (Organic Producers of E.R.), and funded by the Emilia-Romagna Region (L.R. 28/98).

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Yielding and Selected Leaf Diseases of Old Winter Wheat Cultivars in the Organic System

Stalenga, J. & Jończyk, K.

Key Words: winter wheat, old cultivars, cultivar selection, leaf diseases

Abstract

Intensity of leaf infestation by selected fungal pathogens and yielding of old winter wheat cultivars (Ostka Kazimierska, Kujawianka Więcławicka, Wysokolitewka Sztywnosłoma) against a background of modern winter wheat cultivars (Kobra, Roma, Korweta, Sukces, Zyta, Mewa) in conditions of organic farming was assessed. The research was based on a special field experiment established in 1994 year on a grey-brown podzolic soil in which different crop production systems are compared. The research was conducted in 2005 and 2006. Average for 2 years grain yield of winter wheat for all cultivars amounted to 3.0 t/ha. In both years the largest yields were noted for modern winter wheat cultivars. Old cultivars of wheat reacted better on water deficiency than modern ones. The yield decrease for all cultivars was mainly affected by low level of resistance on fungal pathogens responsible for leaf diseases. Only in 2005 leaves of old cultivars were more than modern cultivars infested by fungal diseases.

Introduction

It is not clear whether old cultivars of cereals may be more appropriate than modern ones for Organic Farming. Some authors indicate that modern rather than old cultivars are the best choice presently when choosing small-grain cultivars for production in environments managed organically (Poutala et al. 1993; Kitchen et al. 2003; Carr at al. 2006). Other authors point out that old cultivars of cereals may be more appropriate for organic farming because they have a better ability to form AMF (arbuscular mycorrhizal fungi) symbiosis (Hetrick et al. 1992) and have higher grain protein concentration (Gooding et al. 1999). Eisele and Köpke (1997) point out that cultivars best adapted to Organic Farming should combine an early covering of the soil surface with long and large leaves, with long leaf area duration due to low susceptibility to fungal diseases. Specific conditions of the organic system (no chemical crop protection and quick-acting synthetic fertilizers) makes a selection of appropriate cultivars a crucial task. Assessment of leaf infestation by selected fungal pathogens and yielding of old winter wheat cultivars against a background of modern winter wheat cultivars in conditions of organic farming was aim of our research.

Materials and methods

The research was based on a special field experiment established in 1994 at the Experimental Station in Osiny (Lublin province, Poland) on a grey-brown podzolic soil in which different crop production systems (organic, integrated and conventional) are compared. The research was conducted in 2005 and 2006 on the field of winter wheat in the organic system. In this system (crop rotation: potato - spring wheat - red clover with grass grown two years - winter wheat + catch crop) neither mineral fertilisation nor pesticides were applied. Organic fertilisation included only manure application (30 t/ha) before potato cultivation. The area of a field covered by a particular cultivar was about 0.1 ha. Three old cultivars: Ostka Kazimierska, Kujawianka Więcławicka, Wysokolitewka Sztywnosłoma and six modern cultivars of winter wheat (Mewa, Roma, Kobra, Sukces, Zyta and Korwetta) were compared. Grain yield and intensity of leaf infestation by selected fungal pathogens were assessed. Grain yield was determined on the basis of samples taken from the control plots (20 m2). Assessment of leaf infestation by fungal pathogens responsible for Puccinia recondita and Erysiphe grraminis was done in the milk-dough growing stage (BBCH 77- 83). For each cultivar 40 plants were taken in 4 replications. The percentage of leaf area infested by fungal pathogens was assessed on the basis of EPPO Standards (1999). The analysis of variance was done with use of the statistical programme Statgraphics Plus 6.0. The significance of difference was evaluated on the 5% significance level using Tukey's test.

Results and discussion

Average for 2005 and 2006 grain yield of winter wheat for all cultivars amounted to 3.0 t/ha. In both years the largest yields were noted for modern winter wheat cultivars. Among them Zyta and Sukces yielded the best, respectively – 4.1 and 3.9 t/ha. Ear density was the main factor affecting higher productivity of these two cultivars in comparison to others. The 1000-kernel weight was an additional important factor influencing yield but it was only significant in 2005.

Old winter wheat cultivars yield for 2005 and 2006 averaged about 2.35 t/ha (Tab. 1). Yields were lower (about 1.2 t/ha) in comparison to the modern cultivars.

In 2006 very unfavourable weather conditions for crops were noted. The yields of winter wheat were the lowest since the experiment was established in 1995. A very hard drought in the second half of June and in the whole July significantly reduced nutrient uptake by plants and in consequence influenced the level of yields. However the last concerned only modern wheat cultivars. In such difficult conditions old cultivars gave similar yields as in 2005. This revealed a positive reaction of old cultivars on water deficiency stress.

The decrease of yield for all cultivars was mainly affected by a low level of resistance on fungal pathogens responsible for leaf diseases. In 2005 leaves of old cultivars were more infested by fungal diseases in comparison to modern ones (tab. 2). In the following, very dry year 2006 (Tab. 3), no significant differences between modern and old cultivars were noted with respect to infestation by fungal diseases. In both years Puccinia recondita was the most important pathogen, especially dominant in 2006.

Conclusions

The results showed many differences between old and modern winter wheat cultivars. Modern cultivars yielded about 1.2 t better than old ones. The decrease of yield for all cultivars was mainly affected by low level of resistance on fungal pathogens responsible for leaf diseases. Only in 2005 leaves of old cultivars were more infested by fungal diseases. It should be emphasized that old cultivars reacted better on water deficiency than modern ones.

Tab. 1: Grain yields and other elements of yield structure for winter wheat cultivars (2005-2006)

Year	Wheat type	Cultivar	Grain yield (t/ha)	Ear density (ears/m^2)	1000-kernels weight (g)
2005	**Modern wheat cultivars**	*Kobra*	3.51	330	42.1
		Roma	4.19	297	51.2
		Korweta	3.34	351	43.0
		Mewa	3.74	336	46.0
		Zyta	4.65	471	47.8
		Sukces	4.47	479	43.7
	Old wheat cultivars	***Ostka Kazimier.***	**2.58**	**263**	**31.3**
		Kujawianka Więc.	**2.29**	**298**	**28.2**
		Wysokolitewka	**2.03**	**303**	**25.8**
		Average for old cultivars	**2.30**	**288**	**28.4**
		Average for modern cultivars	**3.98**	**377**	**45.6**
2006	**Modern wheat cultivars**	*Kobra*	3.09	461	35.4
		Roma	3.20	466	35.6
		Korweta	3.39	504	34.0
		Mewa	3.14	472	36.6
		Zyta	3.57	507	38.8
		Sukces	3.32	545	36.1
	Old wheat cultivars	***Ostka Kazimier.***	2.38	411	39.0
		Kujawianka Wię.	2.68	524	35.5
		Wysokolitewka	2.23	442	30.7
		Average for old cultivars	**2.43**	**459**	**35.1**
		Average for modern cultivars	**3.28**	**492**	**36.1**

Tab. 2: Infestation (in %) of flag and under-flag leaf by fungal pathogens for different cultivars of winter wheat in the milk-dough growing stage (BBCH 77-83) in 2005

Cultivar	*Erysiphe grraminis*			*Puccinia recondita*		
	Leaf		In total	Leaf		In total
	flag	underflag		flag	underflag	
Kobra	0.8 c	5.1 c	5.8	0.9 b	10.2ab	11.1
Zyta	0.0 a	5.3 c	5.3	0.4 a	2.5 a	3.0
Roma	0.0 a	2.4 bc	2.1	0.2 a	6.9 ab	7.1
Sukces	0.1 a	0.2 ab	0.2	0.9 b	5.0 ab	5.9
Mewa	0.1ab	1.1 abc	1.2	0.2 a	4.2 ab	4.4
Korweta	0.0 a	0.2 ab	0.2	1.1 b	13.0 b	14.5
Kujawianka	0.2ab	1.0 abc	1.1	0.4 a	8.3 ab	8.7

Wysokolitewka	0.7 c	4.4 c	5.1	1.0 b	11.5 b	12.5
Ostka Kazimier.	0.5bc	1.4abc	2.0	0.2 a	6.5 ab	19.1

Tab. 3: Infestation (in %) of flag leaf by fungal pathogens for different cultivars of winter wheat in the milk-dough growing stage (BBCH 77- 83) in 2006

Cultivar	Share of leaf area with disease symptoms in %	
	Erysiphe graminis	*Puccinia recondita*
Kobra	2.9 de	47.7 f
Zyta	4.6 e	25.0 ab
Roma	1.0 c	46.2 ef
Sukces	1.0 c	43.0 def
Mewa	0.2 ab	35.7 c
Korweta	0.0 a	27.6 b
Kujawianka	1.6 cd	37.9 cd
Wysokolitewka	4.0 e	21.7 a
Ostka Kazimier.	1.0 c	49.6 f

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Biological control of kiwifruit and tomato bacterial pathogens

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Key words: natural extracts, organic agriculture, *Ficus carica*, *Allium sativum.*

Abstract

Biocontrol of bacterial pathogens is effected by using cupric salts associate to appropriate agronomical practices such as seed certification, irrigation and fertilization. In in vitro and in in vivo tests, aqueous extracts from Allium sativum and Ficus carica fruits reduce the survival and the damages (disease incidence and disease severity) caused by bacterial pathogens of kiwifruit (Pseudomonas syringae pv. syringae, Pseudomonas viridiflava) and of tomato (Pseudomonas syringae pv. tomato) plants. In vitro tests, both vegetal extracts show antimicrobial activity against all bacterial strains utilised at different concentrations (10^6 – 10^8 cfu ml^{-1}). In vivo tests Allium sativum and Ficus carica extracts confirm their antimicrobial activity on P. s. pv. tomato reducing DI and DS after two weeks until to 60% and 67% and to 32% and 22%, respectively.

Introduction

Biological control of parasites in organic agriculture crops is based on natural antagonists and substances present in nature. Bacterial diseases are a serious problem in greenhouse and in open field on different plants. Amongst them, *Pseudomonas syringae* pv. *syringae*, *Pseudomonas viridiflava* and *Pseudomonas syringae* pv. *tomato* are particularly dangerous on kiwifruit and tomato plants, respectively. At present, to control these bacterial pathogens, especially in organic agriculture, few effective strategies can be adopted. Copper treatments and appropriate agronomical practices, such as seeds certification, irrigation and fertilization, are suggested (Colin et al., 1984; Varvaro et al., 2001).

Due to the recent EU restriction on copper use in organic agriculture (Reg. EU n° 473/2002) and the increased movement of vegetal material among the EU and not EU countries, found effectiveness natural bactericidal/bacteriostatic compounds assume a relevant importance to control these bacterial pathogens especially in organic agriculture. As an alternative to copper compounds, few natural substances have been recently proposed, but further studies need to optimize their effectiveness (De Castro, 2001; Lo Cantore et al., 2004).

As potential natural substances effective against *P. s.* pv. *syringae*, *P. viridiflava* and *P. s.* pv. *tomato*, vegetal extracts from *A. sativum* and *F. carica* plants were utilised.

A. sativum was chosen for its antimicrobial properties, well known in human healthy, and for its properties to inhibit different enzymes, essential for microbial pathogen infections, by organosulfur compounds (Obagwu and Korsten, 2003).

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F. carica was chosen for their richness in phenols and flavonoids effective on different bacteria (Salameh et al., 2004; Zao et al., 2005).

The aims of this study were to verify, *in vitro* and *in vivo*, the antimicrobial activity of natural extracts, obtained from *Allium sativum* and *Ficus carica* plants, on *P. s.* pv. *syringae*, *P. viridiflava* and *P. s.* pv. *tomato*.

Materials and methods

A. sativum and *F. carica* fruits were sliced into small pieces and blended using twister blender for 10 min at room temperature. The extracts were obtained by centrifuging samples using sorvall RC 5 B (Newton, CT) centrifuge at 8,000 x *g* for 45 min to remove bigger particles.

In *in vitro* tests were carried out by the spot tests; aqueous extracts of *A. sativum* and *F. carica* fruits were utilised at a concentration of 10 g l^{-1} and of 60 g l^{-1} (dry weight), respectively. Spot tests were conducted on NSA medium (nutrient broth 8 g l^{-1}, sucrose 50 g l^{-1} and agar 18 g l^{-1}). Bacterial strains, characterized by an higher level of virulence and isolated from kiwifruit and tomato plants in Central Italy, were utilised at 10^6 and 10^8 colony forming units (cfu)/ml concentration. After distribution of bacterial suspensions (100 µl per Petri dish), natural extracts (4 drops, 30 µl each) were placed on NSA Petri dishes. After incubation at 25 □ 2°C for 48-72 h, eventual inhibition zones, measured in mm without any growth of each bacterial strain, were observed by a stereomicroscope and then measured (Klement et al., 1990). In *in vitro* spot tests were carried out under laboratory conditions and repeated five times, two replicates each.

In *in vivo* tests were carried out in greenhouse on tomato plants cv. San Marzano, 1 month old. Greenhouse conditions (temperature, relative humidity) were maintained at day and night temperatures of 25 □ 2°C and 15 □ 2°C, respectively, and relative humidity (RH) between 70-80% during whole experiments. The extracts of *A. sativum* and *F. carica* were used at a concentration of 10 g l^{-1} and of 60 g l^{-1} (dry weight), respectively. Bacterial strains of *P. s.* pv. *syringae* VT2, *P. viridiflava* VT3 and *P. s.* pv. *tomato* VT14 were utilised at 10^5 cfu/ml concentration.

In greenhouse, tomato plants were sprayed by each natural extract until leaves were homogeneously wet. Considering as preventive treatments by natural substances, 24 h their distribution, bacterial suspension was sprayed on plants with CO_2-pressurized hand-held sprayer; 2 h before and 2 h after bacterial inoculation, RH was maintained at 90% by automatic system to favour stomata opening.

After bacterial contamination, tomato plants were monitored daily for 15 days and disease incidence (DI) (n° of diseased leaflets/plant) and disease severity (DS) (n° of necroses/cm^2 leaflets) were analysed according to Steel et al. (1997).

In *in vivo* tests were repeated five times; for each combination (bacterial pathogen/natural extract) 60 tomato plants were used: 15 plants treated with *A. sativum* extract, 15 with *F. carica* extract, 15 with copper oxychloride (28%) as positive control and 15 untreated as negative control. All data obtained were statistically analysed using GraphPad Prism 4 software for analysis of variance (ANOVA), and the significance of the treatments were determined using Tukey’s HSD test ($P \leq 0.05$).

Results

In *in vitro* spots tests, both natural extracts inhibit the growth of the different bacterial strains utilised. *A. sativum* fruit extract had an effect on all strains utilised, with highest effects against *P. s.* pv. *syiringae* VT2 at both bacterial concentrations (10^6 and 10^8 cfu ml^{-1}) (data not shown).

F. carica extract showed better effects than *A. sativum* extract on *P. s.* pv. *tomato* VT14, and light effects on *P. s.* pv. *syiringae* VT2 and *P. viridiflava* VT3 at both concentration (10^6 and 10^8 cfu ml^{-1}) (not shown).

In *in vivo* tests the use of both natural extracts confirmed their biocontrol effect on *P. s*. pv. *tomato*. Using *A. sativum* extract, considering untreated control values recorded, DI was reduced until to 60% and DS by 67,7%; by using *F. carica* extract, DI was reduced until to 32% and DS by 22% after 15 days (Fig.1).

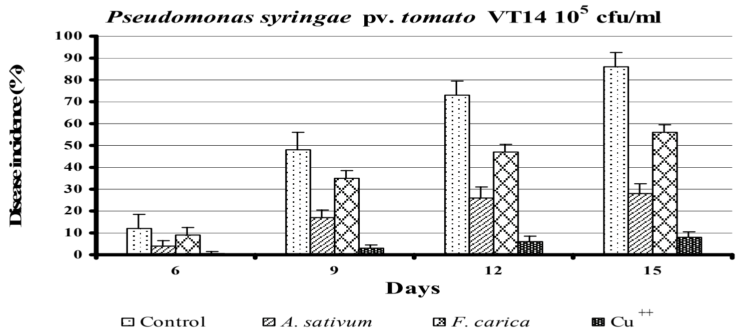

Figure 1: Disease incidence (DI) on tomato plants contaminated by *Pseudomonas syringae* pv. *tomato* VT14 by using *A. sativum* (1%) and by *F. carica* (6%) vegetal extracts.

Discussion and conclusions

The natural extracts tested seem to be useful for a biocontrol of *P. s.* pv. *syringae*, *P. viridiflava* and *P. s.* pv. *tomato* bacterial pathogens.

A. sativum and *F. carica* extracts successfully reduced disease incidence and disease severity caused by *P. s.* pv. *tomato*, and none negative effect was recorded on tomato plants.

The use of these natural substances appear to be particularly interesting to protect tomato plants in greenhouse. The antimicrobial activity of these natural substances showed to be effectiveness at least for 10 days, giving interesting opportunities to substitute or to be associated to copper compounds treatments normally used in organic agriculture.

Further studies are in progress to evaluate field-doses of these natural substances and to characterize their active principles.

Acknowledgments

This research was supported by the Italian Ministry of the Agricultural, Food and Forest Policies (MIPAAF), (N° 893/2006).

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The effect of *Avena sterilis* L. invasion on weed abundance and diversity in conventional and organic cereal fields in the Mediterranean region

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Key words: *Avena sterilis*, invasion, diversity, cropping system, weeds

Abstract

The aim of this paper is to analyse the growth of the native invader weed Avena sterilis *L. (wild oat) and its invasion effect on weed community abundance and diversity in relation to cropping system (organic vs. conventional) in dryland cereal fields under Mediterranean conditions. To achieve this, a comparative experimental design involving one conventional and one nearby organic field was used. Our results show that the effect of* A. sterilis *invasion on resident weeds and cereal biomass depended on the cropping system. Species richness and diversity of weed community were more negatively affected by the invasion in the conventional field, whereas cereal biomass was drastically reduced in the organic field. The cropping system did not affect the invasive ability of* A. sterilis, *but the higher* A. sterilis *biomass recorded in the conventional field suggests strong potential long-term invasions in this system.*

Introduction

The importance of weeds supporting biodiversity in agroecosystems is well known (Marshall *et al*., 2003). However, the agricultural intensification in recent decades (cereal monoculture, fertilisation, herbicides) has dramatically reduced weed diversity in dryland cereal fields. Dryland cereal weed communities are characterized by the dominance of a few species, among which some grasses (i.e. *Lolium rigidum*, *Avena sterilis*) (Romero *et al*., 2008) are now considered to be serious agricultural pests. The effect of native weed infestation and weed management practices on crop yield have been widely studied (Hole *et al*., 2005). In contrast, less research has been conducted on the effect of the invasion by native weeds on weed abundance and diversity. The invasion by native weeds such as *Avena sterilis*, one of the most troublesome weeds in many Mediterranean climate areas (Fernández-Quintanilla *et al*., 1997), could be an important agent driving the decline in abundance and diversity of weed populations.

The pattern of resource availability can affect weed density, time of emergence, and weed-crop interactions. On one hand, these factors can modify weed community abundance and diversity (Liebman *et al*., 2001); on the other hand, they can determine invasive success (Davis and Pelsor, 2001). Thus, the different rate of nutrient release of chemical fertilisers and manure in conventional and organic cereals, respectively, can affect the relationships among wheat, *A. sterilis*, and the resident weeds. Chemical fertilisation usually favours crop species, but this general pattern depends on the life-history traits of the interacting species.

The aim of the present study is to analyse the growth of the native invader weed *A. sterilis* in relation to cropping system (organic vs. conventional) and the effect of its

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invasion on wheat yield and weed community abundance and diversity in dryland cereal fields. The experiment is based on a simulated invasion through seeding *A. sterilis* at three different densities in two nearby dryland cereal fields, one conventionally and one organically managed.

Materials and methods

The study was carried out in an agricultural area in Catalonia (NE Spain). Two nearby commercial winter wheat fields were selected, one conventional and one organic. Both fields had similar organic matter, N content, and C/N ratio. The conventional field was fertilised with a granular application of NPK (10:7:16) at 300 $kg{\cdot}ha^{-1}$ before sowing and with $N\text{-}NO_3$ at 50 $kg{\cdot}ha^{-1}$ in late winter, whereas the organic field had been fertilised with composted manure one year earlier. There was no control of weeds in either field to avoid the confounding effect of management and invasion during the experiment. Six 17 m 2 m plots were randomly delimited in each field. Each plot was divided into four square subplots of 4 m^2, 3 m apart. Three randomly selected plots were sown at three densities of *A. sterilis*: *c.* 165, 830, and 1670 $seeds{\cdot}m^{-2}$ (hereafter referred to as treatments A1, A2 and A3) in order to obtain a gradient of invasive intensity. The fourth plot was not sown with *A. sterilis* and constituted a control (hereafter referred to as treatment A0). Seeds had been collected in June 2006 from natural populations. In mid-October, once *A. sterilis* seeds had been added, 200 $kg{\cdot}ha^{-1}$ of wheat (*Triticum aestivum*) was sown. Two plots were rejected in the organic field because of poor crop establishment. In June four 25 cm 25 cm samples were randomly selected from each subplot and total aboveground biomass was clipped at ground level and sorted into species. The mean weights of wheat, *A. sterilis*, and the resident weed species were computed for each subplot after drying them at 60ºC for 48h.

Weed community structure was evaluated by means of biomass, species richness, and Shannon's diversity index. The effect of management (conventional vs. organic) and *A. sterilis* invasion on crop and resident weeds biomass and on weed community structure were analysed by means of a cross-nested ANOVA using the GLM procedure of SPSS 14.0. Non-proportional data were log-transformed and the arcsine square root transformation was applied for proportional data to achieve normality and homoscedasticity of residuals when necessary. A non-parametric Kruskal-Wallis test was used when transformed data were not normal. The level of significance was α = 0.05.

Results

Total biomass was higher in the conventional than in the organic field ($F_{1,8}$ = 61.9, P < 0.001), and no significant differences between treatments were found within each field (Tab. 1). Wheat biomass was also higher in the conventional field ($F_{1,8}$ = 46.6, P < 0.001), and decreased from A0 to A3 in both fields ($F_{3,24}$ = 37.7, P < 0.001). Note that the ratio of wheat biomass to total biomass was not significantly different in the non-invaded subplots for both fields ($F_{1,8}$ = 0.40, P = 0.85).

A. sterilis biomass was significantly higher in the conventional field ($F_{1,8}$ = 79.3, P < 0.001) and increased from A1 to A3 in both fields ($F_{3,24}$ = 99.7, P < 0.001; Tab. 1). *A. sterilis* invasion, assessed as the ratio of *A. sterilis* biomass to total biomass, did not differ between fields ($F_{1,8}$ = 0.41, P = 0.54), and increased significantly from A1 to A3 in both fields (Tab. 1).

The relative importance of resident weeds (the ratio of resident weed biomass to total biomass) was significantly higher in the organic than in the conventional field ($F_{1,8}$ = 17.4, P < 0.05). Total resident weed biomass of the conventional field decreased significantly in *A. sterilis*-invaded subplots, whereas it was not negatively affected in the organic field (Tab. 1).

Species richness ($F_{1,8}$ = 23.5, P < 0.001) and weed diversity ($F_{1,8}$ = 32.8, P < 0.001) were significantly higher in the organic field. They did not differ significantly among treatments in the organic field but decreased in *A. sterilis*-invaded subplots in the conventional field (Tab. 1).

Tab. 1: Mean (± S.E.) of different crop and weed parameters, species richness and diversity for each *Avena sterilis* treatment. Different letters indicate significant differences between treatments for each variable with LSD test.

	A0		A1		A2		A3	
Conventional								
Total Biomass (TB) (g	1605,	± 116 a	1453,	± 107 a	1579,	± 78,8 a	1723,	± 143 a
Wheat Biomass (WhB) (g m^{-2})	1303,6	± 141 a	682,5	± 46,9 b	500,9	± 56,4 bc	343,4	± 75,6 c
A. sterilis Biomass (AB) (g m^{-2})	20,6	± 11,1 a	678,3	± 55,7 b	1026,3	± 81,7 c	1321,7	± 70,9 d
Weed Biomass (WB) (g m^{-2})	281	± 71,6 a	92,9	± 28,9 b	52,40	± 19,6 b	58,8	± 19,7 b
WB/TB	18,1	± 0,05 a	5,9	± 0,01 b	3,13	± 0,01 b	3,21	± 0,01 b
WhB/TB	80,6	± 0,05 a	47,3	± 0,03 b	32,10	± 0,04 c	19,1	± 0,03 c
AB/TB	1,3	± 0,01 a	46,7	± 0,02 b	64,77	± 0,04 c	77,7	± 0,03 d
Species Richness †	6,2	± 0,5 a	4,0	± 0,00 b	3,17	± 0,31 c	2,33	± 0,42 c
Diversity (H') †	0,7	± 0,2 a	0,7	± 0,13 a	0,40	± 0,18 ab	0,04	± 0,02 b
Organic								
Total Biomass (TB) (g m^{-2})	961,9	± 136 a	682,9	± 69,1 a	1045,2	± 109 a	1062,3	± 113 a
Wheat Biomass (WhB) (g m^{-2})	804,8	± 146 a	138,1	± 30,1 b	135,0	± 29,2 b	33,4	± 12,5 c
A. sterilis Biomass (AB) (g m^{-2})	4,9	± 4,11 a	277,5	± 69,2 b	692,5	± 27,2 c	942,2	± 95,3 c
Weed Biomass (WB) (g m^{-2})†	152,3	± 24,9 a	235,9	± 22,7 b	217,7	± 74,8 ab	86,7	± 17,2 a
WB/TB	17,5	± 0,05 a	38,8	± 0,08 b	19,5	± 0,06 a	8,1	± 0,01 a
WhB/TB	82	± 0,04 a	20,9	± 0,04 b	12,7	± 0,02 b	3,1	± 0,01 c
AB/TB	0,05	± 0,00 a	40,3	± 0,06 b	67,8	± 0,06 c	88,9	± 0,01 d
Species Richness	9	± 1,3 ab	12,4	± 1,23 a	8,3	± 2,21 ab	7,8	± 1,31 b
Diversity (H')	1,2	± 0,2 a	1,4	± 0,08 a	1,0	± 0,29 a	0,8	± 0,19 a

†Paired comparison between treatments carried out by Kruskal-Wallis test.

Discussion and conclusions

Although the higher availability of resources in the conventional field allowed it to sustain a higher total biomass, the ratio of wheat to total biomass in non-invaded subplots was similar in the two fields. Management did not affect *A. sterilis* invasion*,* evaluated as the ratio of *A. sterilis* biomass to total biomass. However, *A. sterilis* invasion affected weed and wheat biomass differently, depending on the cropping system. In the conventional field, *A. sterilis* out-competed efficiently resident weeds. Hence, total weed biomass, species richness and diversity decreased as the *A. sterilis* invasion became more intense. Conversely, weed abundance, species richness and diversity were not significantly affected by the *A. sterilis* invasion in the organic field, but wheat production was drastically reduced. The slow nutrient release from manure in the organic field may slow down wheat establishment, which modifies the competitive interactions among wheat, *A. sterilis*, and resident weeds. The elevated levels of *A. sterilis* biomass in the conventional field suggests that this field could potentially be subjected to intense long-term invasions, as aboveground biomass is related to seed production (high propagule pressure). The effect of an *A. sterilis* invasion on the weed community should be evaluated over the long term, and weed management should be taken into account. In our study, the experimental addition of *A. sterilis* seed under no weed control conditions allowed us to evaluate the short-term effect on the weed community. Despite the importance of seed bank in buffering year-to-year changes in seed production, a decrease in the resident weeds' seed rain as a consequence of their lower biomass in *A. sterilis*-invaded subplots could reduce the population size of some species and contribute to local extinction. According to our results, weed management efforts must be made to keep *A. sterilis* populations under a threshold to prevent yield losses and a decline in weed community diversity in conventional fields, as well as to avoid drastic yield losses in organic fields.

Acknowledgments

This research was partially funded by the Spanish Ministry of Education and Science with a fellowship to the first author, and by the Science and Technology Department of the Spanish Government (project CGL2006-13190-C03-01).

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Efficacy Evaluation of Some Copper Formulations for the Control of Grapevine Downy Mildew with Low Dose Applications

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Key words: *Plasmopara viticola*, downy mildew, copper, organic farming, disease control

Abstract

The aim of this study was to evaluate the efficacy of old and new copper formulations to control downy mildew Plasmopara viticola (Berk. et Curtis) Berl. et. De Toni). Field trials were carried out over the years 2002, 2004 and 2005 in a grapevine growing area in the Po Valley with a high disease pressure. Among the traditional copper formulations, hydroxide-based products gave the best results. Other new copper formulations, including foliar fertilizers, simple adjuvants and resistance inducers were evaluated. In particular, resistance inducers with a low percentage of copper gave promising results even though some of them show some phytotoxic problems.

Introduction

Due to the EU Regulation n.473/2002, the limitation of 6 kg/ha of copper that can be distributed in the environment, led to change the downy mildew (*Plasmopara viticola* (Berk. et Curtis) Berl. *et.* De Toni). control on grapevine (*Vitis vinifera*) in organic farming, particularly in the north of Italy where the disease pressure in some years is very high (Scannavini et al., 2000; Pontiroli et al., 2001; Cravero et al., 2002: Sancassani & Rho, 2002). The efficacy evaluation of reduced dosage of copper formulations along with new alternative copper-based products permitted in organic farming, was needed. In this paper, field trials located in a grapevine growing area with a high disease pressure, over three years, is presented.

Materials and methods

Trials were carried out over the years 2002, 2004, 2005 in a commercial organic farm located in Castelfranco Emilia (Italy) on vines cv Lambrusco Grasparossa of 6 years old, and vine density 3.5 x 2 m. Trials were set up following a randomized block design with 4 replicates and 6 plants/plot. In 2002-2004, the first chemical was applied at 80% of disease incubation, while subsequent sprays were carried out at 7 days interval. In 2005, all the chemicals were applied preventively. Chemicals were applied using a knapsack sprayer distributing 400-1000 l/ha depending on vine growth. Formulation’s features are summarized in table 1. Disease severity and incidence

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were assessed on 100 leaves and 50 bunches per replicate. Data were arcsine transformed and statistically analyzed using ANOVA. Means were separated using SNK test ($p \leq 0.05$).

Tab. 1: Formulations tested each year and doses of application

Year			Commercial name	Active ingredient	a.i. % or g/l
2002	2004	2005			
*			Poltiglia Bord. Disperss	Cu hydroxy sulphate	20
*			Rame azzurro F2	Cu hydroxide	350
*			Cobre Nordox Super 75	Cu oxide	75
*			Peptiram 7	Aminoacids+Cu+peptides	89,6
*			Kendal	Oligosaccarids+glutatione +vegetal extracts	-
*			Fitoil	Soybean oil	40
*	*	*	Cuprocaffaro micro	Cu oxychloride	37,5
	*	*	Kocide 2000	Cu hydroxide	35
	*	*	Kocide 2000+molasses	Cu hydroxide	35
	*	*	ATO FAP 17	Cu hydroxy sulphate	40
	*		Oligal rame	Cu sulphate	172
	*	*	Airone	Cu hydroxide+Cu oxychl.	272
	*	*	Heliocuivre	Cu hydroxide+Terpenics	40
		*	Fertleader rame S	copper (sulphate) + seaweed extracts	6
		*	Kendal TE	Cu (23), Mn (0.5), Zn	23
		*	Netram	Cu Penta-hydrated sulph.	60

Results

In 2002, weather conditions were favourable for disease development. Sprays were carried out on: 7/5, 14/5, 21/5, 28/5, 4/6; 12/6 20/6; 27/6, 04/7; 13/7.. Symptoms of the disease occurred on 17 may after the second spray. Results showed that all formulations and strategies applied, significantly reduced the infection compared with the check. However none of them proved to be effective in reducing the infection on bunches. Among the traditional formulations, rame azzurro F2 gave the best protection. Plots treated with Peptiram showed symptoms of phytoxicity with necrotic spots on leaves.

Tab. 2: Results in 2002: final assessment on 19st july

Commercial name	Dose (g or ml/hl)	Cu ion kg/ha (13/07)	% inf. leaves	% inf. leaf area	% inf. bunches	% inf. bunch area
B.mixture Disperss	600	9.6	30.3 cd	0.8 bc	70.0 bc	9.5 bc
B.mixture Disperss	300	4.8	56.8 b	2.1 c	87.5 ab	14.7 c
B.mixture Disperss + Fitoil	300+300	4.8	52.8 b	1.9 bc	83.8 ab	14.0 b
Rame azzurro F2	230	6.44	19.3 d	0.5 bc	46.3 c	3.4 bc
Cobre Nordox Super 75	110	6.6	31.3 cd	0.9 bc	62.5 bc	4.3 bc
B.mixture Disperss + Peptiram 7 (1)	600+200	5+ 0,896	36.8 c	1.3 bc	50.0 c	4.0 bc
Cuprocaffaro micro	300	9	32.3 c	1.2 bc	62.5 bc	6.2 bc
untreated control	-		94.5 a	7.3 a	100.0 a	65.2 a

(1) Applications with Bordeaux mixture were carried out on 7/5, 14/5, 17/5.

Tab. 3: Results in 2004: final assessment on 1st july

Commercial name	Dose (g or ml/hl)	Cu ion kg/ha (25/06)	% inf. leaves	% inf. leaf area	% inf. bunches	% inf. bunch area
Kocide 2000	200	4,48	53,3 cd	5,0 bc	59,0 c	8,6 c
ATO FAP 17	185	4,736	70,4 b	7,4 b	78,0 b	18,5 b
Oligal Rame	100	1,10	63,6 bc	6,5 bc	68,5 bc	18,6 b
Kocide 2000 + molasses	175 + 300	4,48	33,6 e	2,0 c	61,5 bc	10,8 bc
Airone	250	4,352	51,5 d	4,0 bc	62,0 bc	11,6 bc
Heliocuivre	125	3,2	51,3 d	4,4 bc	69,0 bc	12,7 bc
Cuprocaffaro micro	300	7,2	54,3 cd	5,3 bc	67,5 bc	12,9 bc
untreated control	-		89,1 a	22,2 a	95,0 a	34,9 a

In 2004, at the beginning of the season weather conditions were very favourable for the disease development and infection occurred early on bunches. Sprays were carried out on 7/5,14/5, 21/5, 28/5, 4/6, 11/6, 18/6, 25/6. This situation led to an insufficient disease control for all the formulations tested. Best results were achieved using copper hydroxide formulations, and on bunches in particular, Kocide 2000 applied alone or in mixture with molasses (Table 3).

In the trial performed in 2005 new alternative formulations were tested. Climatic condistions were not favourable for the disease because of very few rain events. All the sprays were carried out preventively on 4/5, 10/5, 16/5, 21/5, 27/5, 8/6, 17/6, 24/6; 1/7, 8/7 before any rain event. At the end of the trial, all the formulations adequately protected the leaves and bunches.

Tab. 4: Results in 2005: final assessment on 22nd july

Commercial name	Dose (g o ml/hl)	Cu ion kg/ha (8/07)	% inf. leaves	% inf. leaf area	% inf. bunches	% inf. bunch area
Kocide 2000	200	5,6	0,6 b	0,1 b	0,0 b	0,0 b
ATO FAP 17	185	5,9	1,0 b	0,9 b	0,5 b	0,0 b
Kocide 2000 + molasses	200 + 300	5,6	0,5 b	0,9 b	0,0 b	0,0 b
Fertileader Rame S	300	1,4	2,4 b	0,3 b	1,0 b	0,0 b
FertileaderRame S & Cuprocaffaro micro	150 + 150	5,2	2,8 b	0,4 b	1,5 b	0,0 b
Airone	250	5,4	0,6 b	0,1 b	0,0 b	0,0 b
Heliocuivre	125	4,0	0,4 b	0,0 b	0,0 b	0,0 b
Kendal Te	300	5,6	3,3 b	0,4 b	0,5 b	0,0 b
Cuprocaffaro micro	300	9,0	2,7 b	0,3 b	1,0 b	0,0 b
Netram	150	0,72	2,0 b	0,3 b	4,0 b	0,1 b
untreated control	-		54,0 a	8,4 a	45,5 a	6,4 a

Conclusions

When climatic conditions are very conducive for the disease and copper sprays have to be applied at shorter interval, the respect of EU limitation may lead to have damage at harvest. With this respect, promising results are given by the new formulations at reduced copper content Peptiram and Netram, even though the former showed phytotoxicity problems. Results showed that, among the traditional copper formulations, only cu hydroxide permits to contain the disease and at the same time reduce the copper distribution up to 5 kg/ha. However more investigations with higher disease pressure are needed

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Olive fly (*Bactrocera oleae*) activity, fruit infestation and temperature in an organic table olive orchard in southern Crete

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Key words: Olive fly, Bactrocera oleae, organic olives, temperature, climate

Abstract

Olive fly activity and olive fruit infestation was monitored in a table olive orchard in southern Crete throughout most of 2006 using McPhail traps. Flies were trapped weekly for 40 weeks, starting at the beginning of February. The fly data was split into 10 four-week periods. Male, female and total fly activity was significantly related to sampling period, maximum temperature and relative humidity but the pattern of catches was not consistent. Activity increased from February until July but declined in August and was very low in September, October and November. The low activity in the last three months was reflected in low fruit infestation levels, with a maximum of 3.6% in October which contrasts with infestation levels usually around 30%. Olive fly mortality is high above 31°C and the average mean maximum temperature in the four months June-September was above 34°C. High summer temperatures, with low humidities, appear to have considerably limited olive fly activity and fruit infestation and pest control measures may have to be adapted to these conditions.

Introduction

Bactrocera oleae (Rossi), the olive fly, is the most important pest of olives throughout the Mediterranean region and has badly affected olive oil yield in Crete for a considerable time (Neuenschwander & Michelakis, 1978). Changes in farming practice in general to more organic and low-input systems, generally the product of concerns over food quality, have been applied to olive production (Crovetti, 1996). Problems such as high resistance to organophosphate pesticides (Skouras et al., 2007) has led to the development of mass trapping to limit olive fly damage (Haniotakis et al., 1991). These baited traps, with food or sex attractants, and a lethal agent are put out throughout an orchard prior to fruit establishment and have been shown to be more effective than spraying in lowering fly numbers and infestation (Broumas et al., 2002).

In 2006, as part of a wide-ranging investigation into a number of aspects of organic olive production, the activity of olive flies in a table orchard near Moires in southern Crete was monitored for 40 weeks using a standard sampling method. The activity of flies in a harvest year was related to temperature and humidity and fruit infestation levels were estimated.

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Materials and methods

The survey area was an organic table olive orchard near the town of Moires in the Messara plain, southern Crete. 16 blocks of 80 olive trees (var Kalamon), of similar height and density, were sampled using McPhail traps with the food attractant Entomela 55SL, a standard method for assessing olive fly numbers. Sampling started on February 1 2006 and 40 weekly samples were taken. The traps were emptied, the catch sorted in the laboratory and the numbers of male and female olive flies counted. Estimations of fruit infestation by olive fly were carried out on six trees in each block. A total of 120 fruit from the six trees were examined for active and non-active infestation involving egg punctures, alive and dead eggs and larvae. These estimations were carried out every week from 1st July to 15th November 2006, when olive fruits were mature and harvesting began. Temperature and humidity measurements were taken by a HOBO HO8 (Onset Corporation) every one hour, in a Stephenson screen in the middle of the orchard. Daily maximum temperature and mean daily relative humidity values were used in the statistics. The weekly male, female and total olive fly catches were combined into 10 sequential four-week periods whilst monthly percent total olive fruit infestation (July-November) was calculated. Linear mixed-effects models were used to generate analyses of variance using sampling period as a fixed factor and maximum temperature and relative humidity as continuous variables, with block as a random factor. The mean fly catches and percent infestations were compared using the Tukey HSD test and all analyses were carried out in the R statistical environment (R Development Core Team, 2007).

Results

The linear mixed effects models produced very highly significant ($P<0.0001$) relationships with male, female and total olive fly catches with sampling period and relative humidity. However, the models with maximum temperature were not as significant. Male and female flies were less significantly related to temperature ($P<0.01$) than the totals ($P<0.001$). The mean number of male, female and total olive flies recorded in the 10 four-weekly periods, together with the mean maximum temperature and relative humidity for each period are shown in Tab. 1. Most male flies were caught in periods 5 and 6 (June and July), significantly different from the other means. There were lower, not significantly different, catches in periods 1, 2, 3, 4 and 7. Fewer females were trapped than males, with the highest mean in period 6, not significantly different from period 4. Similar non-significant mean numbers of female flies were trapped in periods 3, 4 and 5 and in periods 1, 2 and 7. The total means peaked in period 6, with high numbers also in period 5. More flies were recorded in periods 3 and 4 (April and May) than in periods 1, 2 and 7 (February, March and August) but very few flies were trapped in periods 8, 9 and 10 (September, October and November).

The mean maximum daily temperatures were highest and not significantly different in periods 6, 7 and 8. All other mean temperatures differed significantly from each other with an increase in means from period 1 to period 5 and a decrease in periods 9 and 10. The mean daily relative humidity values were lowest means in periods 6 and 8, significantly lower than in periods 7 and 5. Humidity became lower as temperature increased in the first four periods, increasing as the temperature fell in periods 9 and 10.

Tab. 1: Mean number of olive flies, ± SE, caught in McPhail traps in the ten sampling periods, together with the mean daily maximum temperature and relative humidity for the sampling periods.

Period	Males	Females	Total	Maximum Temperature	Relative humidity
1	5 ± 0.8^{bc}	4 ± 0.7^{cd}	9 ± 1.3^{cd}	17.9 ± 0.25^{h}	72.5 ± 0.84^{ab}
2	4 ± 0.6^{bc}	4 ± 0.5^{cd}	8 ± 1.0^{d}	21.2 ± 0.49^{g}	71.0 ± 0.40^{b}
3	8 ± 1.1^{b}	9 ± 0.9^{b}	18 ± 1.9^{bc}	25.8 ± 0.34^{e}	64.8 ± 0.81^{c}
4	7 ± 0.8^{b}	10 ± 1.2^{ab}	18 ± 2.0^{c}	28.2 ± 0.91^{d}	55.3 ± 1.81^{d}
5	18 ± 3.6^{a}	7 ± 1.2^{bc}	25 ± 4.2^{ab}	34.6 ± 1.00^{b}	49.8 ± 1.25^{e}
6	20 ± 2.1^{a}	13 ± 1.2^{a}	33 ± 3.0^{a}	36.8 ± 0.49^{a}	41.6 ± 0.12^{f}
7	4 ± 0.6^{b}	3 ± 0.6^{d}	7 ± 1.2^{de}	37.6 ± 0.28^{a}	47.8 ± 1.91^{e}
8	1 ± 0.2^{c}	1 ± 0.2^{de}	2 ± 0.3^{de}	37.0 ± 0.82^{a}	43.1 ± 1.81^{f}
9	0 ± 0.1^{c}	0 ± 0.1^{e}	0 ± 0.1^{e}	30.6 ± 0.78^{c}	64.6 ± 2.06^{c}
10	0 ± 0.1^{c}	0 ± 0.1^{e}	1 ± 0.2^{d}	23.3 ± 0.41^{f}	74.9 ± 0.52^{a}

Superscripts indicate significant differences between means (P<0.05)

The mean percentage olive fruit infestation in the five months surveyed are shown in Tab. 2, together with comparable results from a survey in central Greece in 1983 by Broumas et al. (1985). Infestation was lowest, and not significantly different, in July, August and September 2006 but although the means for October and November were significantly higher than for July, infestation was still very low at 3.6% in October. The results from central Greece in 1983 indicate a considerable increase in fruit damage in October and November, to around 30%.

Tab. 2: Mean (%) total olive fruit infestation, ± SE, in the five months before harvesting together with comparable data from western Crete in 1983 (data from Broumas et al. 1985).

Month	2006	1983
July	1.5 ± 0.34^{c}	2.4
August	2.7 ± 0.28^{abc}	4.9
September	1.9 ± 0.41^{bc}	5.4
October	3.6 ± 0.49^{a}	28.0
November	3.1 ± 0.48^{ab}	30.4

Superscripts indicate significant differences between means (P<0.05)

Discussion

Although the linear mixed effects models all gave significant responses to sampling period, maximum temperature and relative humidity, the mean catches showed that the relationships were not consistent. Olive fly activity increased throughout the year until the end of July (period 6) in close association with increasing temperatures and decreasing humidity, but there was a rapid decrease in activity in August (period 7) and very little activity in September, October and November (periods 8, 9 and 10). The usually reported pattern of fly activity follows a pattern of a number of generations in the first half of the year, maximum activity in June and July and then two more activity peaks in September/October and November (Broumas et al., 1985). The activity peaks between September and November usually result in fruit infestation, in the case of Broumas et al. (1985), of around one-third of the crop, which was thought not to be economically damaging because of mass trapping. However, in the table olive orchard surveyed the maximum damage was below 5%. Mortality of olive fly eggs and of the first two larval instars is related to daily maximum temperature and mortality of both larvae and adults is considerable above 31°C (Crovetti, 1996). There is also evidence that low humidity make conditions unsuitable for breeding (Katsoyannos, 1992). With mean maximum temperatures above 31°C in June, July, August and September 2006 in the orchard surveyed, it appears that the crash in activity seen in the last three sampling periods was due to high summer temperatures, with low humidities possibly having a compounding effect.

Conclusions

The high summer temperatures recorded in southern Crete since 1995 may have repercussions for olive fly control in the region. If ambient climatic conditions are limiting olive fly activity and fruit infestation, then it is likely that intensive pest control measures will not be required.

Acknowledgments

This work was supported by the European Union Integrated Project QualityLowInputFood (EU FP6 Contract CT-2003-506358).

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Influence of *Vicia hirsuta* control with kainite on winter cereals

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Key words: *Organic farming, hairy tare, kainite, crop damage, corn yield*

Abstract

In four field experiments (2002, 2003) the influence of Vicia hirsuta control with kainite applications (59% NaCl, 17% KCl, and 16% $MgSO_4$) on growth of winter cereals was examined. Leaf damage (yellowing) of both winter wheat and winter rye increased with increasing kainite concentrations. At early application dates [growth stages (GS) 23-32] crop damages were low (up to 16.8%) and crop stands recovered rapidly from the injuries caused by the salts. The application of kainite solutions (350 kg ha^{-1}) at later growth stages of winter wheat (GS 39) caused severe crop damages up to 48% and crop regeneration was low. Yield relevant damages of winter crop caused by using kainite were not determined. The overhead potash fertilisation with kainite granulate (53.5 kg K ha^{-1}) at GS 23-24 of winter wheat and GS 27-29 of winter rye, resulted in lower crop yield and grain weight due to the enhanced growth of V. hirsuta.

Introduction

Hairy tare (*Vicia hirsuta*) as a climbing legume weed can find optimal growing conditions especially in organic winter cereals, in particular in cold springs. Severe infestation with this weed may seriously affect the crop through competition for water, nutrients and light and may also cause problems at harvest resulting in reduced crop yield and product quality.

Weed control under Organic Farming conditions is generally carried out by preventive and mechanical measures (harrowing, hoeing) as well as by flame weeding (Struik & Bonciarelli 1997). A considerable disadvantage of indirect or physical control measures against *V. hirsuta* is often the low efficacy and insufficient reliability particularly at early spring (Lindemuth 1924, Habel 1957). Weed regulation with permitted raw salts like kainite could present a low cost addition of control measures used nowadays. Kainite dust broadcast on the dew wet plants can completely destroy the leaf tissue as a result of plasmolysis, thereby destroying young weed plants (Vasters & Remy 1914, Uhl 1952). The optimal conditions for successful control of *V. hirsuta* in winter cereals are described in detail by Lukashyk et al. (2008). The most important results from this study showed that solutions of kainite were sufficient to control *V. hirsuta* in all developmental stages. Nevertheless, efficacy was highest at early weed growth stages (< 4 leaves). Increasing chloride concentrations of kainite resulted in an increased degree of efficacy. The kainite efficacy was heavily dependent on weather conditions. It was sufficient at the time of high air humidity, warmth and absence of rainfall before and after kainite application.

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The main aim of the investigations presented here was to test the influence of *V. hirsuta* control with kainite on winter cereals at different crop growth stages. Secondly, the efficiency of kainite as crop fertiliser has been investigated.

Materials and methods

In 2002-2003, two-factorial field experiments (randomized complete block design, four replications, plot size 1.5 x 10 m) with kainite (59% NaCl, 17% KCl, and 16% $MgSO_4$, Kali & Salz GmbH 2002) were conducted in winter wheat (*Triticum aestivum* L., cv. *Pegassos*) and winter rye (*Secale cereale* L., cv. *Nikita*), respectively. The trial sites were located at two organic farms in North-Rhine Westphalia, Germany.

In 2002, different concentrations of kainite (dust: 150, 300, 450 kg ha^{-1} and solution: 250 kg ha^{-1}) were applied once at different growth stages (GS) of winter cereals (wheat: GS 24, 30, rye: GS 29, 32). In 2002, the trial in winter wheat was modified due to insufficient efficacy of kainite (dust formulation) on *V. hirsuta* at first application time (GS 24). Plots of this trial that had not been treated until then were applied with kainite solutions only (150, 250 and 350 kg ha^{-1}, 1000 l ha^{-1}) at GS 39 of wheat. Latter kainite concentrations were repeated sprayed in 2003 in both cereal crops (wheat: GS 23, 30, rye: GS 27, 32). The kainite dust (grain size ≤ 0.5 mm) was broadcast on the wet leaves in the morning dew. The kainite solutions including adhesive adjuvants (ProFital fluid, 0.1%) were applied under dry weather conditions. In order to examine the fertilising effect of kainite on the crop one treatment of granulate kainite (600 kg ha^{-1} = 54 kg K ha^{-1}) was included in all trials. Granulate was broadcast among the cereals rows always at first application time. The parameters assessed were crop damage and regeneration, stand density, grain yield as well as thousand-grain weight. Crop damage and regeneration were estimated by visual evaluation of yellowed leaf area (10 days after application) and of covered ground by crop (before and 30 days after application) on entire plot, respectively. The statistical analysis of data was carried out with 'Statistical Analysis System' (SAS-Institute-Inc. 1999). Parameter means were compared by Tukey's multiple post-hoc test (□ = 0.05).

Results and Discussion

Crop damage and regeneration

In 2002 and 2003, kainite applications at GS 23-32 of winter cereals reduced crop leaf area by a maximum of 16.7%. Applications of kainite solutions at later growth stages of winter wheat (GS 39) caused severe crop damages (yellowing of leaf area), which positively correlated with the kainite concentration. The application of 150 kg ha^{-1} kainite (= 13 kg K ha^{-1}) caused significantly lower damages (20%) compared to the highest concentration of 350 kg l^{-1} (= 31 kg K ha^{-1}), which resulted in a loss of 48% of the crop leaf area. Cereal resistance to kainite applications at early growth stages is probably due to morphological features like leaf position/thickness and protecting wax layers (Wehsarg 1931). Leaves of monocots, such as winter cereals are more upright and, therefore, have a smaller contact surface compared to dicotyledonous plants (Vasters & Remy 1914, Korsmo 1930, Hock et al. 1995). This fact would explain the small damage on the cereal crop at GS 23-32. Compared to the early application time the leaf area at GS 39 of the winter crop was larger and the leaf position more horizontal. Consequently, the enhanced adhesion of kainite on the leaf surface allowed an easier penetration into the leaf tissue, thereby inducing greater damages.

Cereal crops recovered rapidly from injuries caused by kainite applications at GS 23-32. Monocots like winter wheat with protected growing points that are located near the soil surface were able to reproduce shoots shortly after the flame weeding induced damage (Ascard 1995). The leaf area loss in winter wheat after the application at GS 39 could only partly be compensated by the re-growth of new leaves.

Yield parameters of winter crop

In 2002, the application of kainite solutions at later development stages of winter wheat (GS 39) tended to result in lower grain yields (not significant) compared to the untreated control (Table 1), although *V. hirsuta* control was sufficient (data not shown). This result can be explained by the severe growth delay of wheat through considerable leaf area loss (up to 48%). At the same time kainite applications (250 kg ha^{-1}) at GS 32 of winter rye increased grain yield significantly compared to the treatment with kainite granulate (54 kg K ha^{-1}) (Table 1).

Tab 1: Grain yield (GY, dt ha^{-1}), stand density (SD, ears per m^2) and thousand-grain weight (TGW, g) of winter cereals as affected by kainite concentration and formulation (D - dust, G - Granulate, S - solution) as well as application time (crop growth stage - GS), 2002.

Kainite concentration (kg K ha^{-1})	Winter wheat (GS 39)					
	GY (dt ha^{-1})	SD (ears per m^2)	TGW (g)			
Untreated control	28,8 a	342 a	40,0 a			
13 (S)	27,9 a	339 a	37,6 a			
22 (S)	28,5 a	336 a	38,7 a			
31 (S)	26,9 a	319 a	38,3 a			
54 (G)	16,2 b	314 a	33,3 b			
	Winter rye					
	GS 29			GS 32		
	GY	SD	TGW	GY	SD	TGW
Untreated control*	49,6 a	368 a	29,4 a	49,6 ab	368 a	29,4 a
14 (D)	49,3 a	359 a	30,0 a	46,4 ab	375 a	29,1 a
22 (S)	51,6 a	365 a	29,7 a	53,0 a	380 a	30,1 a
27 (D)	50,1 a	350 a	29,9 a	48,9 ab	356 a	29,1 a
40 (D)	48,2 a	355 a	29,1 a	49,6 ab	361 a	29,1 a
54 (D)	49,3 a	359 a	30,3 a	48,4 ab	377 a	29,6 a
54 (G)*	44,9 a	367 a	28,2 a	44,9 b	367 a	28,2 a

Different letters within the same column indicate significant differences (Tukey's Test, α= 0.05). *same treatments for both application times

This fact is probably due to the improved crop growing conditions after *V. hirsuta* control. In plots where kainite granulate was applied as a fertiliser *V. hirsuta* growth was enhanced (Lukashyk et al. 2008), resulting in a severe reduction of winter wheat yield (43.8%) and lower thousand-grain weights (16.8%) compared to the untreated control (without kainite) (Table 1). Winter rye also tended to give lower grain yield in fertilised plots compared to the other treatments. To conclude, besides the herbicide effect kainite applications enhance the development of both crop and *V. hirsuta* due to the fertilizing effect. However, *V. hirsuta* as a legume weed with self-sustaining nitrogen supply developed much better than the cereal crops in our experiment. The enhancing effect from kainite on the growth of cornflower (*Centaurea cyanus* L.) has also been observed in winter rye (Remy & Vasters 1915). According to Apenrade (1912) and Wehsarg (1931), kainite can be used for both weed control and overhead potash fertilisation of the crop.

In 2003, crop yield parameters were not significantly affected by the tested treatments. However, all kainite applications tended to result in higher corn yield of both winter cereal crops compared to the untreated control.

Conclusions

The results of this study showed that yield relevant damages of winter cereals caused by using kainite were not determined. In order to avoid fertiliser effects on weeds kainite should be applied to winter cereals under optimal weather conditions at GS 20-25 to achieve greatest efficacy on *V. hirsuta* and lowest potential for crop damages. The time span in which kainite can be applied in winter rye is short due to the rapid development of the crop.

Acknowledgments

The authors wish to thank the Ministry of Environment, Nature, Agriculture and Consumer protection of North-Rhine Westphalia (Germany) for funding this research.

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Efficacy of indigenous botanicals and bio-rationals in the management of cabbage pests in an organic farming system

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Key Words: Biological control, botanicals, cabbage, concoctions, pests

Abstract

Cabbage is an economically important crop in Uganda. Pests are number one constraint limiting qualitative and quantitative production. Organic cabbage production is picking up and farmers use botanicals to control pests. Used botanicals are not evaluated scientifically, though there is a rich indigenous knowledge about pest management. This has resulted into misuse of botanicals, and as such, pest management is labour intensive and uneconomical. Therefore, a study was conducted during to growing seasons to evaluate farmer used botanicals against major cabbage pests. Pests usually found on cabbage were recorded. Note was taken of percentage number of leaves damaged by the diamond back moth, aphids and the cabbage lopper per plant per treatment. Yield was also noted at harvest stage. Generated data was analyzed for variance (ANOVA) using SPSS and graphs were made using Excel computer programme. Use of Tephrosia powder and solution was found to be the most effective treatment against cabbage pests. This treatment was better than a mixture of citronella, chili, andTephrosia solution. Tephrosia powder and solution, as well as chili solution spray are recommended for use against cabbage pests in the organic farming system.

Introduction

White cabbage (*Brassica oleracae*) is one of the most widely grown and eaten vegetables in Uganda (Mukiibi, 2001). Most production takes place during the rain season. For maximum economic benefit and better profit margin, farmers grow some cabbage crop in the dry season. During the dry season, both nursery and field crops are infested with diamond back moth (*Plutella xylostella*) and aphids (*Aphis gossypi*), cabbage lopper (*Helicoverpa armigera*) (Kakuhenzire *et al*., 1997). Some biological control activity has been observed in the field with coccinelids and *Didegma* spp being most common. However, biological control is not sufficient during the dry season. Environment friendly pest management practices are, therefore, required during this time. Farmers control these pests by applying a concoction of botanicals, but with neither specific rates nor concentrations (Table 1).

This situation of smallholder farmers is the same in organic cabbage production. In Uganda, the most commonly used botanicals are Citronella (*Cymbopogon nardus*), African marigold (*Tagetes erecta*.), Muluku (*Tephrosia* spp.), and various types of chilie (*Capsicum* spp.). These materials are used individually or in mixture. Nevertheless, efficacy of these botanicals/ bio-rationals has not been scientifically evaluated in Uganda.

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Tab. 1: Botanicals used in agricultural production (Stoll, 1998)

	Plant species	Part of plant used	Target pests/ used as
1.	Cymbopogon citratus (Lemon grass)	Leaves	Repellent: various insects
2.	*Cymbopogon nardus* (Citronella grass)	Leaves	Repellent: banana weevils, aphids, diamond back moth
3.	*Tagetes erecta* (African marigold)	Leaves and stem	Repellent: various insects
4.	*Tephrosia* spp. (Muluku)	Leaves and roots	Miticide: pigs mange (olukuku), mites

This study aimed at evaluating the efficacy of various botanicals traditionally used against cabbage pests in organic cabbage farming systems.

Materials and Methods

Field experiments were established between October 2005 and June 2006. Two cabbage crops were planted using variety Copenhagen. Twenty five plants were planted in 4 m² plots. Five treatments were applied. Each treatment was replicated three times. Applied treatments included:

T1- Citronella grass was harvested from strip bands elsewhere and mulched in a cabbage crop sprayed with a chili solution spray of 250g of chilli powder per 10 litres of water, prepared just before use

T2- Tagetes solution with 250g of dry powder of Tagetes leaves per 10 litres of water, allowed to stand for 12hrs socked overnight, was applied

T3- *Tephrosia* powder was dusted onto plants at rate of 50g per plant and a *Tephrosia* solution of 250g dry powdered leaves, allowed to sock overnight for 12 hours in 5 litres of water was applied

T4- A mixture of treatment (1) and (3) was applied for this treatment

T5- Water was applied without any mixtures as a control

All treatments were applied once every fortnight. Data was collected once a week from all 25 plants in the plot by counting the number of leaves infested by diamond back moth (*Plutella xylostella*), aphids (*Aphis gossypi*), and cabbage lopper (*Helicoverpa armigera*) per plant per treatment. Yield per treatment was also recorded at harvesting stage. Data was analysed for ANOVA SPSS statistical programme, and graphs were made in excel.

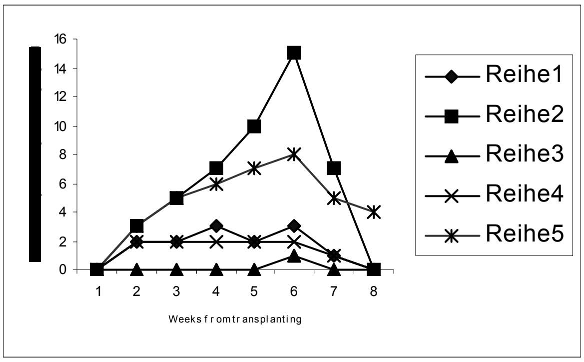
Results

Cabbage pests, which include diamond back moth (*Plutella xylostella*), aphids (*Aphis gossypi*), and cabbage lopper (*Helicoverpa armigera*) were observed in the cabbage field. Application of Tephrosia powder (50g per plant) and *Tephrosia* solution (250g per 5l of water) was most effective in keeping all three pests damage of the cabbage crop low (Figures 1 and 2). These treatments were significantly different from the control for both the first and second seasons (Tables 2). The mixed treatment with citronella mulch, *Tephrosia* powder and *Tephrosia* solution came second in effectiveness against the three insect pests. Both treatments 4 and 3 were significantly different from the control in the first and second seasons. Tagetes solution (250g per 10l of water) alone was least effective, though it was better than the control during both seasons (Figures 1 and 2). A short-term efficacy was noted, where citronella grass mulch only was applied (Figures 1 and 2). A fortnightly rise and fall in pest damage was observed in this case. This treatment was significantly more effective than where mulching and *Tephrosia* powder plus *Tephrosia* solution was applied, as well as the control, which had only water applied as shown in tables 2, and figures 1 and 2.

Even though pest damage in season one was lowest in treatment 3, treatment 4 had better cabbage yield (t/ha) (not shown). It is surprising to note that the yield for the control was better than that in treatment 3, though not significantly different (not shown). Treatment 4 had the highest total yield. Nevertheless, treatment 3 had the highest yield (t/ha) during the second season. It was followed by treatment 1, which involved mulching with citronella grass and spraying with chili solution. Treatment 4 came third and was significantly different from the control. In this case we can say that treatment 4 was most consistent both in controlling pest damage and maintaining high yield.

Discussion and Conclusion

There rich indigenous knowledge on botanicals has scientific justification. Farmers applied botanicals against cabbage pests without validation, but could still observe their effectiveness, which this study unveils. From our results it is evident that all used botanicals are effective against the three major cabbage pests in Uganda. Treatments 3 and 4 were consistently effective and gave high yields. This reflects the reason why farmers always go for a concoction as opposed to single botanical use.



T1

T2

T3

T4

T5

Figure 1: Treatment effect on insect pest damage on cabbage leaves during the first season

However, it is clear that *Tephrosia* powder and solution (T3) gave the most cost effective cabbage pests control package, and could be recommended for use instead of the concoction in treatment 4. This reduces labour intensity and reduces genetic erosion of the beneficial plant.

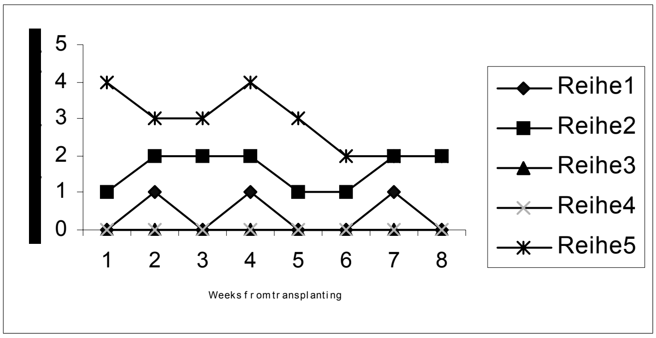


Figure 2: Treatment effect on insect pest damage on cabbage leaves during the second season

T1
T2
T3
T4
T5

The effective use of *Tephrosia* powder formulation indicates the potential to harvest the botanical during periods of less work load and store it for use later in the season. Furthermore, the fortnightly efficacy of treatment 1 (*Citronella* mulch with fortnightly chili spray) shows that chili was more effective than citronella grass mulch. However, its surprisingly high yield could be due to the mulch, which adds to soil fertility and preserves moisture. This, too, is a promising cabbage control package, which could be cost effective for farmers growing both the essential oil crop and vegetables. We, therefore, recommend the use of *Tephrosia*, *Citronella* and chilli botanicals in the organic cabbage production system. However, farmers may not need to go for very complex concoctions as one or two botanicals can be good enough in keeping pests below the economic threshold. Where possible, the chili spray could be done on weekly intervals instead of bi-weekly. However, basing on these findings, it is not advisable to use African marigold (*Tagetes erecta*) alone against cabbage pests.

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Laboratory Studies of the Activity of Spinosad against Leptinotarsa decemlineata (Say) Depending on Different Temperature

Kowalska, J.[1]

Key words: *Leptionotarsa decemlineata*, spinosad, temperature, control

Abstract

Mortality of the Colorado potato beetle larvae (Say) and adults caused by commercial formulation of spinosad at 15, 20 and 25^{0}C was determined under laboratory conditions. The insects and the leaves of potatoes were sprayed with the insecticide. Thus, the insecticide was toxic by exposure to treated surfaces and ingestion. Three concentrations of insecticide were used: 0.2%, 0.1% and 0.05%. The effect was assessed the 6th day after treatment. All concentrations caused mortality both adults and larvae; however mortality of tested insect stages increased as concentration of spinosad increased. For adults was observed the highest mortality in combination with 0.2% at 15^{0}C, whereas at this same temperature in combination with 0.1% was reached the lowest mortality. In tests with the larvae was observed that 0.2% of spinosad caused the lowest mortality at 25^{0}C, whereas concentration 0.1% of spinosad reached the best results at this same temperature. For adults and larvae concentrations 0.05% of spinosad reached the lowest mortality and differences between results in this combination depend on temperature were not observed.

Introduction

Colorado Potato Beetle (*Leptinotarsa decemlineata* Say), CPB, is a very important pest of organic farming. This pest may be managed culturally by crop rotation or destruction of crop debris. In conventional agriculture, the insecticides including imidacloprid or neonicotinoid compounds are commonly used to control of CBP populations, but this pest rapidly develops resistance and additionally these insecticides are forbidden in organic farming system (Council Regulation EEC No 2092/91). In Poland, until now, spinosad is used to control of pests of ornamental plants and in the orchards. Proposed research can contribute to extend the spectrum of susceptible pests. The aim of current study was to evaluate the toxicity of a commercial spinosad formulation to *L. decemlineata*. Effects of post-treatment temperature and stage of development of insects on mortality were investigated.

Materials and methods

In June and July, the adults and larvae of *L. decemlineata* were collected in Western region of Poland. The insects were fed in an insectary. Larvae of the 3th and 4th instar and adults were used in the experiments. Bioassays were conducted in the laboratory using the Petri dishes. The insects and leaves of potatoes were sprayed with different concentrations of spinosad. Experiments have done with Biospin®, a commercial formulation of spinosad (120 g a.i. /L product; DowAgroScience). Solutions of

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spinosad (0.2%, 0.1% and 0.05%) were prepared in distilled water. Volume of water (500 l/ha) were equivalent to that of applied in the field. To investigate the effect of post-treatment temperature the Petri dishes were incubated in the dark at 15, 20 and 25^{0}C. Total number of insects used in each experiment was 50 insects. Each test was performed using two replicates. Summary mortality is presented after 6th day. The data obtained were subjected to ANOVA. The significance of differences was examined using Tukey's test.

Results

Analysis of variance showed significant differences in mortality between temperatures and concentrations of spinosad for both adults (F=13.87, P<0.05) and larvae (F=8.06, P<0.05) (Fig 1 and Fig. 2).

All concentrations caused mortality both adults and larvae, however mortality of tested insect stages increased as concentration of spinosad increased. For adults was observed the highest mortality in combination with 0.2% at 15^{0}C, whereas in this same temperature in combination with 0.1% was the lowest mortality. In tests with the larvae was observed that 0.2% of spinosad caused the lowest mortality at 25^{0}C, whereas concentration 0.1% of spinosad reached the best results at this same temperature. For adults and larvae concentrations of 0.05% spinosad reached the lowest mortality and differences between results in this combination depend on temperature were not observed. In the table are included mean results depending on used concentration and temperatures in replicate.

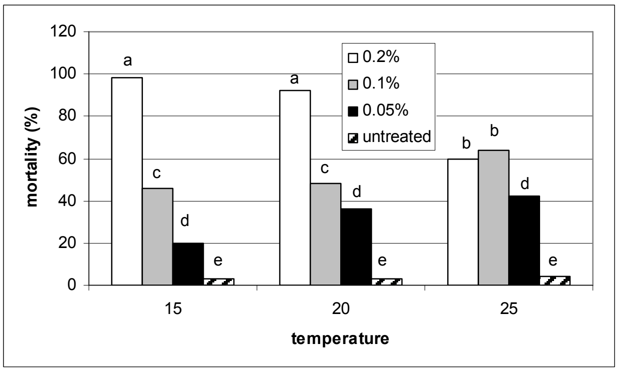

Figure 1: Effect of spinosad on the larvae of *L. decemlineata* depending on temperature (Within the figure, means followed by the same letter are not significantly different)

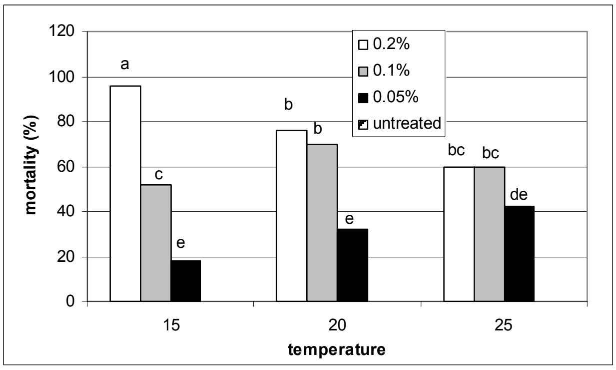

Figure 2: Effect of spinosad on adults of *L. decemlineata* depending on temperature (Within the figure, means followed by the same letter are not significantly different)

Tab. 1: Average mortality of different stages of development of *L. decemlineata* depending on temperature and concentrations of spinosad

Temperatures/ Concentrations of spinosad	Mortality of CPB larvae/replicate ± SD	Mortality of CPB adults/ replicate ± SD
15^0 C	27± 1.8b	28 ± 1.9a
20^0 C	29.3± 1.8b	30.3 ± 1.9a
25^0 C	34 ± 1.8a	27.3 ± 1.9a
0.2%	47.3±1.8a	39.3±1.9a
0.1%	28±1.8b	31±1.9b
0.05%	14.6±1.8c	15.3±1.9c
untreated	2.0±1.8d	0.0±0.0d

Within each columns, means followed by the same letter are not significantly different, n=50 insects/replicate

Discussion

Spinosad is derived from fermentation products of actinomycete bacterium (Mertz and Yao 1990). Depending on the species, stage of development or mode of application spinosad may be various toxic. The active components, spinosyn A and spinosyn D can effective control pests of the orders Lepidoptera (Sparks *et al.* 1995, 1998), house flies (Scot 1998), eggplant flea beetle (McLeod *et al*. 2002) and stored-product insect species (Huang *et al.* 2004). This insecticide is effective to insect species that are resistant to some synthetic insecticides (Lui *et al.* 1999) and has a limited impact on non-targeted organisms (Sarfraz *et al*. 2005). In the laboratory, spinosad treatments were toxic to *Mamestra configurata* Walker, *Phyllotreta cruciferae* Goeze (Elliot *et al*. 2007). Among beetle species toxicity is various, for example spinosad was over 400 times more toxic to adult of *Rhyzopertha dominica* F. than to adult *Tribolium castaneum* Herbst (Toews and Subramanyam 2003). The effect of spinosad depends on mode of application and temperatures. Temperature has no effect on the toxicity of spinosad to stored-product beetles (Fang and Subramanyam 2003), whereas in the grasshoppers that is important factor for mortality of pest (Amarasekare and Edelson 2004).

The data of this study showed that temperature influences an effect of spinosad on larvae of *L. decemlineata* and adults. The larvae of *L. decemlineata,* like *Oulema melanoplus* (L) and adult *Epitrix fuscula* (Crotch) are characterized by different susceptibility to spinosad applied to foliage.

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Plant Health and the Science of Pests and Diseases

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Keywords: agroecology, phytiatry, plant protection

Abstract

The health/disease duality has developed alongside human history either as a struggle for survival or as a challenge of the human being to effectively get to know himself. To speak about pests and diseases of plants may not be as exciting as when speaking of human beings; however, entomology and phytopathology hold methodological similarities to conventional medicine, which, thus, allow for correlations among them. After all, plant protection and human medical science are based under common epistemological principles of modern scientific thought. Hence, the goal of this essay is to disclose certain disagreements of the disciplines of phytopathology and entomology with agroecological based science; yet, giving way to a discussion according to ecological principles. This is a theoretical essay, based on bibliographical research and on the direct experience of the authors with family farmers in the South of Brazil during the last 20 years.

Introduction

It seems unquestionable that human thought has evolved, and, with it, the organization of knowledge as the rest of the real/concrete world. Yet, such thinking is not hegemonic. The science of diseases and epidemic pests of human beings - medicine - has been construed by means of rational thought and observation, by thinking and reflecting on the phenomena, the processes, the causative powers of illnesses; therefore, on the ways in which we could possibly intervene in them. It was the Hellenic civilization that, before 300 B.C., gave way to the first reported account of the Western philosophical tradition, conceiving health as *soteria* [gr.] = harmony or saving; disease/illness as *pathon* = suffering, passion, lack of freedom; and therapy/cure as *therapeia* = body care, serve, to render praying. It is noteworthy that the etymological meanings of these terms are quite different to those underlying contemporary medical practice and, just the same, plant protection science. In spite of efforts to alleviate human suffering, the modern medical system paradoxically cannot avoid the resurgence of infectious diseases (Foladori, 2005). In comparison, agronomical science has established a conventional approach which subordinates the scientific disciplines of entomology and phytopathology to the development of technologies for a maximum yield. This orientation gave rise to the contradiction of offering food security by means of a system that increasingly demands use of pesticides (Tansey & Worsley (1997). The objective of this work is to unveil some contradictions between conceptions of plant protection and agricultural production

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*This research has been partially supported by Guarani-Serra Geral Network Consortium FAPESC/CNPq/ANA.

systems, including intensive organic systems, when analyzed in the light of agroecological principles; therefore, opening the discussion for a new perspective towards the development of a science in actual support of sustainable agricultural.

Materials and methods

This work is based on theoretical analysis of current bibliography and on personal accounts of encounters with organic and non-organic farmers of the South of Brazil.

A) The history of the disease/health process

The illness/health process can be delineated by means of several historical phases, with some overlapping, giving explanation to this phenomenon (Machado, 2000). All the same, it was only by the second half of the XIXth century, with the contributions of Pasteur and Koch, that the modern scientific paradigm of medicine was first construed: biological agents were appointed as the cause of diseases and a method for verification was established. The methodological procedure has since then been successful and, yet, extended to animal and plant disease diagnoses as well. At times, this procedure may be further extended to epidemiological studies, when a population is affected by means of host and pest interaction. Incidentally, at the same time, Darwin stated that natural selection was the major force in the origin of new species, due to the competitive ability among lines within the same genetic basis, which further corroborates the idea that biological interactions, such as parasitism and plagues, are no more than constant faith and struggle for survival (Boff et al., 2003; Abdalla, 2006).

Pasteur determined that the causing agents of diseases among silkworms and of sour wine were microbial agents. By isolating the cause one could make the silkworm healthy and with quick heating, yet, save the wine. The underlying idea of both processes is that the microbiological agent and the host cannot come together.

B) Experience with family farmers

During the last 20 years, several family farms of the “Alto Vale do Itajai” and of the “Planalto Serrano Catarinense” regions were visited and on-farm research was done. This direct contact has allowed us to get a better idea of how farmers actually and effectually deal with pest and disease problems on crops and animals and what their references of knowledge are when deciding to intervene and treat the affected crops or apply drugs to the livestock or, yet, if care is granted to the family members as well.

Results and Discussion

A) Divergencies and contradictions

Pests and diseases on plants are generally perceived as undesirable events on farms. They clearly compete with human beings and, thus, must be eradicated or, at least, well controlled. The conceptual basis of this currently generalized farming way of thought probably came from the green revolution knowledge package, influenced by Pasteur’s microbiological paradigm and the Darwinian ideas of evolution by means of the survival of the fittest.

In the “Alto Vale do Itajai” and “Planalto Serrano Catarinense” regions of Santa Catarina State, Brazil, we observed that the logical basis for the intervention and management of pests and diseases on crops is the same for the conventional as well as for the majority of organic farmers, mainly if they are dealing with intense crop farming. As a consequence, organic farmers increasingly search for external inputs to solve pest and disease problems, for example, biological control agents, resistance inducers, and a series of intervention measures using homemade preparations, plant extracts, etc. When doing so, farmers give expression to the idea that the nearby nature cannot help them under such agricultural conditions; hence, rescue must come from external sources. In spite of worldwide advocation of integrated pest and disease control - IPM - as an ecologically sound program, most experiences in Brazil failed to replace pesticides, and, in some cases, where an alarm system (forecast) was followed, an increase in the use of pesticides was further stimulated in order to fulfill the objectives of the prevention method itself. The use of external inputs for the solution of most internal problems in production systems diverges from the agroecological principle of promoting resilience by conceiving agriculture as an image of nature; consequently, such an approach fails to take into account that local and internal resources are the best solutions (Soule, 1992). Farmer Field Schools, supported by FAO programs, may be a good example to empower farm knowledge. Moreover, the mere implementation of technological interventions does not necessarily increase yield, as demonstrated by Gonçalves (2001), whose data clearly showed no effect of the intervention measures to control pests and diseases on onion crops in comparison to the non-intervention ones, as long as the system was running under healthy soil conditions. In fact, if one considers health as a matter of nutrition as postulated by Chaboussou (1969) through the Trophobiosis theory, perhaps recovering the ancient Hippocratic idea (300 BC) of “your meal is your medicine”, one must ask: why is it that such an idea is not recognized by the whole of the organic movement?

According to our point of view, and from what we could learn with the farmers, the discussion of plant health must start from conceptual principles other than those underlying the parasite/pathogen x host duality. Moreover, in the 60’s to the 70’s, environmental problems were thought to be threatening all life on earth. Society was concerned with the development of new technologies, regardless of their effective need or not. As a consequence, it was from this standpoint that a new approach of science, which took ecological principles into account, gave ground to supporting the public debate, and the world movement of organic agriculture was launched. However in Latin America, because of the socio-economic and political situation, the public debate on conventional agriculture embraces not only environmental questions but social and political issues as well, making the organic movement a further opportunity to change present socio-economic relations into ones based on principles of cooperation, fair market and farmer sovereignty. One may yet argue that Agroecology, as the science to provide appropriate technologies, takes a rather different role, whether it is required merely for environmental concerns, as in the Northern countries, or has, in addition, a socio-political orientation, as in the Latin-American countries.

B) Ecological emergence for new plant health rationality

Ecological based changes of agricultural systems should start from the assumption of mutual aid and cooperation among all living systems, as a permanent call for the improvement of the production systems (Abdalla, 2002; Kropotkin, 1902). Regulatory mechanisms of pest and disease epidemics should be realized by means of symbiosis, multitrophic interactions, antagonism/ synergism, cooperative attitudes and tolerance as to improve harmony in the living systems, which may yet include crops (Boff et al., 2003). The challenge in designing agroecosystems for sustainable agriculture is to optimize yields, considering the diversity of life, the complexity of the living systems and the social compromise with healthy food. Resilience of agricultural systems should be the target for such designs, for it can grant a dynamic equilibrium, absolving the impacts from biologic disturbances, such as pests and diseases. As such, agroecology entails a plant medicine, which has the perspective of promoting cooperation, niche co-existence, and the transversality of knowledge (Abdalla, 2002). If such requires scientific knowledge not to be found within the boundaries of the disciplines of entomology and phytopathology, than it probably is the opportunity to build a new scientific body for the care of plants in agroecosystems. Would Phytiatry be a suitable plant care science?

Conclusions

Agroecology calls for a new rationality other than that which was built within the scientific disciplines of entomology and phytopathology. This new scientific body for plant health must consider cooperation as a common event among all living systems. Complexity, complementarity and multifuntionality are primordial dimensions to build a science to deal with plant health in harmony with agroecological principals.

Acknowledgments

We acknowledge the agroecological team of Epagri and the Brazilian Agroecology Association for frequent debates and discussions and for giving various suggestions for the construction of a new perspective of plant health on scientific bases.

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Soil Fumigation with Allium Sulfur Volatiles and Allium By-Products

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Key words: biofumigation, *Allium* spp., by-products

Abstract

Like Brassicaeae spp., Allium spp.have biofumigation properties attributed to sulfur components, mainly three disulfides: dimethyl disulfide (DMDS), dipropyl disulfide (DPDS); and diallyl disulfide (DADS), with an efficacy superior to that of DMDS. In this study, the biofumigant activity of Allium (onion and leek) by-products was investigated in vitro and in vivo. In vitro, the experimental model consisted of a host-pathogen system: cucumber-Pythium ultimum. The results of the bioassay show that cucumber plants in compost inoculated with the pathogen and containing onion or leek by-products show better vegetative growth than the control. In vivo, soil biodisinfection with onion by-products in asparagus leads to a yield intermediate between the untreated soil and the methyl bromide treatment. Another aim of the present study was to get more data about the nematicidal activity of disulfides. The activity of DMDS and DADS was evaluated on two nematode species.

Introduction

The substances implicated in the beneficial effect of *Allium* spp. on human health are mainly sulfur compounds, such as disulfides (DS) and thiosulfinates (Ti) (Agarwal, 1996). These chemicals are also responsible for the natural defences of these species against herbivoro[1]us pests and pathogens. They are insecticidal, fungicidal, acaricidal, nematicidal, and bactericidal (Auger et al, 2004).

When tissue of an *Allium* is crushed or degraded by micro-organisms, an enzyme, alliinase, which is stored in the vacuoles, reacts with S-alk(en)yl-L-cysteine sulfoxides (RCSO) (Lancaster et al, 1988) to give sulfenic acids (Ferary and Auger, 1996). In onions and leeks, several RCSO (R= methyl, propyl, 1-propenyl) are present and a complex rearrangement occurs to give mainly dipropyl disulfide, DPDS (Arnault et al, 2004) as the endproduct of biosynthesis. For some wild *Allium* spp., such as bear's garlic (*A. ursinum*), the major RCSO is methiin (S-methyl-L-cysteine sulfoxide); it gives dimethyl thiosulfinate (DMTi), which gets rearranged into DMDS.

The nematicidal and fungicidal activity of *Allium* has been widely reported (Auger et al, 2004); this great pesticidal potential allows us to envisage the use of *Allium* spp. for soil fumigation (Auger et al., 1994).

In the Val of Loire, asparagus is a traditional crop representing an important economic activity. However, the soils increasingly show the phenomenon of soil stress.

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Therefore, in place of methyl bromide, which now is definitively banned, the maintenance of these cultures requires the use of new fumigants. Among the alternatives, biodesinfection with *Allium* spp. is an interesting method. In this study, we evaluated the fungicidal activity of onion and leek by-products *in vitro,* with an experimental model, and *in vivo,* with field experiments (asparagus). We also studied the nematicidal effect of DMDS on other soil pests, especially two nematodes, *Meloidogyne graminicola* and *Heterodera sacchari*

Materials and methods

Fungicidal test: *Pythium ultimum* type test

The compost used in glass jars was artificially infected with *Pythium ultimum*, with its presence controlled to obtain a high level of infection and a homogenous inoculate.

The by-products were mixed, wetted, and homogenised with the compost and transferred into the jars, just covered by an aluminium sheet that allows gas exchange.

For each test, we used a sterile standard without *P. ultimum* inoculation, and an infected standard inoculated with the fungus. We tested the activity of *Allium* by-products at three different times: 15 days, and one and two months. After these periods, we tested the capacity of the compost to be used for a culture. For this purpose, seeds of cucumber, a plant very sensitive to *P. Ultimum*, were put in contact with the compost. At the end of the growth period (13 days) the healthy, necrotic, and dead plants were counted.

Two disulfides were tested, DMDS and DPDS, with two amounts of by-products in the compost: 120 and 240 tonnes/ hectare (T/Ha).

Nematicide tests

Heterodera sacchari is a cyst nematode common in Africa and some Asian countries. This cyst-forming nematode has sedentary endoparasitic habits (Nobbs et al., 1992). Rice (*Oryza sativa*) and sugarcane (*Saccharum officinarum*) are the major field crops infected by this nematode.

Meloidogyne graminicola (rice-root nematode) is a common species in the tropics and subtropics, where it infects numerous grasses, including rice (Prot et al., 1993).

Because infesting larvae are the most sensitive to biofumigants at day 2 (d2), we calculated the LC50 (lethal concentration for 50% of the population) with DMDS for the two nematodes species at d2.

Field experiment

In 2002, the asparagus parcel was prepared and disinfected with *Allium* by-products and methyl bromide, which constitutes the reference. An undisinfected parcel was also used. An elementary parcel was composed of three ranks of asparagus (128 plants, 144 m²). The control was the central rank. The biodisinfection effect was evaluated by incorporation of onion and leek by-products (75 T/ha).

Asparagus was planted in the parcel in April 2003; we measured productivity at the harvests in April 2004 and 2005.

Results

Fungicidal tests

Compared to the infected standard, where the plants show necrosis, not only was the sample with DMDS treatment healthy, but moreover a stimulant effect could be observed. Furthermore, DMDS was more toxic than DPDS.

Figure 1 shows the results for 240 T/ha of *Allium* by-products in the soil. With onions we can observe a Concentration-Time (CT) effect that is characteristic: 74% at 15 days and 94% at 1 month. Leek by-products were less efficient than the onion treatment. The optimum disinfectant effect is reached sooner for the 240 T/ha dose (1 month) than with 120 T/ha (2 months).

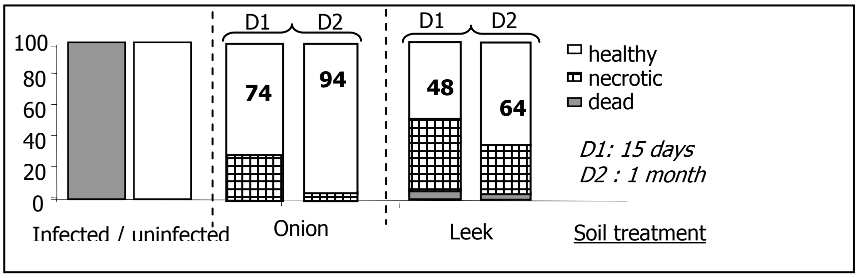

Figure 1: Percentage of healthy, necrotic and dead cucumbers after *Allium* by-products were incorporated in the soil (240 T/ha).

Nematicide tests

The LC50 of d2 larvae *(H. sacchari*) is 0.79 µl/l. *M. graminicola*, for which LC50 = 1.6 µl/l, seems to be more sensitive to DMDS than *H. sacchari*.

Field experiments

Two years after planting, the parcels disinfected with *Allium* by-products had lower productivity than the ones disinfected with methyl bromide. But the incorporation of onions leads to an intermediate yield between the methyl bromide reference and the undisinfected parcel (Figure 2).

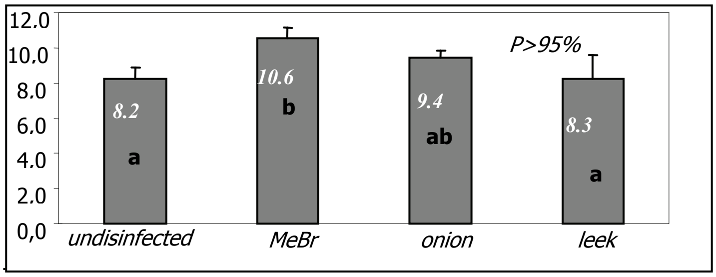

Figure 3: Yield (T/ha) of asparagus under four different disinfection conditions: undisinfected, MeBr, onion, and leek.

Conclusion

This study shows *in vitro* and *in vivo,* with field experiments, the disinfection effect of *Allium* spp., particularly onion by-products. The result can be explained by the kind of by-product used. For onions, the by-products are unmarketable onions bulbs, while for leeks they are the wastes from peeling, i.e. the green leaves, which are well known to contain less sulfur compounds, in accordance with their lower dry matter content. DPDS, the gas produced by onion and leek by-products in soil, persists for more than one month (Arnault et al., 2004). The results point to the ability of *Allium* by-products to disinfect a soil. The doses, contact time, and characteristics of the by-products are very important.

Discussion

Allium spp. offer good potential for soil disinfection, but the practice in the field must be improved. For this purpose, the choice of *Allium* spp. can be modified. As DMDS is much more effective as a disinfectant and pesticide than DPDS, *Allium* spp. with high potential levels of DMDS could be tested, so that the doses incorporated in the field could be reduced. Some wild *Allium* species contain more DMDS than marketable *Allium*. For example, *A. vineale (*wild garlic*) and A. ursinum (*bear's garlic), contain more than 50% of methiin, the DMDS precursor (Keusgen et al, 2002).

Acknowledgments

We acknowledge the “Region centre” and “Delegation regionale à la recherche et à la technologie” for their financial support.

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Pest and Disease Management of Potato Crops with Homeopathic Preparations and Germplasm Variability *

Boff, P.[1], Madruga, E.[1], Zanelato, M.[2,3] & Boff, M.I.C.[2]

Keywords: plant homeopathy, genetic resistance, potato

Abstract

The Plateau of Santa Catarina state, Brazil, is the main potato seed producer of the country. Its regional climate, however, with wet summers has been pointed out as the main factor for restricting productive quality and raising prices. This research had, thus, the objective of studying the efficacy of homeopathic preparations, homemade formulations and genetic variability in the management of pests and diseases at field conditions on organic farming systems of potato crops. Two field experiments were installed during the 2006/07 crop season. In experiment 1, the following genotypes were planted as treatments: Catucha and Epagri (landrace), Monalisa and Agata (Holland), and Panda (Germany). In experiment 2, the statistical design was a split plot with the Monalisa, Catucha and Epagri genotypes as sub plots, and nine spray preparations as the main plot as follows: Chamomilla 60CH, Silicea 60CH, Kali 60CH, Thuya 60CH, biotherapic of Phytophthora infestans 60CH, water 60CH, the homemade preparations of Bordeaux mixture at 0,3% and of propolis extract at 0,5%, and, finally, a no-intervention treatment. Results showed that the Catucha genotype, a bred landrace, yielded 21 t ha^{-1} and presented the lowest disease incidence. Even though no preparation differed significantly from another; the Thuya homeopathic treatment yielded the best results with more than 26 t ha^{-1}. Natural enemies were not affected by any of the spray preparations.

Introduction

The state of Santa Catarina, in the South of Brazil, is a main producer of potato seed tubers (*Solanum tuberosum*) (Souza, 2005). The crop is typically grown in family farms with a high labor input. Climatic conditions allow breeding in almost every season of the year, but commercial varieties show high susceptibility to pests and diseases (Souza & Silva, 2007). As a consequence, farmers use a lot of pesticides to fill commercial requirements of consumers and industries alike (Bull and Hathaway, 1986). On the other hand, such use raises public concerns, either due to chemical residues in food or in the public water supply, as crops are located within the micro catchment area. Hence, farmers are changing and adopting more ecologically integrated or purely organic production systems (Boff et al, 2004). And as the latter

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[3] Scholarship sponsored by CNPq-Brazil.

* This research was partially supported by CNPq, proj.n. 55.3361/2005-08, and the Guarani-Serra Geral Network Consortium FAPESC/CNPq/ANA.

grow, so does the demand for potato tuber seeds from organic production systems as well. All the same, during transition from one system to another, an alternative technology, completely replacing agrochemicals, is required. Accordingly, this research was carried out to evaluate the efficacy of homeopathic preparations and the use of landrace bred clones for managing pests and diseases on potato crops.

Materials and methods

Two field experiments were carried out at the Lages Experimental Station of EPAGRI–Agricultural Research Institute of Santa Catarina, Brazil, in an organically managed area during the last two years.

Experiment 1 was planted on October 19, 2006, and Experiment 2 was planted on October 26, 2006. In experiment 1, the statistical design was of randomized blocks with four replicates. Treatments were represented by the Catucha and Epagri (landrace varieties), the Monalisa and Agata (Holland) and the Panda (Germany) germplasms. All plots were sprayed equally with the homeopathic preparation *Silicea 60CH*.

In experiment 2, the statistical design was a split plot with randomized blocks and four replicates. In the subplot, the germoplasms of Catucha and Epagri (landrace germoplasm), and of Monalisa (Holland) were planted. In the main plot, plants were treated with the following homeopathic preparations: *Chamomilla* 60CH, *Silicea* 60CH, *Kali* 60CH, *Thuya* 60CH, biotherapic of *Phytophthora infestans* 60CH, water 60CH, and a homemade preparation of Bordeaux mixture at 0,3% and propolis extract at 0,5%. The control treatment consisted of non-sprayed plots.

Homeopathic remedies were prepared according to the Hahnemann method as described in the Brazilian Homeopathic Pharmacopoeia (1997). The dosage used for the homeopathic preparations was 12 ml per liter. Preparations were applied in two-week intervals, 15 days after emergence until flowering.

Evaluations of disease intensity, pest incidence and yield at harvest were made. Diseases were estimated according to the intensity of the foliar symptom (1=absent to 6=more than 50%). Insects were directly counted and expressed in numbers per plant.

Results

A) Experiment one - Potato genotypes

The highest yield was obtained with the Catucha landrace potatoes, in contrast to Agata (Holland), which granted the lowest yield (Tab. 1).

The Epagri landrace germplasm was as good as Monalisa but worse than Catucha.

Agata was the most susceptible to *Phytophthora infestans* and to *Alternaria solani*. Monalisa presented the high number or *Diabrotica pest.*

Tab. 1: Yield, disease and pest intensity of potato varieties grown under organic systems, 2006/07, Brazil. Data from four replicates.

		Intensity (1 to 6)		Number per plant	
Cultivar	T ha^{-1}	Alternaria solani	Phytophthora infestans	Diabrotica speciosa	Natural enemies
Catucha (Brazil)	21.36 a	1.4 c	1.7 b	9,5 ab	3,5 nd
Monalisa (Holland)	12.22 ab	1.7 bc	4.1 a	14 a	5,0
Epagri (Brazil)	14.25 ab	1.3 c	1.1 b	7,5 b	3,0
Panda (Germany)	11.68 ab	2.2 b	1.3 b	8,3 b	4,3
Agata (Holland)	3.30 b	5.3 a	5.2 a	9,8 ab	2,0
C.V.(%)	54	12	20	25	37

* Different letter in the columns indicate statistically significant differences for P<0.05;

nd=not significantly different

B) Experiment two - Homeopathic preparations

Cultivars and homeopathic preparations were not statistically correlated concerning yield, pest and disease. Although treatments did not statistically differ from one another, the homeopathic preparation *Thuya* 60CH rendered the highest yield (Tab. 2). Preparations did not affect natural enemies.

Tab. 2: Yield, disease and pest intensity of potatoes treated with homeopathic preparations, 2006/07, Brazil. Data from five replicates.

		Intensity (1 to 6)*		Number per plant*	
Preparation	T ha^{-1} *	Phytophthora infestans	Alternaria solani	Diabrotica speciosa	Natural enemies
Bordeaux mixture	23.25	1.6	0.7	0.7	0.3
Bee propolis	23.78	1.9	0.5	0.5	0.5
No Intervention	21.32	2.1	0.4	0.4	0.2
Chamomilla 60CH	22.39	2.0	0.9	0.9	0.3
Silicea 60CH	23.68	2.3	0.4	0.4	0.2
Kali 60CH	26.24	1.9	0.4	0.4	0.5
Thuya 60CH	26.63	1.9	0.8	0.8	0.9
P.infestans 60CH	25.27	2.2	0.4	0.4	0.5
Water 60CH	26.26	1.8	0.6	0.6	0.4
MSD					

* Not statically significant different for P<0.05;

Discussion and Conclusions

Cultivars seem to play a more significant role than spray interventions for managing pests and diseases on organic potato crop systems. Homeopathic preparations are as good as the Bordeaux mixture, a standard spray generally used on organic farm systems.

Landrace bred cultivars are more resistant to pests and diseases and also grant higher yields than introduced ones. The "Catucha" genotype presented the best performance. Despite no significant differences among themselves, homeopathic preparations improved yield in comparison to the untreated plots.

It can be argued that the homeopathic cure for plant diseases is a holistic and complex system that interacts with other agroecological factors, such as soil and climate (Toledo et al., 2003). Even though its impact is statistically insignificant, a homeopathic treatment is as sufficient for an organic system as the standard Bordeaux mixture, without any residual effect as well (Bonato, 2006).

Acknowledgments

Marcia Mondardo for statistical analysis.

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Cropping techniques wheat

Improvement of winter wheat baking quality in ecological cultivation by enlargement of row spacing and undersown intercrops

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Key words: organic farming, winter wheat, row spacing, baking quality, undersown intercrops

Abstract

Under ecological crop growing conditions, considerable problems consistently arise in fulfilling the baking quality of winter wheat demanded by consumers. The "wide row" procedure shows promising potential for effectively using the nutrient supply in ecological cultivation for the production of winter wheat with high baking performance. Increasing the distance between rows of winter wheat from 12.5 cm to 50 cm proved advantageous for the indirect quality parameters sedimentation value and gluten and crude protein concentration. Either no yield decreases or low decreases only up to 10% were noted. Because of an increased tendency to erode and in order to improve of the preceding crop's value, creation of a green zone with legumes between the rows is necessary. To prevent competition between cover and catch crops, mulching of catch crops is required.

Introduction

In ecologically cultivated fields, winter wheat is typically planted with narrow row spacing. However, because of the limited nitrogen supply, the resulting baking qualities do not meet consumers' and processors' demands. This problem comes to a head in stockless ecofarming because of the additional deficiency of forage legumes as a good previous crop, as well as the non-availability of nitrogenous fertilizer from livestock. Both practical experience and initial scientific insights have shown that this problem can be counteracted by increasing the row spacing (GERMEIER 2000).

Materials and methods

During the crop growing periods 1999/2000 and 2000/2001, exact field tests were conducted at four ecologically farmed locations in three different German federal states (fully randomized block design with four replicates). In two control variants, the wheat was planted in rows respectively spaced 12.5 cm (normal procedure) and 50 cm apart. Both variants were kept free of weeds mechanically.

Each of the effects of the wide row system without undersown crops was compared with the normal planting procedure. Of significant interest, however, were analyses regarding the impact of clover catch crops cultivated within the 50-cm rows, sown on three different dates (autumn, early spring, late spring). In addition, the effect of catch crop regulation in spring with the help of a specially developed row-mulching machine

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was investigated. Besides the effects on the yield and quality of winter wheat, environmental effects and the cost-effectiveness of the method also were examined.

Results

Yields of winter wheat were not significantly influenced by the variants of the wide row cultivation system analyzed during the 2000 crop year (Table 1). More advantageous conditions for winter wheat cultivation predominated in 2001. Under conditions of wide row cultivation, the harvest in 2001 was insignificantly diminished (by up to 11%) compared with the normal cultivation method. Autumn catch crops in the wide-row system (mulched and non-mulched) caused significantly lower winter wheat yields compared with the normal cultivation method (a strong competition between cover and catch crops could be the reason). Compared with the variant with 12.5-cm between the rows, the mulched spring catch crops of 2001 had the smallest yield losses, which were statistically significant.

Tab. 1: Grain harvest of winter wheat (Bussard type) in conjunction with row width, catch crop and mulching during the analyzed years 2000 and 2001 (results averaged from the four examined locations, n=128)

Variants**		2000 dt/ha		2001 dt/ha	
Control groups	12,5 cm	33.7	a*	46,7	A
	50 cm	35.7	a	41.5	Ab
Row width 50 cm without mulching	US I	34.7	a	37.5	B
	US II	35.2	a	42.3	Ab
	US III	35.8	a	41.3	Ab
Row width 50 cm with mulching	US I	33.3	a	37.5	B
	US II	33.1	a	43.1	Ab
	US III	34.8	a	44.6	Ab
	$\bar{x}$	34.5		41.8	

* Different letters label significant differences, Tukey test □ 0,05

** Variants:
12.5 cm common row spacing
50.0 cm wide row spacing
US I sowing of catch crops in autumn
US II sowing of catch crops in early spring
US III sowing of catch crops in late spring

Row spacing, catch crops, and mulching technique had clear effects on the baking quality of Bussard winter wheat (Table 2). Merely increasing the row spacing from 12.5 cm to 50 cm resulted in a significant increase of sedimentation value, as well as a tendency towards an increase in gluten and crude protein concentrations.

To guarantee the sustainability of production, recommendations for the implementation of the wide row system must also include consideration of environmental effects. For example, soil in the examined variants showed a variably strong disposition to erosion (Table 3). Simply increasing the row spacing from 12.5 cm to 50 cm significantly increased erosion by ca. 30%. By sowing catch crops in early spring, this negative effect was offset for the most part. Autumn catch crops had the strongest erosion-reducing effect. However, because of the observed decrease in yields in 2001 and the insignificant quality effects in comparison to the control variant with 12.5-cm row spacing, this variant probably cannot be considered for dependable production of baking wheat in ecological cultivation.

Tab. 2: Baking quality parameters of winter wheat (Bussard type) in relation to row width, catch crop, and mulching in 2000 and 2001 (results averaged from the four examined locations, n=256)

Variants**		Crude protein concentration (%) (N x 5,7)		Gluten concentration (%)		Sedimentation value (ml)	
Control groups	12,5 cm	10.6	a*	25.0	a	32.2	a
	50 cm	11.3	ab	27.2	ab	38.0	b
Row width 50 cm without mulching	US I	11.1	ab	26.8	ab	35.7	ab
	US II	11.1	ab	26.7	ab	36.4	ab
	US III	11.3	ab	27.0	ab	37.8	ab
Row width 50 cm with mulching	US I	11.1	ab	25.8	ab	35.4	ab
	US II	11.3	ab	27.8	b	38.4	b
	US III	11.5	b	27.9	b	38.5	b
	$\overline{x}$	11.2		26.7		36.6	

Footnote: see fig. 1

Tab. 3: Erosion (t/ha) in relation to row width and catch crops under laboratory conditions (measured in overgrown soil before sprouting, samples taken from the Wetterau location, vegetation year 2001)

Variants**		Light rain 10 min		Light rain 10 min		Heavy rain 2 min		Heavy rain 2 min		Total	
Control groups	12.5 cm	2.1	a *	1.7	a	6.8	a	9.3	a	20	a
	50 cm	1.2	B	1.9	a	12	b	11	b	26	b
Row width 50 cm with mulching	US I	0.0	C	0.6	c	0.8	c	1.7	c	3.1	c
	US II	1.6	B	2.3	b	9.0	ab	9.0	ab	22	a b
$\overline{x}$		1.2		1.6		7.2		7.7		18	

Footnote: see fig. 1

Discussion

Compared with the control variant with rows spaced at 12.5 cm, the quantity of catch crops produced in the 50-cm spaced rows did not result in a significant increase in quality, as long as these catch crops were not mulched. In comparison with the control variant with rows spaced at 50-cm, the non-mulched catch crops again showed a tendency towards lower indirect quality parameters. This relates to the existence of a competitive correlation between grain cover crops and undersown clover crops at the expense of baking quality. Mulching the catch crops sown in spring apparently eliminated this competition, which, with one exception, was evident in the significantly higher quality parameters than in the control variant with 12.5-cm row spacing.

Conclusions

A detailed description and commentary on the field experimental analyses can be found in BECKER and LEITHOLD (2003) and BECKER (2007). Increasing the distance between rows of winter wheat from 12.5 cm to 50 cm proved advantageous for the indirect quality parameters sedimentation value and gluten and crude protein concentration. Either no yield decreases or low decreases of up to 10% were noted. As a whole, the investigations led to the conclusion that by growing winter wheat in rows 50 cm apart instead of 12.5 cm, a level of quality can be attained in ecological cultivation that meets the demands of high baking quality. The use of E-wheat types remains a prerequisite for meeting this objective, as well as good nitrogen supply from the previous crop. Because of an increased tendency to erode and in order to improve the preceding crop’s value, creation of a green zone with legumes between the rows is necessary. To prevent competitive relationships between cover and catch crops, mulching is required. If no mulching is done, this will lead to losses in quality. The following combination was best able to meet the demands of crop yields, quality, environmental benefit, and preceding crop’s value: 50-cm row spacing, undersowing early enough in spring after raking and/or hoeing, and mulching of the catch crop. The specially developed and tested mulch machines can be considered well tried and proven. Reducing the sowing density by up to 50% compared with normal cultivation was not disadvantageous for the crop or quality. The microeconomic analyses have shown that, provided price premiums are given for quality wheat, the winter wheat’s contribution to overall profit increased by cultivating it with the wide-row system (NIEBERG et al. 2003). With shared use of the expensive row mulching machine by cooperating farms, the cost effectiveness of the procedure is increased further. Implementation of the cultivation procedure is particularly advantageous when it results in positive effects on the other production methods used (by the effects of undersown intercrops) and adoption is possible for the overall enterprise.

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Agronomic and environmental factors explaining Grain Protein Content variability in organic winter wheat

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Key words: organic winter wheat, Grain Protein Content, limiting factors, diagnosis

Abstract

A regional agronomic diagnosis was implemented to identify factors responsible for low values of Grain Protein Content (GPC) in a network of 35 organic winter wheat fields in South-Eastern France. The influence of water nutrition, radiation and temperature, weed density at flowering, nitrogen (N) status of crop at flowering and variety type were studied. Two statistical methods were used successively: classical linear regression and a mixing model approach based on a weighted sum of all possible linear combinations of explanatory variables. GPC was significantly related to variety type, crop N status and weed density. An analysis of variance showed that weed density was related to soil type and nitrogen supply.

Introduction

French organic wheat production is characterized by low and variable Grain Protein Content (GPC). For instance, in South-Eastern France, the GPC ranged from 7.6 to 16.2% grain dry matter (DM). Moreover, 39% of the fields presented a GPC under the threshold for breadmaking (10.5% grain DM) (David et al., 2007). This results in a decline in prices as well as disqualification or discounting of grain batches when GPC does not reach this threshold. Taylor et al. (2001) and David et al. (2005) have shown that low and variable organic wheat yields are explained by several limiting factors: nitrogen (N) deficiency, water shortage, weeds, pest and disease pressure or compacted soil structure. The purpose of this study was (i) to assess whether these limiting factors can explain GPC variability across site-years, using two statistical methods and (ii) to determine the characteristics of the cropping systems in which limiting factors arise.

Materials and methods

We studied a field network within the Rhône-Alpes region (South-Eastern France), the French region with the highest amount of organic cereal collected. A two-step regional agronomic diagnosis method was implemented (Doré et al., 1997) to identify: (i) the agronomic and environmental factors for GPC variability and then (ii) the characteristics of cropping systems associated with these limiting factors.

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Field network

A network of 35 fields belonging to 23 farmers and involving 9 varieties was studied over 6 years (between 1993 and 2006). Fields displayed a wide range of environmental conditions (soil type, temperature, radiation, and water availability) and cropping systems (crop rotation and fertilization management). Crop management varied according to variety type (VT), classified according to baking quality grade: superior (BPS) or improved (BAF), previous crop (PC: cereals, oilseed, legumes or other crops), sowing date (SD: before or after the 10^{th} of November), nitrogen supply (NS: amount of N applied in kg ha^{-1}) and weed control (WC: number of weeding operations).

Measurements and analytical procedures

The soil texture (ST: determined by granulometric analysis) and organic matter content (OM) were determined by sampling 10 soil cores to a depth of 30 cm. Daily weather data (mean temperature, rainfall, radiation and evapotranspiration) were recorded nearby each field. At maturity, GPC was determined from four samples per field (0.25 m² each). Four indicators of limiting factors were measured. Water shortage from flowering to maturity (WS) was estimated from a dynamic water balance to evaluate the incidence of water availability on nitrogen and biomass accumulation in the grains (Gate, 1995). Photothermal quotient (PQ) (ratio of mean daily solar radiation by mean temperature) was calculated for the 30-day period prior to flowering knowing its effect on kernel number (Fischer, 1985). Weed density at flowering (WD) was also considered, knowing its negative effect on grain yield (Cousens, 1985; David et al., 2005). Finally, the nitrogen nutrition index, which is the ratio between the actual aerial and the critical N content (Justes et al.,1997), was calculated at flowering (NNI), knowing its effect on GPC (Justes et al., 1997) and grain yield.

Statistical analysis

Statistical analyses were performed using the statistical program R (version 2.5.1, 2007) (Ihaka and Gentlemen, 1996). First, K being the number of explanatory variables (here, VT, NNI, WD, WS and PQ), 2^K possible models, relating GPC to these variables, were fitted to the data by classical linear regressions. Then, the 32 fitted models were weighted by AIC (Akaike's criteria) and summed, leading to a new model mixing all the possible linear models according to their quality of fit (Burnham and Anderson, 2002). Finally, an analysis of variance was performed to identify the crop management techniques and the environmental conditions associated with the limiting factors selected in the linear models.

Results

GPC ranged between 7.8 and 13.9% grain DM within the given field network and the limiting factors indicators displayed contrasted values (Table 1). The values of the different indicators were not significantly correlated (results not shown).

Tab. 1: Ranges of GPC and explicative variables within the field network.

	GPC (% DM)	Variety type [VT]	Crop nitrogen status [NNI]	Weed density [WD] (plants m^{-2})	Water shortage [WS] (mm)	Photothermal quotient [PQ] ($kJ°C^{-1}$)
Min Value	7.8	BAF or BPS	0.27	0	193	0.6
Max Value	13.9		0.71	567	0	1.6

Identification of limiting factors

A linear regression with all the indicators was fitted (Table 2) (R^2=0.68 and RMSE=0.851). Variety type had a very significant effect on GPC: BPS wheat types had lower GPC than BAF wheat types. Significant effects were also found for the crop N status and weed density (Table 2), but not for photothermal quotient and water shortage.

Tab. 2: Results of the linear regression explaining GPC with all 5 explicative indicators.

	Estimate	Std. Error	t value	Pr(>|t|)
Intercept	7.919	1.177	6.727	2.21e-07
VT (BPS)	-2.099	0.346	-6.067	1.33e-06
NNI	4.711	1.484	3.175	0.00354
WD	0.006	0.002	3.055	0.00480
PQ	0.667	0.629	1.065	0.29571
WS	0.002	0.003	0.676	0.50432

The 32 tested models were ranked according to their AIC values. The five best ones (with the lowest AIC) were found to involve VT, NNI and WD systematically (Table 3) while PQ and WS were involved in two of these models (Table 3).

Tab. 3: AIC, R^2 adjusted, R^2 and RMSE (Root Mean Square Error) of the 5 best models

Tested model	AIC	Weight	R^2	RMSE
$GPC = a_0 + a_1VT + a_2NNI + a_3WD$	99.9	0.388	0.66	0.874
$GPC = a_0 + a_1VT + a_2NNI + a_3WD + a_4PQ$	100.6	0.268	0.67	0.858
$GPC = a_0 + a_1VT + a_2NNI + a_3WD + a_4WS$	101.4	0.180	0.66	0.868
$GPC = a_0 + a_1VT + a_2NNI + a_3WD + a_4PQ + a_5WS$	102.1	0.130	0.68	0.851
$GPC = a_0 + a_1VT + a_2WD$	107.4	0.009	0.55	1.001

Mixing model

The mixing model provided a good quality of fit (R^2=0.67 and RMSE=0.860). Its equation is: GPC=8.62-2.10*VT-0.0005*WS+0.005*WD+4.49*NNI+0.27*PQ. The probability that the explanatory variables have an effect on GPC is, for a given variable, equal to the sum of the weights of the models, among the 32 fitted models, including the variable of interest. These probabilities are equal to 1.00, 0.978, and 0.984 for VT, NNI and WD respectively. They are much lower for WS and PQ, 0.320 and 0.413, respectively, but are not negligible. Thus, an effect of WS and PQ on GPC cannot be excluded, though the tests were not significant for these two variables.

Effects of crop management on limiting factors

David et al. (2005) have evidenced significant correlation between NNI and preceding crop. Consequently, the incidence of PC, NS and OM in soil on NNI at flowering was tested. The analysis of variance of our data showed no significant effect of these variables. Effects on weed density at flowering of PC, NS, WC, SD and ST were tested. Analysis of variance showed effect of NS (at 10%) and ST (at 1%) on WD.

Discussion

Variety type, which is a crop descriptor, had a strong effect on GPC. Negative effect of BPS could be explained by the fact that BAF varieties were bred in order to increase GPC. Nitrogen nutrition index at flowering and weed density at flowering had a positive effect on GPC. Positive effect of NNI at flowering on GPC is in accordance with the findings of Justes et al. (1997). David et al. (2005) showed that weed density had a negative effect on kernel number. Moreover, a decrease in kernel number generally leads to nitrogen concentration in grains, thereby increasing GPC. Positive effect of weed density on GPC in our case is thus in line with those previous results. The results obtained by the mixing model approach confirmed the strong effects of NNI and VT and led to a slightly better quality of fit (RMSE=0.860) compared to linear regression (RMSE=0.851). The interest of this approach is that all the explanatory variables are included in the final model. Low parameter estimates were given to the variables which did not have a strong effect on GPC (i.e. WS and PQ). In the near future, we will evaluate the ability of this approach to accurately predict GPC values. No effect of crop management on NNI at flowering was found. It could be explained by variable nitrogen efficiency: N supply (total amount of N applied by the farmers) did not completely match available N for the crop. Effect of ST on WD is consistent with previous results (David et al., 2005). Positive effect of NS on WD could be explained by an improved nitrogen uptake by weeds when nitrogen supply is higher.

Conclusions

This regional agronomic diagnosis clearly demonstrated the effect of variety type, nitrogen nutrition index, and weed density at flowering on GPC and it confirmed the benefits of using mixing model methods in agronomy. The identification of the characteristics of the cropping system that most influence GPC will help people involved in drafting technical adaptations to increase and stabilize GPC in organic winter wheat.

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Organic winter wheat: optimising planting

Haigh, Z.E.L.[1], Baddeley, J.A.[2], Boyd, H.E.[1], Clarke, S.[1], Jones, H.[1], Rees, R.M.[2] & Wolfe, M.[1]

Key words: wheat, agronomy, interactions, composite cross populations

Abstract

Data from the second year of experiments at three sites (Wakelyns in SE and Sheepdrove in SW England; and Chapel Farm in SE Scotland) to investigate the effects of interactions among a range of agronomic practices (row spacing, seed density, weeding and undersowing with clover) on winter wheat performance are presented, and compared with first year results. Trends seen at all years and sites indicate that narrow row drill arrangements with high seed rates result in the highest yields. This combination also performed well for emergence and establishment. The effect of drill arrangement was significant (P<0.05) at two of the three experimental sites with establishment of 282 and 232 plants m-2 at Sheepdrove and Chapel farm respectively. There were significant interactions between row spacing and seed density at all three sites. A new composite cross population integrated into the experiment has performed well for a number of traits including canopy cover and grain yield.

Introduction

Organic farming has been, and should be, regarded as a form of ecological farming (Weiner, 2003), making optimal use of interactions among plants, soil and other factors. However, previous work in this area has often taken a reductionist approach to farming systems, focusing on the importance of single factors (Gooding *et al*., 2002). It is essential, however, that as many relevant factors of the system as practicable are analysed together, in order to understand a range of potentially complex interactions (Gooding and Davies, 1997). The main objective of this study was to undertake a multifactorial analysis of different wheat genotypes, with or without clover bi-cropping, planted at different seed rates in a range of different spatial patterns under contrasting site conditions.

Materials and methods

The second year of trials took place at three sites (Wakelyns Agroforestry, Suffolk, Sheepdrove Organic Farm, Berkshire and Chapel Farm in East Lothian in 2006/07). Each site contained a randomised, replicated split-plot design integrating three winter wheat genotypes: Hereward (a benchmark Nabim Group 1 variety), Aristos (bred for

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low input systems) and a 'Yield-Quality Composite Cross Population' ('YQ CCP', output from The Organic Research Centre's Wheat Breeding trial (Wolfe *et al.*, this conference); two seed rates (low, and high, 150 kg ha^{-1} and 250 kg ha^{-1}); three spatial arrangements (wide row (20 cm), narrow row (10 cm) and strips (a seeded band 20 cm wide with 30 cm centres, at Wakelyns and Sheepdrove only); with or without white clover mixture (undersown at 7 kg ha^{-1}) and with or without weeding (tine harrow on half of the wide row plots, at Wakelyns and Chapel only). Standard agronomic assessments on crop, weed and clover growth were taken throughout the growing season and post harvest. Analysis of variance was used to evaluate the main component effects and interactions. Variables in the second year of the experiment were amended from the first year in consultation with farmers, advisers and the project consortium. Additional factors in the second year: Chapel as an extra site; YQ CCP as an extra genotype and weeding.

Results

This paper discusses a selection of results from the second year (2006/07) of experiments. They are compared with results of the first year of experiments, details of which can be found in Haigh *et al.* (2006).

Drill arrangement and seed rates

The combination of narrow rows and high seed rates tended to produce the highest yields in both years. Narrow rows produced the highest yields at all sites in both years, at SAC in 2006/07 this was significant (P= 0.022; Figure 1); in the previous year this was significant at both sites (Wakelyns and Sheepdrove, P<0.001). Highest yields were attained using high seed rates in 2006/07 at Wakelyns and Sheepdrove, at Sheepdrove this trend was significant (P= 0.015; Figure 1). In the previous year this trend had occurred at both sites, and was significant at Sheepdrove (P<0.001).

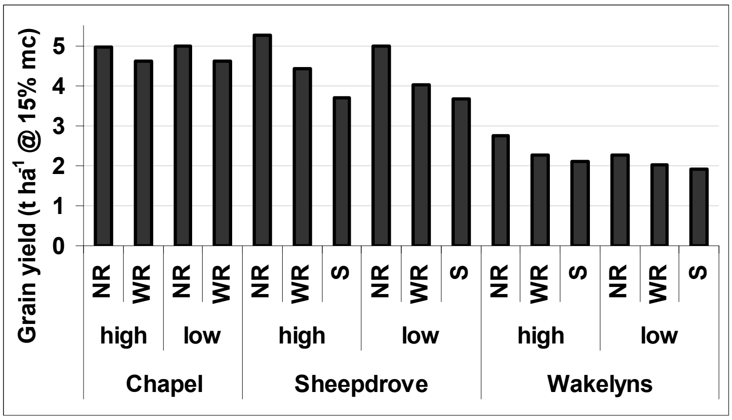

Figure 1: Mean grain yield (t ha^{-1} @ 15 % moisture content) at each site (Chapel, Sheepdrove and Wakelyns) for high and low seed rates (150 kg ha^{-1} and 250 kg ha^{-1}) under narrow (NR), wide (WR) or strip drill arrangements (S) in 2006/07. At Chapel NR yielded significantly more than WR (P= 0.022, l.s.d.= 0.1911); at

Sheepdrove high seed rates produced significantly higher yields than low seed rates (P= 0.015, l.s.d.= 0.2253).

The highest emergence was under high seed rates: Wakelyns= 298 versus 226 plants m-1; Sheepdrove= 310 versus 200 plants m-1 (P<0.001 at both sites), and tended to be in the rank narrow rows > wide rows > strips. Establishment was highest with narrow rows and high seed rates at all sites. The effect of drill arrangement was significant at both Sheepdrove (NR= 282 plants m-1, S= 192 plants m-1, WR= 249 plants m-1, P= 0.025, l.s.d.= 55) and Chapel (NR= 232 plants m-1, WR= 177 plants m-1, P= 0.041, l.s.d.= 50). The interaction between drill arrangement and seed rate was also significant at Chapel where narrow rows and high seed rates produced higher establishment (261 plants m-1) than wide rows and low seed rates (168 plants m-1, l.s.d. = 37, P= 0.038). These results were similar to the previous season where narrow rows also performed well for emergence and establishment. Narrow rows also performed well for canopy cover; they tended to have the highest leaf area index. At Sheepdrove this was significant throughout the season (early: NR= 1.66, WR= 1.55, S= 1.02, l.s.d.= 0.2303, P= 0.003; mid: NR= 2.58, WR= 2.45, S= 2.11, l.s.d.= 0.3332, P= 0.04; and late: NR= 2.80, WR= 2.42, S= 2.25, l.s.d.= 0.3611, P= 0.031). Although weed pressure differed at each site, again narrow rows and high seed rate plots tended to have the lowest weed cover. This trend was seen across sites; it was significant at Wakelyns where narrow rows had fewer weeds than other drill arrangements, early in the season (NR= -10.79 %, WR= 0.16 %, S= 0.61 % weed cover relative to un-cropped ground), l.s.d.= 5.162, P= 0.006).

Varieties

In the 2006/07 season the YQ CCP yield was significantly greater than either Hereward or Aristos at Wakelyns (YQ CCP= 2.60 t ha^{-1}; Aristos= 2.25 t ha^{-1}; Hereward= 2.16 t ha^{-1}, l.s.d.= 0.3027, P= 0.013). Although the YQ CCP was not present in this experiment in the previous season, this result is consistent with another variety trial at Wakelyns, where the YQ CCP yielded 104 % of Hereward. In the previous season Aristos was the highest yielding variety at Wakelyns (Aristos= 7.27 t ha^{-1}, Hereward= 6.83 t ha^{-1}, l.s.d.= 0.2513, P<0.001). At Chapel, varieties yielded significantly differently in the rank Hereward (5.34 t ha^{-1}) > Aristos (4.92 t ha^{-1}) > YQ CCP (4.23 t ha^{-1}, l.s.d.= 0.2684, P<0.001). The YQ CCP performed well for other aspects; it tended to have the highest canopy cover over the season at all sites. (often significant). At Sheepdrove, the YQ CCP had significantly higher early (P<0.001), mid (P= 0.021 and late (P= 0.024) canopy cover than other genotypes (Table 1).

Tab. 1: Mean canopy cover (leaf area index) for the three genotypes at three sites on three assessment occasions, 2006/07.

		Mean leaf area index			
	Site	**YQ**	**Ar**	**He**	**l.s.d.**
Early canopy cover	**Sheepdrove**	1.59	1.27	1.37	0.145
	Chapel	2.23	2.08	1.87	0.251
	Wakelyns	1.41	1.18	1.28	0.168
Mid canopy cover	**Sheepdrove**	2.57	2.34	2.23	0.244
	Chapel	2.73	2.56	2.25	0.311
	Wakelyns	2.45	2.18	2.35	0.240
Late	**Sheepdrove**	2.65	2.42	2.39	0.206

canopy	**Chapel**	3.12	2.86	2.67	0.286
cover	**Wakelyns**	3.30	3.31	3.42	0.247

At Chapel the YQ CCP had higher early canopy cover than Aristos (P= 0.02), for mid canopy cover both YQ CCP and Aristos were higher than Hereward (P= 0.01) and late in the season, YQ CCP had significantly higher late canopy cover than Hereward at Chapel (P= 0.01). YQ CCP canopy cover was higher at Wakelyns only at the early assessment (P= 0.029; Table 1). The YQ CCP also performed well for weed suppression; varieties with least weed cover tended to be in the rank YQ CCP > Aristos > Hereward. Although this was not always significant, YQ CCP did have significantly fewer weeds early in the season at Chapel than other varieties (YQ CCP= -1.49 %, Aristos= -1.21 %, Hereward= -1.06 % weed cover relative to un-cropped ground, l.s.d.= 0.339, P= 0.041); and Hereward had significantly more weeds than other varieties later in the season (YQ CCP= -14.64 %, Aristos= -14.06 %, Hereward= -13.37 %, weed cover relative to un-cropped ground, l.s.d.= 0.882, P= 0.038).

Discussion

The beneficial effects of narrow rows and high seed rates were seen from the beginning of the year, in both crop emergence and establishment. This combination of factors also tended to produce high canopy cover and fewer weeds, and ultimately led to the highest yields. In order to maximise yields, a high number of plants is required, hence high seed rates produce highest yields. However, in order for each plant to perform to its best it also needs to experience as little competition (for light, water, and nutrients) from other crop plants as possible, therefore even plant spacing (best achieved in narrow rows) is essential to realising high yields. The drill arrangement with the optimum plant spacing (fewest numbers of neighbouring plants) was narrow rows, followed by strips and then wide rows.

Although the YQ CCP yielded relatively poorly at Chapel this year, it can potentially adapt to local conditions so that re-sown seed from this site should perform better in next year’s experiment.

Conclusions

Narrow rows and high seed rates tended to produce the highest yields. The YQ CCP is performing well and may adapt further to the sites where it is grown.

Acknowledgements

The authors are grateful to all participating farms for their cooperation in this experiment, and technical staff at SAC for their support.

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Improving nutrient uptake in wheat through cultivar specific interaction with *Azospirillum*

Hoagland, L.[1], Murphy, K.[2], Carpenter-Boggs, L.[3] & Jones, S.[4]

Key words: nitrogen, plant breeding, organic farming, diazotrophs

Abstract

Obtaining sufficient plant available nitrogen in organic dryland wheat cropping systems is difficult. This study was conducted to determine whether inoculation with Azospirillum could improve nitrogen uptake and increase crop yield, and whether there are differences among wheat cultivars in the ability to benefit from inoculation of these diazotrophic bacteria. Seed from twenty historic and modern wheat cultivars were either left untreated, or treated with a commercial inoculant of Azospirillum, and planted at two locations under certified organic management. In one location with lower fertility, inoculation significantly increased yield and protein, and clear differences existed among individual cultivars in response to the inoculant. In another location with higher fertility, none of the cultivars responded as favorably to the inoculant, and yield in some cultivars was reduced. Plant breeders should be able to select for beneficial cultivar interactions with Azospirillum to increase wheat yield and protein levels. Additional research is needed to determine the impact of site-specific soil conditions on the effectiveness of Azospirillum in organic systems.

Introduction

In low-input organic dryland grain cropping systems, obtaining sufficient plant available nitrogen (N) can be problematic. Organic producers often utilize manure or compost to meet N needs, but in many areas the cost of transportation and application make bulky organic fertilizers uneconomical. Low rainfall also limits the ability of some growers to utilize leguminous green manure crops. One alternative to help supplement N is through exploitation of diverse diazotrophic bacteria capable of biological nitrogen fixation (BNF). Associative BNF can contribute 10-50% of the total N requirement of wheat (Solimon et al., 1995; Kennedy and Islam, 2001). In addition to BNF, these bacteria may increase plant growth through production of phytohormones, phosphorous release, increased nutrient uptake, enhanced stress resistance, biocontrol of both major and minor plant pathogens and improved water status (Creus et al, 2004). However, these plant-microbial interactions are dependent on plant genotype (Iniguez et al., 2004) and site-specific soil conditions (de Oliviera et al., 2006).

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Historically, plant breeders have not selected directly for interaction with beneficial soil bacteria, yet in Brazil, sugarcane breeders selecting for high yield under low-input conditions inadvertently selected for interaction with native diazotrophic bacteria (Baldani et al., 2002). Prior to the advent of chemical fertilizers that have high plant available nitrogen, breeding programs of other graminaceous crops like wheat, may also have indirectly selected for this association. However, after decades of cultivar selection under conditions that utilize chemical fertilizers, modern cultivars may not interact efficiently with these bacteria, and relevant levels of native diazotrophic bacteria may no longer be present in the soil.

To improve nutrient uptake and yield in low-input organic wheat systems, we tested the efficacy of a commercial inoculant of *Azospirillum,* a diazotrophic bacteria that has been shown to positively interact with wheat. Twenty historic and modern winter wheat cultivars were evaluated for the ability to interact with, and benefit from inoculation, and to identify cultivars for use in organic production systems.

Materials and methods

In autumn 2006, field trials were established in two certified organic fields with moderate rainfall near Pullman, WA. Each trial contained five historic and five modern hard red cultivars, and five historic and five modern soft white cultivars, each replicated four times. Each trial was arranged in a split block design, with seed from all cultivars in one block receiving a commercial inoculant of Azospirillum brasiliense (EMD Crop Bioscience) according to the manufacturer's recommendation (9.8 ml kg^{-1}), and cultivars in the other block left untreated. A previous winter pea plowdown provided approximately 40 kg ha^{-1} of N. Weed control was accomplished by hand weeding throughout the growing season. Plant emergence, leaf greenness using a SPAD chlorophyll meter, plant height, yield and protein were recorded. In each of the four blocks within each split block, ten soil samples were randomly collected to a depth of 10-cm and pooled for analysis. Soil samples were analyzed for total carbon (C) and nitrogen (N), inorganic N, and potentially mineralizable N, and organic matter (OM) was estimated. Field plot locations were recorded permanently using GPS coordinates to track survival of the introduced bacteria in the soil over time.

Results

Seed treatment with a commercial inoculant of Azospirillum had little overall impact on seedling emergence, leaf greenness, or plant height in either location, but did have an impact on crop yield and protein. In location A, average crop yield was increased among all cultivars by 538 kg ha^{-1}; however, yield increase ranged from 134 to 1,209 kg ha^{-1} among individual cultivars, and was significantly increased in only five cultivars (Figure 1). In location B, yield data was compromised due to harvest difficulties resulting from the slope of the land, but in general, the cultivars did not respond as favorably to the inoculant, and yield was decreased in some cultivars (data not shown). In location B, average crop yields among all cultivars were 638 kg ha^{-1} greater than average yields in nursery A. Only two historic hard red cultivars responded favorably to the inoculant in both locations, but yield increases were not significant.

In both locations, protein levels were increased in response to the inoculant. Overall protein levels were greater in location B, but increases in response to the inoculant were greater in location A. In location A, six cultivars had significantly increased protein levels (data not shown). Modern cultivars, Masami and Bauermeister had both significantly increased yield and protein in location A. In location B, only two cultivars had significantly increased protein levels, and correspondingly, these two cultivars had significantly reduced yield in response to inoculation. Only one cultivar, Buchanan, had significantly increased protein levels in both locations. Total C and N, inorganic N, and OM were lower in nursery A than in nursery B (Table 1).

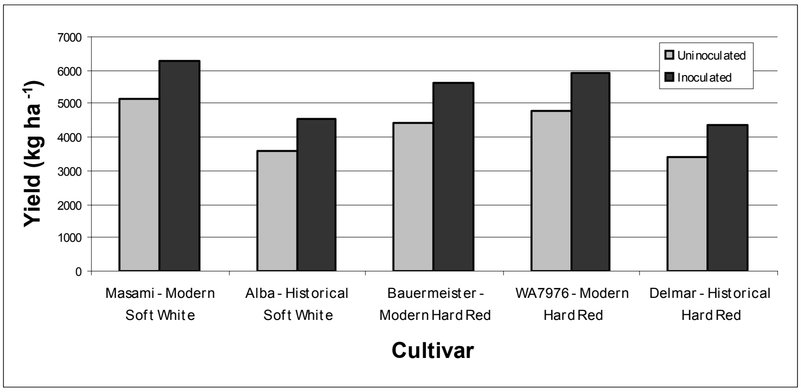

Figure 1: Wheat cultivars with significantly increased yield as a result of Azospirillum inoculation in location A (P<0.05).

Tab. 1: Soil nutrient levels in *Azospirillum* inoculation trials

	Total C	Total N	Inorganic N	Organic Matter
Location	**(mg kg^{-1})**			**(%)**
A	13,700	980	9.31	2.37
B	20,200	1460	14.35	3.49

Discussion

Treatment of wheat seeds with a commercial inoculant of *Azospirillum* increased crop yield and protein in organically managed systems, but the interaction was dependent on plant genotype. Five of the twenty wheat cultivars inoculated with *Azospirillum* had significantly increased crop yield, suggesting that wheat breeders can select for this interaction. The ability to benefit from *Azospirillum* inoculation was present in some modern cultivars, indicating that this trait can co-exist with other beneficial plant traits like high yield and disease tolerance that have been traditionally selected for in modern breeding programs. Inoculation also resulted in increased protein levels in some cultivars, suggesting that this interaction can be used to select wheat cultivars for use in the hard red market class, where high protein levels are required. Site-specific soil conditions also had an impact on wheat yield and protein in response to inoculation. In our study, greater soil fertility levels were correlated with an insignificant, or deleterious response in some cultivars to inoculation with *Azospirillum*. This is consistent with the findings of Martinez de Olivera et al. (2006) who found sugarcane productivity to be reduced as a result of inoculation with diazotrophic bacteria in a high fertility soil. However, these findings contradict company reports on the activity of the *Azospirillum* inoculant under conventional wheat management. More research is needed to determine how site-specific soil conditions affect interaction of graminaceous crops with diazotrophic bacteria. To better meet our objectives, we expanded our trials in autumn 2007. Ten advanced lines from our organic breeding program were included and the trials were planted in five different locations that include regions of low and intermediate rainfall, and organic and conventional management. Soil samples from all 2006 and 2007 planted sites will be evaluated for additional chemical and biological factors to help determine how site-specific soil conditions influence the interaction of wheat and *Azospirillum*. A subset of the cultivars used in our field studies were planted with and without inoculation in greenhouse trials using zero fertilizer, or either organic or chemical fertilizer at both a low and high rate. Root abundance of *Azospirillum* and mycorrhizae, and nitrogen fixation by *Azospirillum* among individual cultivars will be determined. Abundance and diversity of native diazotroph communities will be evaluated in soils from across Washington State.

Conclusions

Initial results from the first year of this study suggest that inoculation of wheat with *Azospirillum* can improve nutrient uptake and increase crop yield and protein under organic management, but this is dependent upon genotype and site-specific soil conditions. Wheat breeders may be able to select for cultivars that benefit from association with these bacteria, but additional research is needed to validate the findings of cultivars differences, and determine the impact of site-specific soil conditions before recommending this to organic farmers as a management tool.

Acknowledgments

We thank the USDA-CSREES Organic and Integrated Grant Program for support of this research; EMD Crop Bioscience for donation of *Azospirillum* inoculant; and, Steve Lyon, Kerry Balow, and Meg Gollnick for assistance in field and lab experiments.

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Sustainability assessment of wheat production using Emergy

Coppola, F.[1], Haugaard-Nielsen, H.[2], Bastianoni, S.[1] & Østergård, H.[2]

Key words: Organic and conventional production, soil type, wheat, emergy, sustainability assessment

Abstract

Sustainability of crop production has to be given high priority when global biomass resources are limited. Here emergy evaluation is applied in order to assess sustainability of crop production exemplified by winter wheat. Emergy evaluation takes into account all inputs involved in a production system (i.e. renewable and non-renewable, local and imported) and transforms them into a common measure of direct and indirect solar energy requirement. The evaluation of winter wheat production is conducted by comparing conventional and organic management on two soil types using Danish reference conditions. The resource use efficiency of wheat production per kg biomass is higher using conventional management practices. This is due to high yield based on large use of non-renewable resources. The environmental loading ratio from organic management practices is about a third of the conventional implying that the organic management can be considered more sustainable.

Introduction

Increasing oil prices and foreseeable limitations of fossil resources has put emphasis on crops as a resource of raw materials for fuels and fibres in addition to their importance for food and feed. Also the many functions of crops in ecosystem services such as securing water reservoirs, biodiversity and landscape has been reconsidered. The crop resource is, however, limited since the inputs, which are needed for its production, are limited, e.g., fertiliser (organic or non-organic), fuel for machinery, human labour, as well as available land. In order to address the sustainability of crop production, assessments of material and energy flows are needed.

The concept of sustainability has many definitions all based on ensuring resources for future generations. Many sustainability assessments consider balances of energy and materials flows without qualifying to what extend the inputs are from renewable or non-renewable resources. The emergy evaluation methodology (Odum, 1996) emphasizes how to exploit renewable resources more efficiently such that the costly (with respect to resource limitations) non-renewables may last longer. The basis of emergy evaluation is the conversion of all process inputs, including energy from climatic resources like precipitation and global radiation, energy inherent in materials such as machinery and in services like human labour, into total amount of solar energy by means of a conversion factor called transformity. In this way, all flows get the same common unit for the analysis.

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Emergy has been used to assess sustainability of crop production in relation to bioenergy production (Bastianoni and Marchettini 1996), for comparison of different land uses (Lefroy and Rydberg, 2003) and to compare organic and conventional farming (e.g. Ortega *et al.* 2005). Here we describe the method and demonstrate its usefulness with four types of winter wheat production in Denmark: organic and conventional management on two locations with different soil types and climate.

Materials and methods

The present emergy assessment compares winter wheat production conducted under conventional and organic reference management practises on two Danish locations with slightly different climatic conditions; site I: sandy soil in south of Jutland and site II: sandy loam soil in east of Zealand. Data for inputs, field operations and yields were mainly obtained from farmers' advisory manuals (Dansk Landbrugsrådgivning 2003 and 2006), norms for direct and indirect energy consumption from Dalgaard *et al.* (2001), average actual evapotranspiration at similar sites from Barlebo *et al.* (2007) and global radiation from the Danish Meteorological Institute.

Emergy represents the solar energy used up directly or indirectly to make a product or to support a process; it is measured in sej (solar emergy joule). The basis of emergy evaluation is the conversion of all process inputs into emergy by means of the conversion factor transformity expressed in sej J^{-1} (emergy per Joule). When comparing two products from different processes, the product having the highest transformity requires most emergy (direct or indirect solar energy) for its production and is thus more costly. By definition, transformity of solar energy is equal to 1 sej J^{-1}. List of transformities are found in Emergy folios (2000-2002).

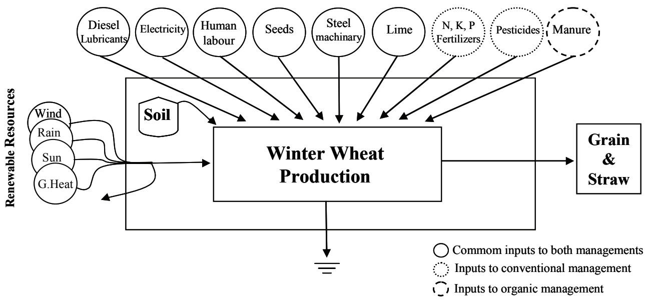

Figure 1: Energy System Diagram of organic and conventional winter wheat production

Flows of energy and matter for wheat production in Denmark were described by an Energy System Diagram (Figure 1) showing all resources contributing being i) renewables (R) such as sun, rain (only the amount evapotranspirated by crop), geothermal heat and wind, ii) local (within the system) non-renewables (N) such as soil, and iii) imported (from outside the system) non-renewables (F) such as fossil fuels, fertilizers, seeds and chemicals. Also the emergy based indicator Environmental Loading Ratio (ELR) was considered. This is the ratio of all non-renewable emergy flows both from inside and outside the system (N + F) to the renewable emergy flows (R). The ELR is generally high for systems with a high level of technology and/or with high environmental pressure.

Results and discussion

For each system considered, a table with energy and material flows, transformities and resulting emergy flows was calculated for wheat grain and straw yield; here, only the summary of the calculations is shown (Table 1).

The crop yield increased about 2-fold between the four scenarios from the organic production on the sandy soil to the conventional on the sandy loam soil. The total annual emergy flow (e.g. total solar energy used up) per hectare had the highest value in the conventional management at both sites, implying that this production lead to a greater use of resources per hectare. In all scenarios, three inputs contributed substantially to the emergy flow: i) fertiliser application (manure approx $3x10^{15}$ sej ha^{-1} y^{-1} and synthetic fertiliser approx $4\text{-}5x10^{15}$ sej $ha^{-1}y^{-1}$ mainly from N fertiliser), ii) lime application (approx $0.8x10^{15}$ sej $ha^{-1}y^{-1}$) and iii) evapotranspiration (approx $0.7x10^{15}$ sej $ha^{-1}y^{-1}$). The difference between conventional and organic systems was mainly due to synthetic versus organic fertiliser use. The two sites differed by higher input of synthetic fertiliser at site II compared to site I and higher evapotranspiration at site I compared to site II (480 and 420 mm y^{-1}, respectively).

Tab. 1: Summary of Emergy assessment of winter wheat grain and straw production for organic and conventional management at different sites

	Sandy soil, site I		Sandy loamy soil, site II	
	Organic	Conventional	Organic	Conventional
Total dry matter (t ha^{-1} y^{-1})	5.6	8.0	8.2	12.4
Total emergy flow (sej ha^{-1} y^{-1})	$5.6x10^{15}$	$6.6x10^{15}$	$5.4x10^{15}$	$6.9x10^{15}$
Transformity wheat crop (sej J^{-1})	$7.1x10^{4}$	$5.8x10^{4}$	$4.6x10^{4}$	$3.9x10^{4}$
Environmental Loading Ratio	2.3	7.3	2.4	8.5

The transformity values indicate the use of solar energy related to the energy of the final product. These values decrease from organic production on sandy soil to conventional production on sandy loam soil corresponding inversely to the increase in yield. This implies that the efficiency of the production system per unit biomass is higher using conventional management practises. However, this efficiency is caused by the much larger use of non-renewable resources as seen from the Environmental Loading Ratio (ELR); ELR is more than 3 times higher as compared to organic management practices. This implies that under these growing conditions the organic management needs much less non-renewable inputs.

So far, the analysis has considered the total crop biomass (grain + straw); traditionally, only grain is considered. If this was the case in the present study, all emergy flows would be accounted for in the production of the grain giving somewhat higher values. The highest efficiency per kg (or Joule) as seen from the transformity for grain would again be for conventional production on sandy loam soil ($6.1x10^{4}$ sej J^{-1}), and the average value over all systems would be $8.6x10^{4}$ sej J^{-1}. The latter value is a little lower than the average transformity value for winter wheat production in Italy ($15.9x10^{4}$ sej J^{-1}, Ulgiati et *al.*, 1994) and nearly similar to the Siena Province value ($11.3x10^{4}$ sej J^{-1}, Bastianoni et *al.*, 2001). Such differences may be due to a more efficient production in Denmark primarily caused by a higher grain yield potential. Unfortunately, no other published transformity values could be found for comparison. Wheat straw is, however, also a valuable raw material: i) if we consider the straw as residual biomass usable as feedback in the wheat production systems (e.g. to generate electricity for grain drying), the transformity of product output (wheat grain) would decrease; ii) if the straw is left in the fields as a carbon source we would have an increase in soil fertility and a feedback potentially improving subsequent crop production. A detailed analysis of the role of straw as raw material for energy purposes and/or bio-fertilizers is under preparation.

Conclusions

This emergy evaluation of winter wheat production conducted under Danish reference growing conditions concluded that organic production (sandy loamy soil) was the most favorable growing system due to the lowest ELR value. However, the best efficiency of the resource use per kg biomass (lowest transformity value) was obtained on the rather fertile sandy loamy soils on east Zealand and highest for the conventional management due to high yield based on large use of non-renewable resources. We see emergy assessment as a tool to emphasize the use of natural and especially renewable resources, and an accounting method where environmental costs are evaluated using a common scale for all energy and materials flows, i.e., the direct and indirect solar energy used up to obtain a product.

Acknowledgments

Input values from Danish Meteorological Institute; Ingeborg Callesen, RISØ-DTU; and Preben Olsen, University of Aarhus, are acknowledged.

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Organic crops

Impact of agronomic measures on yield and quality of organic potatoes (*Solanum tuberosum* L.) for industrial processing

Haase, T.[1], Haase, N.U.[2] & Heß, J.[3]

Key words: Nitrogen; Potassium; Preceding Crop; Pre-sprouting; Cultivar

Abstract

Three field experiments were conducted during 2002 and 2004 on two sites in Germany in order to examine the impact of preceding crop, pre-sprouting, N- and K-fertilization and cultivar on total tuber fresh yields, tuber DM, glucose and fructose concentration, as well as the colour of crisps and the quality score of French fries at harvest and after storage. Generally, total tuber yields depended very much on the growing season. However, highest yields were obtained when horn grits were applied along with potassium sulphate. Increasing yields after cattle manure fertilization could be attributed to K rather than N. Combined N and K fertilization may cause DM concentration to fall short of the required minimum for crisps. Pre-sprouting and storage increased tuber DM concentration considerably. Cultivars belonging to the very early and early maturity type showed the largest relative increase of reducing sugars due to storage.

On the whole, results suggest that the effect of agronomic measures such as fertilization, preceding crop and seed-tuber preparation may be rather small and the response of internal tuber quality and quality of fried products difficult to predict. The quality standards for tuber raw stock can be accomplished best when adequate cultivars suitable for storage are chosen.

Introduction

Organic cultivation of potatoes for industrial processing into French fries or crisps may be a new source of income for organic farmers in European countries. For potato processing, high proportions of larger tubers are required for French fries and also for crisps. In addition, there are ranges and thresholds for tuber dry matter (DM), as well as for the concentration of reducing sugars (glucose and fructose) of tubers. Tubers should not only meet these standards shortly after harvest, but also after storage. Tuber size is mainly determined by nitrogen (N), and tuber yield response is mainly dependent on the rate at which N is released from preceding crops or organic amendments such as animal manures. Little is known about the potential interactions between N supply and crop growth as a function of seed-tuber preparation and cultivar. In organic farming, where N is usually very limited, the correlation between available potassium (K) - applied as mineral K or with cattle manure - and potato crop response may be low.

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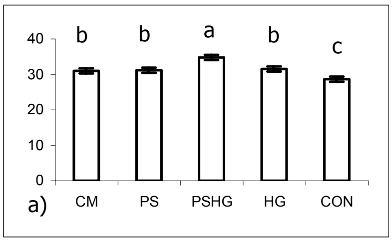
Materials and methods

Three field experiments were conducted over two and three years, on two organically managed sites (DFH: 51°4, 9°4', BEL: 52°2', 8°08') in Germany in split-plot designs (Exps 1 and 2) and in a RCB design (Exp. 3) on loamy sand (Exp. 1) and silt loam (Exps 2 and 3) with factors fertilization (cattle manure, potassium sulphate, horn grits, both combined, and a control)) and cultivar (Agria and Marlen) in Exp. 1, preceding crop (oats, peas, grass-clover, winter wheat), pre-sprouting (yes or no), cultivar (Agria and Marlen) and harvest date (two early and one final) in Exp. 2, and cultivar (see results) in Exp. 3. Details on site and weather conditions, agronomic measures and statistical analysis are presented in Haase et al. (2007 a-b). Parameters discussed in this paper are total tuber fresh matter (FM) yields, tuber DM, glucose and fructose concentration, as well as the colour of crisps and the quality score of French fries.

Results

In Exp. 1, tuber fresh matter (FM) yield was consistently and significantly increased ($p<0.0001$) by any fertilizer treatment as compared with the control. Combined potassium sulphate and horn grits application (PSHG) gave the strongest yield response (+6.1 t ha^{-1}), while cattle manure (CM) and PS or HG alone did not differ significantly from each other (Fig. 1a). While in 2002, cv. Marlen yielded significantly higher than cv. Agria, the opposite was true in 2004. In 2003, total FM tuber yield (mean of both cultivars) was 31.3 t ha^{-1} (Fig. 1b).



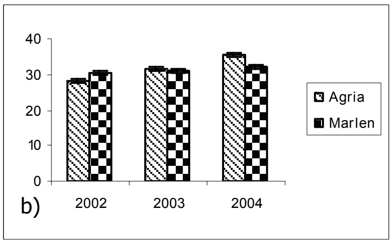


Figure 1: Fresh matter tuber yields (t ha^{-1}) as affected by (a) fertilization and (b) cultivar during 2002, 2003 and 2004 (means ± standard error)

In Exp. 2, cv. Marlen in 2003 had higher tuber FM yields than cv. Agria in most cases at the two early harvests, while Agria gave higher yields at the later harvest (Table 1). In 2004, the positive response of tuber FM yield to pre-sprouting (PS) lasted throughout the season, but could not be established at final harvest in 2003 (Table 1).

Tab. 1: Fresh matter tuber yields (t ha^{-1}) as affected by pre-sprouting for two cultivars at subsequent harvests during 2003 and 2004

cv.	PS	2003			2004		
		15 Jul	28 Jul	17 Sep	28 Jul	13 Aug	9 Sep
Agria	yes	22.6	31.5	39.9	29.9	31.1	30.0
	no	19.6	28.2	39.0	26.6	27.6	28.1
Marlen	yes	23.9	32.5	36.1	27.8	29.8	30.7
	no	21.5	30.7	35.2	25.6	27.4	27.4
S. E. of mean		0.53			0.59		

At harvest in September 2004, yield increase by pre-sprouting still amounted to +2.6 t ha^{-1} (+2.8 t ha^{-1} at the end of July) (Table 1). A similar response to pre-sprouting depending on year and date of harvest was established for size-graded (marketable) yields (data not shown). Dry matter (DM) concentration of tubers was significantly affected by fertilization (Exp. 1; Table 2a), cultivar (Exps 1-3) and pre-sprouting of tubers (Exp. 2; Table 2b). Moreover, significant interactions of these treatments with the year were established. Storage increased DM concentration significantly (Exp. 1; Table 2c), in two of three experiments.

Tab. 2: Tuber dry matter concentration (%) as affected by (a) fertilization and cultivar, (b) pre-sprouting and year and (c) storage (means ± standard error)

	cv.			Pre-sprouting	
Fertilizer type (a)	Agria	Marlen	(b)	Yes	No
CM	21.2	22.5	2003	27.6	27.5
PS	21.2	22.7	2004	25.6	24.1
PSHG	20.1	22.0	S.E. of mean	0.11	
HG	20.6	23.0	(c)	At harvest	After storage
CON	21.9	23.5		21.7	22.1
S.E. of mean	0.17		S.E. of mean	0.08	

No effect of fertilization (Exp. 1) and no consistent effect of preceding crop or pre-sprouting (Exp. 2) on reducing sugar concentration (RSC) could be established, but significant ($p<0.0001$) interactions for storage*year were found in all experiments.

Tab. 3: Tuber reducing sugar concentrations (g kg^{-1} FW), crisp L-values and French fry quality scores (in italics), respectively (both in brackets) as affected by storage and cultivar during 2003 and 2004 (means ± standard error)

		2003		2004	
Exp.	cv.	At harvest	After storage	At harvest	After storage
1	Marlen	6 (70.5)	16 (70.3)	15 (71.6)	66 (64.2)
2		10 (69.6)	17 (70.1)	27 (70.6)	104 (65.8)
3		1 (70.5)	2 (70.5)	2 (71.0)	15 (62.8)
3	Carmona	2 (70.1)	24 (62.8)	6 (69.1)	64 (50.8)
3	Delikat	4 (67.7)	44 (58.1)	18 (62.7)	113 (44.7)
3	Saturna	1 (69.3)	4 (69.2)	5 (71.2)	19 (62.2)
1	Agria	5 (*3.9*)	10 (*3.8*)	15 (*3.9*)	70 (*3.5*)
2		16 (*4.4*)	28 (*4.0*)	29 (*3.9*)	136 (*3.5*)
3		1 (*4.5*)	3 (3.8)	2 (*4.1*)	21 (*3.5*)
3	Premiere	11 (*4*.1)	56 (*2.8*)	23 (*3.0*)	90 (*2.2*)
3	Velox	6 (*3.9*)	39 (*2.6*)	21 (*3*.3)	102 (*2.6*)
3	Camilla	2 (*3*.6)	10 (*3.8*)	11 (*2.9*)	72 (*2.4*)
3	Freya	2 (*4.1*)	3 (*3.6*)	3 (*3.8*)	24 (*3.2*)
3	Marena	2 (*4*.1)	3 (*4.0*)	2 (*3.7*)	11 (*3.5*)

For the 2003 crop, RSC increased during storage (Exp. 1-3), but was still very low after four months of storage (8°C). In 2004, the RSC at harvest was comparatively higher than in 2003, and increased during storage appreciably (Table 3). The response of French fry quality score (mean of weighted characteristics colour [2x], texture [3x] and taste/odour [5x]) was mostly affected by storage (Exp. 1-3) and, additionally, interactions for cultivar*storage (Exp. 3) occurred. For crisp quality, significant interactions for storage*year ($p<0.0001$) were established. Lighter crisps (higher L-values) were assessed after winter wheat than after the two leguminous crops (data not shown), while after oats L-values were lower than after grass-clover.

Discussion

The positive response of tuber FM yield to cattle manure application in one of three years could be traced back to the increased supply of K, and – possibly a more balanced nutrition with regard to N and K. This suggestion is further strengthened by the profound effect of combined K and N fertilization(PSHG) on FM tuber yield compared with sole application of N (HG) and K (PS) (Fig. 1a). Results show clearly that performance of cultivars may vary considerably between the years (Fig. 1b) and seems to depend on the length of the growing season which - in organic potato cropping – is often shortened by late blight (*Phytophthora infestans*). Pre-sprouting could be shown to promote early tuber yield formation and DM accumulation and thereby reduce the risk induced by *P. infestans,* like in 2004. Results show that tubers from organic potato cropping may be expected to have sufficiently high tuber DM concentrations for processing into French fries (>19%). However, DM concentrations of tubers may fall short of the minimum of 22% required for crisps when a combined N and K fertilizer is applied. Results give evidence that the development of reducing sugars cannot necessarily be foreseen from the initial reducing sugar level at harvest. Moreover, sugar accumulation during storage seems to be mainly cultivar-specific. The marked increase due to storage for very early and early cultivars suggests that reducing sugars accumulation may strongly depend on maturity type. Throughout the experiments, results confirmed that the individual growing season has a tremendous impact on both, the initial level of reducing sugars and the increase of reducing sugars during storage. The medium-early cv. Agria and medium-late Marena proved to be well suited for cultivation of organic potatoes for French fries. Even in the season with marked quality losses due to storage, the quality score did not fall below the threshold of 3.5. There was no consistent response of crisp colour to an increased N supply brought forth by leguminous preceding crops or fertilization with horn grits. Even though L-values were significantly reduced by grass clover and peas, preceding crops do not seem to have any relevance to marketability of crisps. Overall, the results indicate that final product quality is much more influenced by growing season, storage and cultivar than by fertilization, preceding crop, or pre-sprouting.

Acknowledgments

This work was funded by the German Federal Agency for Agriculture and Food, Bonn.

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Effect of Compost versus Animal Manure Fertilization on Crop Development, Yield and Nitrogen Residue in the Organic Cultivation of Potatoes

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Key words: fertilization trial, compost, potato yield, N-residue, organic

Abstract

Organic farmers in Flanders use manure from extensive conventional livestock systems due to a lack of animal manure from organic producers. The research question was if on-farm prepared compost mainly consisting of vegetal residues can be a good alternative. A long-term fertilization trial with a 4-year crop rotation of maize - potatoes - spring barley - red clover is carried out on two fields with a time difference of one year. The fertilization treatments are on-farm prepared compost, applied as a single dose and a double dose, farmyard manure, slurry and slurry combined with composted municipal waste. This paper concerns the experimental results of the potato crop in 2006 and 2007. The nitrate content of the plant juice was monitored and the potato yield and nitrate content in the soil profile at the end of the growing season were determined. In 2006 the potato yields were significantly higher for both farm compost treatments while the nitrate residues in soil were significantly lower. The early, high and constant leaf blight disease pressure in 2007 resulted in lower yields and less marked treatment effects. This investigation demonstrated that application of mature compost can result in a faster development of the potato crop in the first weeks of the growing season, which is important for sufficient yields in organic potato growing.

Introduction

Organic farmers in Flanders use manure from extensive conventional livestock systems due to a lack of animal manure from organic producers. We questioned whether on-farm prepared compost mainly consisting of vegetal residues can be a good alternative.

It was hypothesised that the type and application method of the organic fertilizer input affect the yield and quality of the potato crop. In a field experiment carried out in 2001 in North Yorkshire with an identical level of N-input, cattle manure-based compost increased potato yield significantly compared with chicken manure fertilizer pellets (Leifert, 2005).

Differences in the organic fertilization regimes can lead to large differences in the environmental effects of organic farming (Thorup-Kristensen, 2007). Potato crops are very sensitive to losses of soil mineral nitrogen by post-harvest leaching. It was questioned whether the type of organic fertilizer input would affect the nitrate N-residue in the 0-90 cm soil profile.

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Materials and methods

On two fields a long-term fertilization trial is executed. The crop of the conversion period was a fallow of grass-clover. The adopted crop rotation is a 4-year cycle of maize - potatoes - spring barley - red clover. The experiment has been repeated on two fields in two consecutive years (starting in 2005 and 2006 resp.).

Two treatments concern on-farm prepared compost: a single dose (FC) and a double dose (2xFC). Other treatments were farmyard manure (FYM), slurry (S) and slurry combined with compost of municipal waste (S+MWC). The organic matter input by fertilization is equalized for the treatments FC, FYM and S+MWC, 6,5 t organic matter per ha in 2006 and 6 t per ha in 2007. Considering organic matter input 30 t FYM was equivalent to 50 t and 65 t FC in 2006 and 2007 respectively. The total nitrogen input with FC was 160 kg per ha in 2006 and 185 kg per ha in 2007 and the dose of 30 t FYM resulted in a total nitrogen input of 150 kg per ha in 2006 and 125 kg per ha in 2007. The nitrogen input with 20 t slurry was about 100 kg per ha. Municipal waste compost resulted in an additional nitrogen input of 140 and 175 kg per ha in 2006 and 2007 respectively. Compost application is combined with reduced tillage techniques, so that compost is incorporated to a shallow depth. Both types of manure, farmyard manure and slurry, were incorporated by ploughing to a depth of 30 cm. Each treatment counts 4 replicates, consisting of 15 m by 25 m plots.

The nitrate content (ppm) of the plant juice of the FC and FYM treatments was monitored (n=1) in 2006. Samples of petioles were taken weekly from the beginning of June until mid-August 2006. Nitrate concentration was determined in the plant juice, using a Horiba ion-selective measurement device. The potato yield was determined (n=4) by harvesting two adjacent rows of 6 m (plots of 9 m^2). The nitrate N-content of three soil layers (0-30, 30-60 en 60-90 cm) was determined (n=4) after extraction with a 1N KCl solution at the end of the growing season. Potato yield and nitrate N-residue (0-90 cm) of the different fertilization treatments were compared with each other using a variance analysis (One-Way Anova, Scheffé multiple comparison of means).

Results

Large differences in initial development of the potato crop were observed between the treatments with farm compost and those with animal manure. By the middle of June 2006 the crops from the farm compost treatments were better developed. The leaf color was lighter for the potatoes of the compost treatments than for the potatoes fertilized with animal manure and the mean plant juice nitrate concentrations, over the measurement period, were three times lower for the FC (807 ppm) compared to the FYM treatment (2473 ppm).

The potato crop in 2007 was planted earlier and similar differences in initial development were observed between the treatments with farm compost and those with animal manure.

In 2006 significant yield differences were observed between treatments (Figure 1). Multiple comparison of the yield in function of the fertilization (via Scheffé) showed that in 2006 the yield for the compost treatments was significantly ($p<0.05$) higher than the yield for the three other treatments. For 2007 multiple comparison of the yield (via Scheffé) revealed no significant differences in yield (Figure 1).

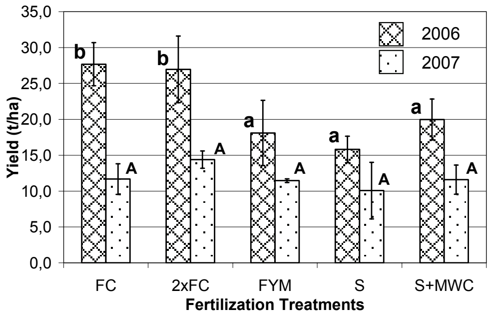

Figure 1: Potato yields 2006 & 2007 (t/ha >35mm)

Error flag indicates +/- standard deviation;
Means that are not significantly different are denoted with the same letter;
Fertilization treatments FC: single dose farm prepared compost, 2xFC double dose farm prepared compost, FYM: farmyard manure, S: slurry, S+MWC: slurry plus municipal waste compost

In autumn, October 3, 2006 the N-residue (kg NO_3^--N per ha, 0-90 cm soil depth) was determined for the different treatments (table 1, n=4). For all treatments the residue was lower than the standard of 90 kg N/ha. Significant differences (p<0.01) between the treatments were found in 2006 using ANOVA. Fertilization with compost (for both compost treatments) resulted in significantly lower amounts of nitrate than in the three other treatments where animal manure was applied. In October 31, 2007 no significant differences in N-residue were found between treatments (table 1, n=4).

Tab. 1: N-residue in 2006 & 2007 after the potato crop

	kg NO_3^--N per ha, 0-90cm	
	2006	2007
FC	47^{a}	79^{A}
2xFC	49^{a}	79^{A}
FYM	77^{b}	101^{A}
S	67^{b}	90^{A}
S+MWC	75^{b}	87^{A}

Means that are not significantly different are denoted with the same letter;
Fertilization treatments FC: single dose farm prepared compost, 2xFC double dose farm prepared compost, FYM: farmyard manure, S: slurry, S+MWC: slurry plus municipal waste compost

Discussion

The higher potato yield for the compost treatments in 2006 was a consequence of the earlier start and ripening of the potato crop. When *Phytophtora infestans* became detrimental for the potatoes, the plants on the compost treatments were already ripening while the potato plants on the manure treatments were greener and their growth was interrupted by the disease. The reason for lower yields and less marked treatment effects in 2007 was probably the early, high and constant leaf blight disease pressure in that year. In 2006 leaf blight appeared late. Accelerating development by agronomic practices is an important strategy for organic growers in order to obtain sufficient yields and an acceptable tuber size grading. For the earliness of the crop a fast crop development, early tuber formation and fast tuber growth are important (Tiemens-Hulscher, 2007). The leaf development after emergence is strongly influenced by the nitrogen availability in the first weeks after emergence (Vos, 1995). Mature compost is already transformed organic matter and is a product with a limited but guaranteed nitrogen supply. This can explain the early start of the potato crop on the compost treatments. In the case of the animal manure treatments the squat growth and the high nitrate concentration in the leaves, together with the dark colour indicates that plants could not respond to the nutrient availability by growth because of a soil-related stress factor. Root development was possibly hindered by the decomposition of fresh organic matter from the organic fertilization. The lower N-residues in 2006 for both farm compost treatments compared to those for treatments with cattle manure in combination with the higher potato yields for compost treatments indicate that compost application in potato cultivation has potential for obtaining a successful crop and lowering potential nitrate losses following harvest. In 2007 the lower yields resulted in a lower N-uptake and in higher N-residues. Less marked treatment effects on yield coincide with less marked treatment effects on N-residue.

Conclusion

Application of compost can result in a faster initial development of the potato crop. This is important in organic farming when leaf blight rapidly becomes fatal for the crop because of limited crop protection measures. In 2006 the organic fertilizer type had a significant influence on the yield response. This confirms the hypothesis that the form of the organic fertilizer input may affect yield even though blight infection may not be affected. The fact that significantly lower nitrate residues were found in 2006 in the compost treatments indicates that the type of the organic fertilizer input influences potential nitrogen losses. Plant juice nitrate concentration measurement may be used to indicate the speed of the initial development of the potato crop.

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Effects of Farm Type and Different Intensities of Soil Tillage on Cash Crop Yields and Soil Organic Matter

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Key words: crop rotation, tillage, long-term field experiment

Abstract

An organic long-term field experiment has been carried out at the experimental station Gladbacherhof (Giessen University, Germany) since 1998 to survey the performance of agronomical, economical and ecological indicators dependant on farm type and tillage intensity. This article presents results on cash crop yields and changes in humus contents in the first two rotations of the experiment. It can be concluded that organic stockless farming without ley affects cash crop yields and demands special attention with regard to a sustainable humus management. Stockless farming with rotational ley on the other hand up to now showed a satisfactory performance when compared to a mixed farm type with livestock. As for the yields, reduced tillage systems could cope with the regularly ploughed reference system if at least a shallow turning of the soil was carried out. An increase of humus contents was not induced by reduced tillage systems.

Introduction

In the context of specialization and intensification processes taking place even in organic farming, an increase of organic stockless farm types can be observed. However, it has been suggested that organic stockless farming faces particular challenges with regard to nutrient supply as well as sustainable management of humus resources. A careful assessment of the economical and ecological performance of such systems is therefore necessary in order to promote sustainable management. Further, the reduction of tillage intensity has often been considered as desirable in organic farming. The reasons for this are manifold. Lately the issue has been given special attention in the context of climate change and carbon sequestration in agricultural soils. Still it has to be investigated whether reduced tillage systems in organic farming can cope with the requirements of nutrient availability and weed control (Drinkwater et al. 2000).

These issues are being investigated in a long-term field experiment at the experimental farm Gladbacherhof of Giessen University (Germany), started in 1998. This article presents the results on the changes in cash crop yields and soil organic matter (humus) in the first ten years of the experiment in order to discuss the agronomical as well as ecological impact of farm type and tillage intensity with regard to selected indicators.

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Materials and methods

The long-term field experiment Gladbacherhof is located at Villmar (Hesse, Germany) on the north-western spur of the Taunus hill landscape (altitude 170 masl., mean annual temperature 9.5°C, mean annual precip. 649mm, orthic luvisol, silt with high clay content). In 1998, the experiment was set up in split plot design with four replications. Main factor is farm type, second factor is tillage intensity. Three farm types are displayed in the experiment comprising different crop rotations and fertilization (tab.1).

Tab. 1: Design of crop rotations and fertilization for farm types in the long-term trial Gladbacherhof (Hesse, Germany) from 1998 to 2009

field number in crop rotation	year	Farm type		
		a1 (mixed farm, 0.7 LU cattle stocking)	a2 (stockless farming with ley)	a3 (stockless farming without ley)
1	1998,2004	alfalfa-grass	cereal + US	cereal + CC
2	1999,2005	alfalfa-grass	ley (alfalfa-grass)	faba beans
3	2000,2006	w. wheat + CC	w. wheat + CC	w. wheat + CC
4	2001,2007	## potatoes	potatoes	potatoes
5	2002,(2008)	oats/peas* + US	peas	peas
6	2003,(2009)	#w. rye + US	w. rye + CC	w. rye + CC

* Oats/peas in 2002, winter wheat in 2008, #20 t farmyard manure, ## 30 t farmyard manure, CC=catch crop (non-legume/legume mix), US=underseed alfalfa-grass

Furthermore, four levels of tillage intensity are included with the following tillage systems:

b1: regular tillage with plough (30 cm)

b2: two-layer plough (soil turning in 0-15 cm, soil break up 15-30 cm)

b3: until 2003: as b2 but without tillage in autumn before spring crops
from 2004: max. cultivation depth 15 cm, various standard tillage equipment

b4: cultivator & rotary harrow, max. cultivation depth 30 cm, no turning of soil

Results

Winter wheat yields showed a difference between farm types already in the first rotation period (Schmidt et al. 2006), indicating an advantage of the stockless farm type with rotational ley (a2) and the mixed farm type (a1), when compared to the stockless farm type without ley (a3). In the second rotation period, winter wheat yields in a1 decreased nearly down to the level of yields in a3 (fig.1). Wheat yields in a2 in 2006 were even higher than in 2000, thus exceeding the yields of the other two farm types significantly.

As compared to the deeply ploughed system (b1), the reduction of tillage intensity significantly affected winter wheat yields. In the second rotation period a significant difference between the tillage systems was evident with considerably lower yields in b4 than in all other three variants.

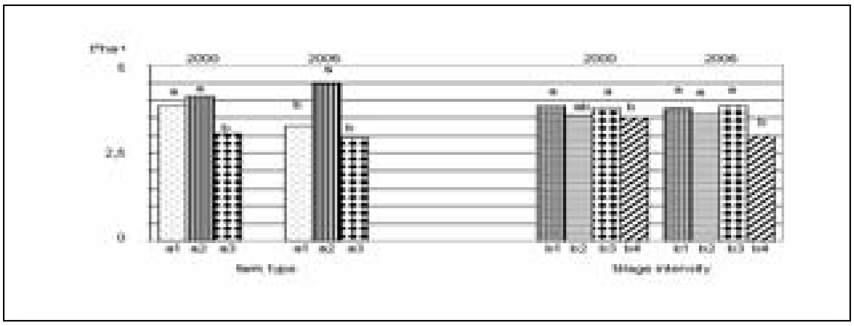

Figure 1: Winter wheat yields (t*ha^{-1}) dependant on farm type (left) and tillage intensity (right) in the first two rotation periods of the long-term experiment Gladbacherhof. Differing letters denote significant distinctions (P≤0.05).

No significant differentiation of potato yields according to farm type or tillage intensity could be observed (without figure). Statistically firm interactions between farm type and tillage intensity could not be observed for any of the crops.

Tab. 2: C_{org}[1)] and N_t[1)] contents in topsoil (0-30 cm) and C/N ratio dependant on farm type and tillage intensity in the long-term experiment Gladbacherhof in 2007 after nine trial years.

farm type	C_{org} mg (100g)$^{-1}$	N_t mg (100g)$^{-1}$	C_{org}/ N_t	tillage intensity	C_{org} mg (100g)$^{-1}$	N_t mg (100g)$^{-1}$	C_{org}/ N_t
a1	1323 a	147 a	9.0 a	b1	1285 a	143 a	9.0 a
a2	1264 ab	139 b	9.1 a	b2	1250 a	139 ab	9.0 a
a3	1201 b	131 c	9.2 a	b3	1241 a	133 b	9.4 a
				b4	1274 a	141 a	9.0 a

C_{org} and N_t values have been corrected with reference to initial values in 1998. Within a column differing letters denote significant distinctions (P≤0.05).

After nine years, C_{org} and N_t contents again were lower in the stockless farm type without ley (a3) than in the mixed farm type (a1) (tab.2). Concerning the higher C_{org} and N_t values in a1, the short-term effect of farmyard manure application (tab.1) must be taken into account. A significant differentiation of C and N contents by tillage intensity on the other hand could not be confirmed (tab. 2). This holds true even if bulk density is considered (Krawutschke 2007).

Discussion

The positive precrop effect of alfalfa-grass obviously is stronger for ley with the mulched plant material remaining on the plot than for fodder cropping (Loges et al. 1999). This situation was reflected in the experiment despite of a considerably higher yield level of the alfalfa-grass precrop in a1 compared to a2 before 2000. As for potato yields, it can be assumed that the pre-precrop effect of mulched alfalfa-grass in a2 is at least compensated by farmyard manure application in a1. The lower yield level for winter wheat in a3 reflects the low N supply in this farm type (Schmidt et al. 2006).

A negative impact of tillage intensity reduction on cash crop yields is evident for the lowest intensity level (b4). There is some evidence that losses caused by lower yields in no-till systems in organic farming may not easily be compensated by the lower energy consumption (Kainz et al. 2005).

The impact of farm types on humus contents in the experiment supports the assumption that farmyard manure application and perennial legume cropping have a decisive impact on humus content dynamics (e.g. Leithold et al. 2007). Since manure application adds to legume cropping in a1, the higher humus content produced by this farm type compared to a2 and a3 is likely to become even more apparent in the long run. Reduced tillage intensity did not raise humus contents in the Gladbacherhof experiment. Similar results have recently been published (e.g. Baker et al. 2007), contradicting an assumed carbon sequestration potential of tillage intensity reduction. Still it is necessary to further investigate the potential for saving fossil energy (fuel).

Conclusions

After 10 years of differentiated management in the long-term experiment Gladbacherhof it can be concluded that perennial legume cropping has to be considered beneficial in agronomical terms as well as with regard to humus reproduction. Stockless farming without ley in the rotation obviously cannot easily cope with nutrient supply, even with optimized inclusion of catch crops.

Reduced tillage intensity in the trial affected SOM allocation in the soil profile but did not raise humus contents. On the other hand, a similar yield level as in the reference system could be reached with reduced tillage intensity in the experiment, if at least shallow ploughing was not categorically excluded.

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Searching for an alternative oil crop for organic farming systems in temperate climates

Weber, E.A.[1], Elfadl, E.[2], Reinbrecht, C.[3], Graeff, S.[4] & Claupein, W.[5]

Key words: safflower, accessions, selection, seed yield, oil content

Abstract

Safflower is an oil crop widely grown in semiarid and arid regions whose oil is valuable because of its high concentration of polyunsaturated fatty acids. The aim of this contribution is to give an overview of the methods for identifying potential genotypes suitable for cultivation in temperate climates. From 2002 to 2005 a great many safflower accessions from a worldwide safflower collection were screened at several locations in Germany and Switzerland. More than 75 % of the accessions tested failed under the humid conditions of the first year because they did not set seed. During 2004 and 2005, seed yield per row and oil content from 486 tested accessions varied between 0 and 428 g and between 0 and 21 %, respectively. Twenty selected accessions showed seed yields between 1.4 and 2.1 t ha^{-1} and oil contents ranging between 21 and 23 %. Although yield potential of given accessions was strongly dependent upon climatic factors, well adapted safflower accessions for more humid conditions were identified. For future research there are several agronomic challenges to be solved for cultivating safflower in organic farming systems, such as increasing oil content and optimizing weed and disease control.

Introduction

Safflower (*Carthamus tinctorius* L.), a member of the family of the Asteraceae, is one of the oldest cultivated crops. It often is grown on a small scale for personal use and thus remains a minor crop, with world seed production around 800 000 t per year (Gyulai, 1996). Commercial oil production from safflower seeds has been conducted for about 50 years, first for the paint industry and now mainly for its edible oil (Li and Mündel, 1996). Safflower is grown in more than 60 countries, but mainly in India, USA, Mexico, Ethiopia, Argentina and Australia (Li and Mündel, 1996). Safflower has very valuable oil for human nutrition, because of high contents of polyunsaturated fatty acids, especially linoleic acid (Honermeier, 2006). Apart from the use as an edible oil, safflower is a crop for multiple purposes. Dyes extracted from florets can be used as natural food colours or to tint natural cosmetics. Florets as well as seeds are used for cosmetic products and medicinal purposes in traditional Chinese medicine. Seeds are also used as birdseed (Li and Mündel 1996). Although, safflower can be grown across a wide range of latitudes (from 60°N to 45°S) and its product has many uses, cultivation in Germany currently is negligible (Honermeier, 2006). Because of its applicability in the human health sector as well as its usability for natural cosmetics

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and natural medical products, safflower seems to be a very favourable crop for organic plant production in Central Europe. However, there currently is a lack of knowledge on potential genotypes suitable to be grown under temperate climatic conditions, as well as on agronomic factors to optimize seed yield and oil content and to control weeds and pests. The aim of this study was to search for genotypes adapted to temperate climatic conditions within a great number of accessions from all over the world. A methodical approach is given on the ideotyping already done and the prototyping intended for prospective research.

Materials and methods

In 2002, 741 safflower accessions, obtained from different gene banks, breeders and official institutions from all over the world, were evaluated at the two locations Ihinger Hof (SW Germany) and Göttingen (Central Germany). The field trials were set up in a randomized block design with two replicates. Because of the limited number of seeds, safflower accessions were sown in microplots of one row of 1.2 m length. Row distance between different accessions was 40 cm. From the tested pool, 65 accessions were selected according to an index summarizing disease resistance, seed set, seed yield, etc. These selected accessions were cultivated in 2003 at three locations, Kleinhohenheim, Göttingen and Klettgau (SW Germany), on plots 1.8x3.0 m. In 2004 and 2005, 20 selected accessions were evaluated at four sites in SW Germany and Switzerland in a lattice design with four replicates. Fifty seeds per m^{-2} were drilled in rows with a row spacing of 20-40 cm. Crop management in all trials was done according to organic standards. Weeding was done mechanically at the rosette stage, and if necessary, manually. No fertilizer was applied. Twenty agro-morphological traits were evaluated. Oil content in per cent was estimated using near infrared reflectance spectroscopy (NIRS). In parallel, 468 accessions from 49 countries across 15 geographical regions were evaluated at the location Kleinhohenheim across two seasons. In a simple lattice design with two replicates, 25 seeds from each accession were drilled in a 1.2-m-long row with 75 cm inter-row distance. Statistical analyses were performed with PLABSTAT (Utz, 2002). An overview of the selection process is given in Fig. 1.

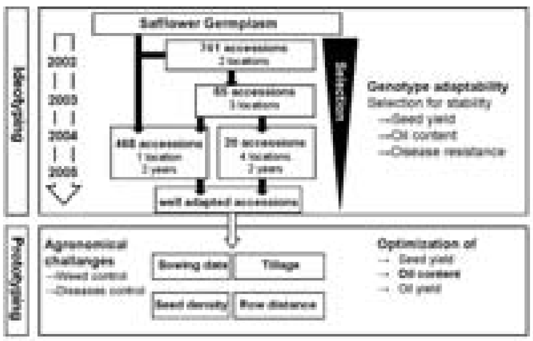

Figure 1: Methodology of searching for safflower genotypes adapted to temperate climates (Ideotyping according to Reinbrecht et al. 2005, Elfadl et al. 2008a,b).

Results and discussion

Although highly significant genotypic effects for all evaluated parameters could be observed in 2002, about 75 % of the tested accessions failed because of high disease attack and thus no seed set (not shown). Most accessions showing satisfying values originated from Europe, especially Central Europe. Figure 2 depicts in a simplified way the broad ranges for seed yield, oil content and sensitivity to head rot infestation of the 468 accessions tested in 2004 and 2005. About 5 % of the evaluated accessions had a mean oil content ranging between 20-25 %, and about 8 % showed a low sensitivity to head rot infestation between 10 and 20 %.

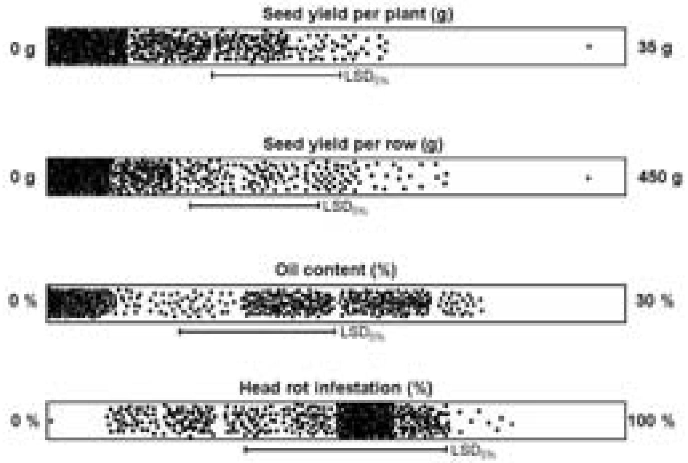

Figure 2: Ranges in seed yield, oil content and head rot infestation of 468 safflower accessions grown in 2004 and 2005 at Kleinhohenheim (means across years and locations). Each dot represents one accession. Simplified illustration according to data of Elfadl et al. (2008a).

Figure 3 shows the average ranges in seed yield, oil content and head rot infestation of the 20 selected accessions evaluated across two growing seasons (2004 and 2005) and four locations. Thirteen of the 20 selected accessions showed average seed yields ranging from 1.7 to 2.0 t ha^{-1}, with five between 2.0 and 2.2 t ha^{-1}. Oil content showed a lower variability, ranging between 21 and 23 %. Head rot infestation ranged between 13 and 28 %. Although the evaluated parameters depended on climatic factors, well-adapted safflower accessions could be identified for more humid conditions that showed satisfactory yield and oil content and low susceptibility to head rot disease. Since cultivation of the two main oil crops in Central Europe, oilseed rape and sunflower, entails several problems under organic farming conditions, such as strong attack by insects, the high demand for nitrogen, and the high susceptibility to fungal diseases, safflower is considered to be a valuable alternative oil crop for organic farming systems under temperate climate conditions.

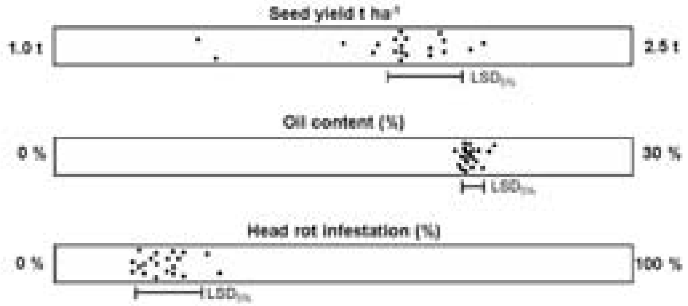

Figure 3: Ranges in seed yield, oil content and head rot infestation of 20 selected safflower accessions tested in 2004 and 2005 at four locations (means across years and locations). Each dot represents one accession. Simplified illustration according to data of Elfadl et al. (2008b).

Conclusions

The studies showed that although weather during the particular growing year had an evident impact on seed yield and oil content, safflower genotypes suitable for organic farming systems in temperate climates could be identified. However, there are still agronomic challenges to be solved, such as weed and disease control, to ensure a successful implementation in organic cropping systems. Additionally, breeding should be encouraged to increase the oil content of safflower to make it competitive with other oilseed crops.

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Effect of Biofertilizers on Agronomic Criteria of Hyssop (Hyssopus officinalis)

Tabrizi, L., Koocheki, A. & Ghorbani, R.[1]

Key words: hyssop, biofertilizer, agronomic criteria, essential oil

Abstract

An experiment was conducted under field conditions to evaluate the effects of pure or combinations of biofertilizers on agronomic and quality criteria of Hyssop (Hyssopus officinalis), a medicinal and aromatic plant from Labiateae family at the Research Station of the Faculty of Agriculture, Ferdowsi University of Mashhad, during 2006 and 2007. A complete randomized block design with three replications was used. Treatments containing Azospirillum/Azotobacter(Nitroxin), Azospirillum/Bacillus subtilis/ Pseudomonas fluorescens (Super Nitro Plus), Glomus intraradices (Mycorrhizal inoculant), Pseudomonas fluorescens, Glomus intraradices / Pseudomonas fluorescens, Azospirillum/ Azotobacter/ Glomus intradica / Pseudomonas fluorescens and a control. The results indicated that in general application of biofertilizers enhanced yield and other plant criteria in this plant. In terms of all plant criteria, the plants performed better with application of Super Nitro Plus and a mixture of Glomus intraradices and Pseudomonas fluorescens.

Introduction

Good soil fertility management ensures adequate nutrient availability to plants and increases yields. High above-ground biomass yield is obviously accompanied by an active root system, which releases an array of organic compounds into the rhizosphere (Mandal *et al.,* 2007). It is well known that a considerable number of bacterial and fungal species possess a functional relationship and constitute a holistic system with plants. They are able to exert beneficial effects on plant growth (Vessey, 2003) and also enhance plant resistance to adverse environmental stresses, such as water and nutrient deficiency and heavy metal contamination (Wu et al., 2005).

Biofertilizers are products containing living cells of different types of microorganisms (Vessey, 2003; Chen, 2006) that have an ability to convert nutritionally important elements from unavailable to available form through biological processes (Vessey, 2003) and are known to help with expansion of the root system and better seed germination. Biofertilizers differ from chemical and organic fertilizers in that they do not directly supply any nutrients to crops and are cultures of special bacteria and fungi. Some microorganisms have positive effects on plant growth promotion, including the plant growth promoting rhizobacteria (PGPR) such as *Azospirillum*, *Azotobacter*, *Pseudomonas fluorescens*, and several gram positive *Bacillus* spp. (Chen, 2006). The diazotrophic rhizobiocoenosis is an important biological process that plays a major role in satisfying the nutritional requirements of the commercial medicinal plants (Deka *et al*., 1992) The strong and rapidly stimulating effect of fungal elicitor on plant secondary metabolism in medicinal plants has attracted considerable attention and research efforts (Zhao et al., 2005).

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Azotobacter and *Azospirillum* are free-living N_2-fixing bacteria that in the rhizospheric zone have the ability to synthesize and secret some biologically active substances that enhance root growth. They also increase germination and vigour in young plants, leading to improved crop stands (Chen, 2006). Various *Pseudomonas* species have shown to be effective in controlling pathogenic fungi and stimulating plant growth by a variety of mechanisms, including production of siderophores, synthesis of antibiotics, production of phytohormones, enhancement of phosphate uptake by the plant, nitrogen fixation, and synthesis of enzymes that regulate plant ethylene levels (Abdul Jaleel et al., 2007). Arbuscular mycorrhizal fungi (AMF) are a major component of rhizosphere microflora in natural ecosystems and have been reported to form obligate symbiotic associations with most angiospermic plants, including several medicinal species (Venkateshwar Rao et al., 2000).The ability of AMF to enhance host plant uptake of relatively immobile nutrients, in particular P, and several micronutrients, has been the most recognized beneficial effect of mycorrhiza. Therefore, mycorrhizas are multifunctional in (agro)ecosystems, potentially improving physical soil quality (through the external hyphae), chemical soil quality (through enhanced nutrient uptake), and biological soil quality (through the soil food web) (Cardoso and Kuyper, 2006).

Hyssop *(Hyssopus officinalis*), which belongs to the family Labiateae, is a perennial, branched semi-shrub and one of the most important pharmaceutical herbs. Since efficient plant nutrition management should ensure both enhanced and sustainable agricultural production and safeguard the environment, the objective of the present investigation was to evaluate the .effects of different biofertilizers on growth and productivity of *H. officinalis*.

Materials and methods

This experiment was conducted over two years (2006-2007) with a complete randomized block design with three replications. Treatments containing N-fixing *Azospirillum/Azotobacter* (Nitroxin), *Azospirillum/Bacillus subtilis/ Pseudomonas fluorescens* (Super Nitro Plus), *Glomus intraradices* (Mycorrhizal inoculant), *Pseudomonas fluorescens* (P solubilizer), *G. intraradices /P. fluorescens*, *Azospirillum/ Azotobacter/G. intraradices /P. fluorescens,* and a control. A few months before the experimental practices were introduced, all plots were given 20 t ha^{-1} of cow manure. In April seeds of hyssop were mixed with different biofertlizers on the basis of 2 l ha^{-1} for Nitroxin, Super Nitro Plus, and *P. fluorescence* and for Mycorrhizal inoculant the seeds were inoculated with a proper amount of powder. Arabic gum was used as surfactant. Seeds were planted in early April in plots of 2×2 m in rows 50 cm apart with 40 cm separation between plants in rows. The field was managed organically, with no application of chemicals including fertilizers and pesticides. In the flowering stage, morphological parameters such as plant height and plant diameter were measured in the samples from 1 m^2 of each plot, then the plants were cut at a height of 10 cm above soil level and dried in a shaded area. Dry weight of aerial parts and essential oil content were determined. The essential oil content of the dry herbage was determined by hydro-distillation for 3 h, using a Clevenger-type apparatus. Since this investigation was to compare the treatments' effects in two years, the analysis was done as a split plot design in time, using SAS statistical software (SAS Institute, 2002).

Results

Table 1 shows that as expected, although there were some differences in plant height among different biofertilizer sources, the differences were not considerable. However, a pronounced difference could be seen between the control and biofertilizers. This was also true for plant diameter, where the trend was almost the same as with plant height. In other words biofertilizers affected plant height and plant diameter in the same manner.

Although dry weight showed no significant difference in response to biofertilizers, the yield in biofertilizered plots were 2-3 times higher than the control. In addition, applications of Super Nitro Plus and a mixture of *G. intraradices* and *P. fluorescens* were more effective in terms of all these plant criteria. A similar trend as with dry matter yield was also observed for essential oil yield. However, no significant effect was observed between control and biofertilizers in terms of percent of essential oil.

Tab. 1: Mean values for agronomic criteria of hyssop grown under different biofertilizers

Treatments	Height (cm)	Diameter (cm)	Dry Weight (gm^{-2})	Essential Oil (%)	Essential Oil Yield (gm^{-2})
B1	54 ab	35 c	566 a	0.7 a	4 a
B2	59 a	44 a	629 a	0.8 a	4 a
B3	52 ab	37 bc	470 a	0.7 a	3 a
B4	52 ab	39 b	558 a	0.7 a	4 a
B5	55 a	39 b	591 a	0.8 a	4 a
B6	53 ab	38 bc	586 a	0.7 a	4 a
Control	48 b	28 d	279 b	0.8 a	2 b

B1: Azospirillum/Azotobacter, B2: Azospirillum/B. subtilis/ P. fluorescens, B3: G. intraradices, B4: P. fluorescens, B5: G. intraradices /P. fluorescens, B6: Azospirillum/ Azotobacter/ G. intraradices /P. fluorescens, Means in each column followed by the same letter are not significantly different ($P<0.05$) using Duncan's Multiple Range Test.

Discussion

Productivity in an ecosystem is influenced by several factors, such as availability of nutrients and water. In the present study, increases in agronomic criteria were observed following inoculation with biofertilizers. This may be due to better utilization of nutrients in the soil through inoculation of efficient microorganisms. A positive effect of biofertilizers on plant height and diameter has been reported in the literature (Migahed *et al*., 2004).

In addition, higher dry matter production by the inoculated plant might be because of the augmented uptake of N and P, which in turn was a consequence of the root proliferation. Also, the increased growth parameters in hyssop might be due to the production of growth hormones by the bacteria. Ratti *et al.* (2001) found that a combination of the arbuscular mycorrhizal fungi (*G. aggregatum)*, the PGPR (*B.*

polymyxa) and *A. brasilense* maximized biomass and P content of the aromatic grass palmarosa (*Cymbopogon martinii*) when grown with an insoluble inorganic phosphate.

In general it appears that, as expected, application of biofertilizers improved yield and other plant criteria; this has also been reported elsewhere (Venkateshwar Rao *et al*., 2000). Therefore, it appears that application of these biofertilizers could be promising in production of medicinal and aromatic plants.

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Comparison of Different Intercropping Arrangements of Cumin (*Cuminum cyminum*) and Lentil (*Lens culinaris*)

Jahani, M., Koocheki, A. & Nassri Mahalati, M.[1]

Keywords: row intercropping, strip intercropping, cumin, lentil, LER.

Abstract

To evaluate the effect of different intercropping pattern of cumin and lentil on plant growth and yield, an experiment was conducted in Agricultural Research Station of Ferdowsi University of Mashhad, Iran in the growing season of the year 2004. Treatments were: A: row intercropping of cumin and lentil B: strip intercropping of cumin and lentil (three cumin rows and three lentil rows) C: strip intercropping of cumin and lentil (four cumin rows and four lentil rows) D: sole crop of cumin (six rows) E: sole crop of lentil (six rows). For this purpose a complete randomized block design with 4 replications was used. Results showed economic and biologic yield of cumin, 1000-seed weight, number of seed per umbel were affected by different intercropping and there was a decreasing trend in these parameters from intercropped to the sole crop. Biological and economic yield and also harvest index for lentil were higher in sole crop compared with intercrop. The highest Land Equvalent Ratio -LER (1.86) was obtained from treatment A (row intercropped) and the least (1.26) was obtained in treatment C (strip intercropped). There was a decreasing trend in LER from row intercropped to strip cropping.

Introduction

Intercropping has been considered as one of the practice for enhancing biodiversity of cropping system and it has been reported to increase sustainable yield production when it is done particularly with combination of medicinal plant and a field crop the beneficial effect may be increased (Guldan, *etal*.1999). In other words intercropping crops such as lentils (nitrogen fixer) with medicinal plants may increase nitrogen availability for the medicinal plants. Also intercropping lentil with other plants has been reported to reduce lodging and thereby facilitating mechanical harvesting of lentils (Bagheri, *etal.* 1998).

Pulses are the second source of food after cereals for humans. Lentil which is a pulse crop is an important crop in Iran with more 260.000 ha. Iran ranks forth in term of lentil acreage (Sabaghpour, et al. 2003). Cumin is an important medicinal cash crop of Iran with 35.811 ha (Kafi, *etal*. 2003). Iran is the major cumin producing country and the main growing area is Khorasan province. Growing nature of cumin and lentil are almost similar in terms of period of growth, time of sowing and scale of biomass production and therefore intercropping of these two plants is facilitated. The purpose of this study was to evaluate intercropping cumin and lentil with different planting pattern in terms of feasibility of intercropping and yield advantages.

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Materials and methods

Our experiment was conducted in 2004 as a Complete Randomized Block with four replications and five treatments including different planting pattern for lentil and cumin:

-Row intercropping of lentil and cumin

-Strip intercropping of lentil and cumin with three rows each

-Strip intercropping of lentil and cumin with four rows each

-Pure stand of lentil and cumin

Seeds were sown in April on rows at a distance of 25 cm. The distance in the rows was 10 cmr for lentils and 5 cm for cumin. At the time of harvest total biomass and yield and yield components were measured. Land Equivalent Ratio, which shows relative area under sole crop to achieve intercrop yields under the same conditions, was calculated as follows:

$$LER= I_a/S_a+I_b/S_b$$

where LER is land equivalent ratio , I= multiple cropping yield, S= sole cropping yield and a, b refer to the component crop.

Statistical analysis of the results was carried out by MSTAT-C software. For the comparison of means Duncan Multiple Range Test (DMRT) was used.

Results

Table 1 and 2 show different plant criteria associated with intercropping pattern. As it is apparent plant height for both cropping was not affected by planting pattern but out of the expectation height of plant particularly for lentil was somehow higher in pure stand.

Biological yield in row intercropping was somehow more than strip intercropping. However, in case of lentil biological yield in pure stand was much higher compared with the other treatments.

Harvest index for both plant species was higher in pure stand. Similar findings have been reported elsewhere (Abbasi, 2005). Economic yield for lentil was also higher in pure stand. This was not the case for cumin and in general yield in intercropped plots was slightly higher than in strip intercropped plots.

Thousand seed weight was higher in intercropped than in other systems. There are reports (Calavan & Weil 1988) which confirm our results.

Tab. 1: Yield structure of lentils under intercropping and strip cropping

Treat-ment	Biological yield (kg/ha)	Har-vest index	Econ. Yield (kg/ha)	Thousand seed weight (g)	Number of pods per plant	Number of seeds per pod	Par-tial LER	Total LER
A	2651[b]	0.17[ab]	453[b]	35.55[a]	2.12[a]	1.43[a]	0.53[b]	1.9a
B	2272[c]	0.13[b]	302.3[c]	21.32[b]	1.55[b]	1.25[b]	0.36[c]	1.5b
C	1047[d]	0.13[b]	185.1[d]	20.89[b]	1.27[b]	1.1[b]	0.22[d]	1.3c
D	3159[a]	0.2[a]	858.9[a]	25.29[b]	1.36[b]	1.25[b]	1	

significant for P<0.05

A-Row intercropping of lentil and cumin, **B**-Strip intercropping of lentil and cumin with three rows each, **C**-Strip intercropping of lentil and cumin with four rows each, **D**-Pure stand of lentil and cumin

Number of pods per plant for lentil and number of umbels per plant for cumin was also higher in intercropped. However for cumin no differences were observed between different planting patterns. This was also to some extent true for number of seeds per pod for lentil and number of seeds per umbel for cumin.

In general partial land equivalent ratio for cumin was higher than for lentil. Total land equivalent ratio for intercropped was higher than for pure. It appears that intercropping of cumin and lentil is advantageous compared with sole cropping.

Tab. 2 Yield structure of cumin under intercropping and strip cropping

Treat-ment	Biological yield (kg/ha)	Har-vest index	Econ. Yield (kg/ha)	Thousand seed weight (g)	Number umbels per plant	Number of seeds per pod	Par-tial LER	Total LER
A	1220[a]	0.33[d]	394.2[a]	1.757[a]	15.49[a]	17.74[a]	1.34[a]	1.86[a]
B	803.7[b]	0.42[c]	339.9[b]	1.375[ab]	18.67[a]	9.29[ab]	1.14[b]	1.5[b]
C	598.1[c]	0.51[b]	308.8b[c]	1.34[ab]	16.91[a]	7.87[b]	1.04[bc]	1.26[c]
D	505.7[c]	0.58[a]	298.6[c]	1.056[b]	16.15[a]	8.71[b]	1	

significant for P<0.05

A-Row intercropping of lentil and cumin, **B**-Strip intercropping of lentil and cumin with three rows each, **C**-Strip intercropping of lentil and cumin with four rows each, **D**-Pure stand of lentil and cumin

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Yield and quality of organic versus conventional potato crop

Mourão, I.[1], Brito, L.M.[1] & Coutinho J.[2]

Key words: Compost, N uptake, nutrient content, potato grades.

Abstract

The improvement of organic fertilization practices is essential to increase organic potato production in the highland region of NW Portugal, with environmental benefits and better returns. For that reason, the response of organic potato was evaluated throughout a randomized block design experiment, with two cultivars (Raja and Virgo) and increasing rates of composted organic pig manure (0, 15, 30 and 45 t ha^{-1}). These cultivars were also grown with mineral N fertilizer (120 kg N ha^{-1}) under conventional practices to compare the results between crop systems, 30, 45, 60, 80 and 125 days after planting.

Crop yield was not improved with increasing rates of compost application because the N mineralization rate of the compost was small and soil organic matter was high (8%). Organically grown cv. Virgo yielded 66.0% of the conventional crop, whereas Raja yielded 46.6%. The N uptake of the organic crop (tubers and foliage) was 37.0 kg ha^{-1} for Raja and 50.5 kg ha^{-1} for Virgo, respectively 21.1% and 27.8% of the N uptake by the same cultivars grown with mineral fertilizer. Although foliage N content was increased for the conventional crops, differences between N content of organic and conventional tubers were not significant, as well as for K, Ca and Mg.

Introduction

In Portugal, 233.5 thousand hectares were under organic farming in 2005, where herbaceous crops represented 85.4%, mainly with pasture (77.6%) and only 1.4 thousand hectares with vegetables or aromatic plants. The remaining area of 34.1 thousand hectares included olives (82.6%) followed by dry fruits (10.3%), fresh fruits (3.8%) and viticulture (3.3%) (IDRHa, 2007). The small area of organic production and the increasing consumption of horticultural organic products in Portugal is a scope for increasing home production. In addition, considering the potential environmental benefit of organic production, the highland regions as in NW Portugal may take this advantage, at the same time as higher agricultural returns could be taken from organic compared to conventional agriculture, leading to a more sustainable rural development.

Yield is frequently limited by nitrogen (N) availability in organic production and soil amendment with organic fertilizers is a current practice for soil nutrient replenishment. However, there is much uncertainty regarding the rate of N mineralization and the time required for organic fertilizers to release sufficient mineral N for crop growth. The objective of the present work was to evaluate organic potato growth, N uptake and

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tuber quality with soil application of composts and to compare organic with conventional production.

Materials and methods

A randomized block design experiment with 3 blocks was performed on a sandy loam soil (pH 4.9 and OM 80.05 g kg^{-1}), at 680 m high, in NW Portugal, with potato (*Solanum tuberosum L.*) organically produced with the application of 0, 15, 30 and 45 t ha^{-1} of composted pig manure with straw from an organic farm (table 1). Two certified cultivars were used, Raja (B1) and Virgo (B2) (Eurobatata), of 35-45 mm grade. Sprout emergence was induced before planting. Planting took place on 4 May 2005, with a plant spacing of 0.75 m x 0.3 m, and tubers were placed at 10 cm depth. Each experimental plot with 22.5 m^2 included 4 plant rows. The crop was sprinkle irrigated at 48 and 75 days after planting and hand weeding was carried out at 43 days after planting. The crop was sprayed against late blight (*Phytophthora infestans*) with copper hydroxide (Kocid DF) on 6, 17 and 24 of June and control of Colorado potato beetles (*Leptinotarsa decemlineata*) was performed with pyrethrum (Pelitre Hort) on 2 and 15 of June. In a nearby farm, with a similar soil type (pH 4.7 and OM 80.0 g kg^{-1}), a conventional potato crop experiment with 3 blocks was carried out, with the same cultivars planted in the same day. This included mineral fertilizer application (120 kg N ha^{-1}). Comparisons with the organic experiment were made by using the t test. All crops were monitored 30, 45, 60, 80 and 125 days after planting, based on 4 plants of each replicate treatment, to quantify the number of stems, fresh and dry (70ºC, 2-4 days) weights of tubers and foliage and N, P, Ca and Mg tuber content at commercial harvest. Mean daily air temperature was 17.4ºC (ranging from 8.1 to 26.2ºC), daily mean soil temperature (10 cm) was 16.7ºC (ranging from 9.5 to 19.7ºC) and rainfall was 257.0 mm during the growing period.

Compost pH was measured with a pH meter in samples extracted with water at 22ºC±3ºC in an extraction ratio of 1:5 (v/v) and the specific EC was measured in the same extract with a conductivity meter. For the organic matter (OM) determination, compost samples were dried at 103ºC, then ashed at 450ºC in a muffle furnace. The N content of the sample was determined using a modified Kjeldahl method based on a sulphuric acid/potassium sulphate digestion and copper selenium catalyst, with a Kjeldahltherm digestion unit and a compact distillation unit. Mineral N of fresh compost samples was extracted with KCl 2M 1:5. Mineral N content of the extracts (NH_4^+-N and NO_3^--N) were determined by molecular absorption spectroscopy in a segmented flow analyser system equipped with dialysers to prevent interferences from colour or suspended solid particles in the extracts. For the C/N ratio calculation, C content in compost was estimated by dividing the OM content by a factor of 1.8.

Tab. 1: Characteristics of the pig manure composted with straw.

DM (%)	pH	EC (dS m^{-1})	OM (g kg^{-1})	C/N	N-NO_3^- (mg kg^{-1})	N-NH_4^+ (mg kg^{-1})	N (g kg^{-1})	P (g kg^{-1})
25.3	7.1	0.41	495.3	14.1	1.4	201.8	19.5	9.9

Results

Throughout the growing period and at harvest (125 days after planting), crop yield was similar for all organic crop treatments and to the crop without organic fertilizer application. Yield of cv. Virgo (27.5 t ha^{-1}) was higher than cv. Raja (20.1 t ha^{-1}). Cultivar Virgo yielded 66.0% and cv. Raja 46.6% in comparison to conventional crops (fig. 1). However, commercial tuber yield (tuber >45 mm) was 29.4% and 46.8% for Virgo and Raja cv. respectively, compared to conventional crops. The total number of tubers was similar for all organic and conventional crop treatments, but the number of commercial tubers was higher in the conventional crops (fig. 1).

Nutrient content for organic crops was 8.9 g N kg^{-1}, 2.0 g P kg^{-1}, 4.2 g Ca kg^{-1} and 0.70 g Mg kg^{-1}. Differences between N, K, Ca and Mg content of organic and conventional potatoes were not significant. N uptake was 37.0 kg ha^{-1} for Raja and 50.5 kg ha^{-1} for Virgo cv, respectively, 21.1% and 27.8% of the N uptake by the same cultivars grown with mineral fertilizer (fig. 2). The N recovery rate for the mineral N application in conventional crops was 54.6% and 36.0%, respectively, for Raja and Virgo cultivars. Dry matter content of tubers was different for both cultivars, respectively, 23.2% and 18.9% for Raja and Virgo cultivars. Conventional potatoes of cv. Raja had significantly lower dry matter (22.1%) compared to organic potatoes (24.3%).

Discussion

Crop yield was not improved with increasing rates of compost application because the N mineralization rate of the compost was small and soil organic matter was high (8%). Compost utilization in soils with very high OM content may be beneficial to maintain soil fertility. However, the compost used in this experiment had a higher ammonium content compared to the nitrate content, indicating that compost was not completely mature and could immobilize soil mineral N, decreasing N availability to the crop. Therefore, compost should be more mature and must be evaluated in soils with a lower OM content.

The organic potato yield in this experiment compared to conventional yield was similar to that reported by Mäder et al. (2002) of 40% and Tamm et al. (2004) of 50 to 80% of conventional yields. Rembialkowska (2005) reported higher P and Mg tuber content in organic compared to conventional potatoes. Here, in agreement with Quenum et al. (2004), differences between these two systems were not significant.

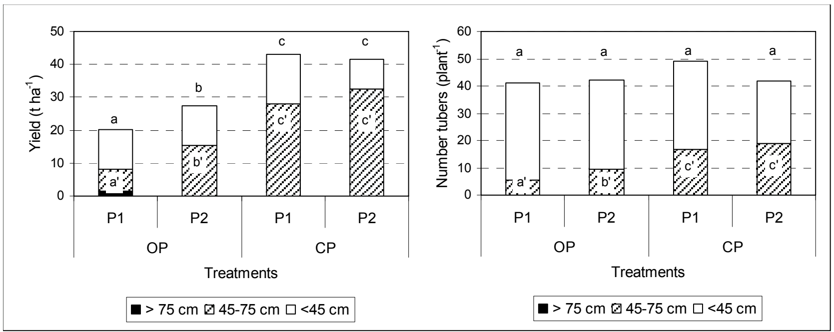

Figure 1: Potato yield (t ha^{-1}) and number of tubers (planta^{-1}) per each grade at commercial harvest, for cv. Raja (P1) and cv. Virgo (P2), organically grown (OP) (mean of the 3 compost rates) and for conventional crops with mineral fertilization (CP). Different letters means significant differences between crop treatments.

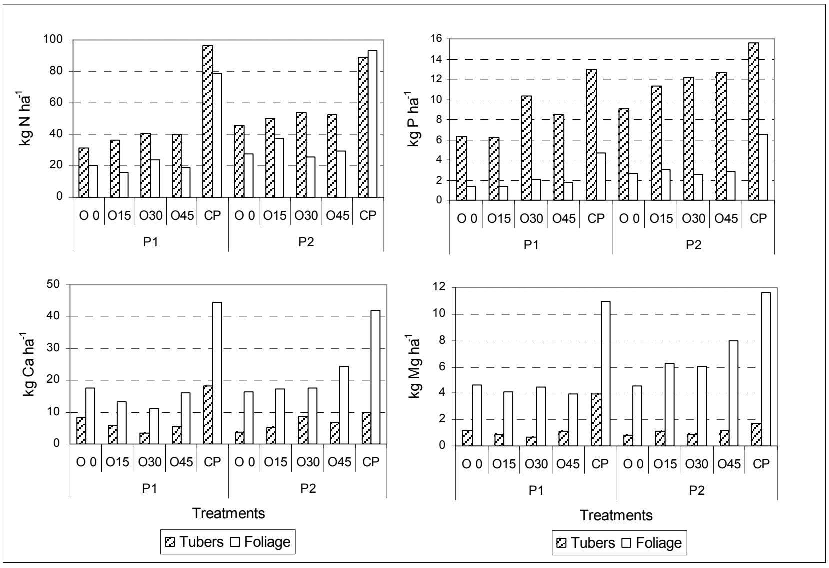

Figure 2: Nutrient extraction (kg nutrient ha^{-1}) by the foliage (80 days after planting) and by tubers at final harvest (125 dap), of nitrogen (N), phosphorus (P), calcium (Ca) and magnesium (Mg), for cv. Raja (P1) and cv. Virgo (P2) and for the 0, 15, 30 e 45 t ha^{-1} compost rates application.

Acknowledgments

This project was funded by UE and the Portuguese Ministry of Agriculture / INIAP (Project AGRO 747).

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Quality of thyme herb (*Thymus vulgaris* L.) from organic cultivation

Seidler-Łożykowska, K.[1], Golcz, A.[2], Kozik, E.[2] & Wójcik, J.[1]

Abstract

In five field experiments the quality of thyme herb and usefulness of Polish cultivar 'Słoneczko' for organic cultivation were tested. The following features were tested: dried herb yield, stem content in dried herb, essential oil content, nitrate content, macro- and microelements content and microbiological purity. Only from Słońsk thyme herb yield was higher compared with the yield from conventional cultivation though it contained high amount of stems. Thyme herb was characterized by higher content of essential oil and increased content of macro- and microelements except calcium. Evaluation of microbiological purity showed that for both types of cultivation herb contamination did not exceed standard for raw materials treated with hot water.

Material and Methods

The main aim of field experiments was the investigation yield and quality of organically produced raw material of thyme. In 2005-2006 the experiments were carried out in five different locations of Poland: Cedry Wielkie (north), Wiry (south-west), Bolewice and Plewiska (central), Słońsk (west). The experiments were established in the randomized complete block design in three repetitions. Each plot had 10 m^2. Thyme cultivar 'Słoneczko' was examined for its usefulness for organic cultivation. Seeds were sown directly to the soil in rate 6 g/plot [1]. At the end of August raw material was collected by hand, from the area of 1,0 m^2 of each plot. The herbs were dried in natural conditions, in a shaded and well ventilated places.

The raw material from the conventional cultivation from Plewiska was used as a control.

The following traits were estimated: total yield of dried herb, content of stems in dried herb, essential oil content, macro- and microelements content, N-nitrate content and the microbiological purity.

The essential oil was hydrodistillated with Dering's apparatus from herb without stems following the methods recommended by Polish Pharmacopoeia VI [3].

To determined macro- and microelement content the plant material was subjected to „wet" mineralization:

1. in sulphosalicylic acid, sodium thiosulphate and selenium mixture in order to determine N-total by distillation method with Parnas-Wagner apparatus,

2. in concentrated sulphuric acid to determine P colorimetrically with ammonium vanadomolybdate and K, Ca, Mg, Fe, Zn, Cu, Mn by the method of atomic absorption (ASS) [4,5].

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N-nitrate content in dried herb was determined by Bremner distillation method in modification done by Starck after extraction in 2 % acetic acid [5].

In Microbiology Laboratory the evaluation of raw material microbiological purity was carried out following Polish Pharmacopoeia VI standards for raw materials treated with hot water (gr. III e) [3]. Number of aerobic bacteria, number of yeasts and moulds and number of *Escherichia coli* were estimated in dried herb. Additionally the number of intestine bacteria from family *Enterobacteriaceae* was evaluated. Investigations were done after 6 and 12 months of storage in darkness and room temperature.

The obtained data were evaluated by analysis of variance. The mean values were compared by the use of Students' t test with the confidence level of 5%.

Results and Discussion

The yield of dried thyme herb varied from 120,1 (Cedry) to 1150,0 g/m^2 (Słońsk) and was significantly different (table 1). Stem content in thyme herbs was also significantly different and oscillated from 34 (Wiry) to 49 % (Słońsk). The yield of herb from Słońsk contained a lot of stems and was higher than that from conventional cultivation. Following the breeder's characteristic of thyme cultivar 'Słoneczko' stem content should not be higher than 34 % (Seidler-Łożykowska. & Kazmierczak 2001).

Tab. 1: Thyme herb yield [g/m^2], stem content [%], essential oil [%] and N-nitrate content [mg/kg d.m.]

locality	Dried herb yield	Stem content	Essential oil content	N-N0$_3$ content
Bolewice	**155,2 ab**	**39 a**	**2,20 b**	**250,0**
Cedry W.	**120,1 ab**	**39 a**	**1,93 a**	**trace**
Plewiska	**293,9 b**	**38 a**	**2,35 b**	**trace**
Słońsk	**1150,0 c**	**49 b**	**2,18 b**	**118,5**
Wiry	**162,2 ab**	**34 a**	**2,37 b**	**trace**
Cont. Plewiska	**437,8 b**	**38 a**	**2,00 a**	**425,0**
LSD $_{0,05}$	**203,07**	**7,77**	**0,222**	**-**

Essential oil content ranged from 1,93 (Cedry W.) to 2,37 % (Wiry) and was high in all the experiments; these results exceeded the one given by Dachler and Peltzman (1999) ranging between 0,5 and 1,5 %.

The content of N-nitrate in dried herb oscillated from traces (Cedry, Plewiska, Wiry) to 425,0 mg/kg d.m. (control) and varied according to its origin. Different results were obtained by, who analyzed nitrate content in medicinal plant raw materials of different origin. In her experiment the range of nitrate content oscillated from 207,9 (St John's wort herb) to 16 921,0 mg KNO_3/kg d.m. (nettle herb). Ours and the cited study of Leszczyńska (1999) showed that although spices are used in small amounts in daily diet, the nitrate content should be regarded while day allowance intake (ADI) is calculated. The mean content of nitrogen, phosphorus, potassium, magnesium and microelements (Fe, Mn, Cu, Zn) was higher in the organic thyme herb compared to conventional one, except the content of calcium (table 2).

Tab. 2: Macro- [%] and microelements [ppm] content in thyme herb

element	Organic cultivation		Conventional cultivation Plewiska
	range	mean	
N	1,89 - 2,70	2,28	2,12
P	0,22 - 0,40	0,30	0,35
K	2,07 – 2,50	2,35	2,07
Ca	1,09 – 1,89	1,42	1,54
Mg	0,31 – 0,51	0,39	0,27
Fe	251,2 - 725,2	552,0	404,10
Mn	25,9 – 334,5	146,6	54,90
Cu	12,3 – 18,2	15,2	8,10
Zn	56,9 – 116,8	87,3	65,10

In organic herb the content of Fe, Mn and Cu was higher, while in conventional herb Fe and Cu content was lower compared with the results obtained by Marsh et al. [9]. According to Kabata-Pendias and Pendias (1999) in Polish climatic conditions Cu content ranged from 5 – 20 mg kg^{-1} (Kabata-Pendias & Pendias 1999). The levels of Cu content in herbs obtained from both types of cultivation could be placed in the ranges set also by Suchorska-Orłowska et al. 2006. The results of microbiological analysis showed a great diversification of microbiological contamination of thyme herb depending on its origin (table 4). The most contaminated herb was from Słońsk and the lowest – from Bolewice. Though, all of the investigated herbs were below the level of standard contamination. Soil and organic fertilization are the main sources of microbiological contamination of raw material. After 12 months of storage the microbiological contamination of storage herb was diminished in the different rates. According to Kędzia (1999) there are two main reasons of this process: 1. bacteria have different susceptibility for dryness and 2. plant active substances (essential oil, anthocyanins and tannins) have strong effect on raw material microbes. Although *Escherichia coli* content was very low in all tested trials, the contamination of raw material organically produced should be controlled, following the fact that manure is a basic type of fertilization there.

Tab. 3: Microbiological purity of thyme after 6 and 12 months of storage

locality	Aerobic bacteria in 1g		Yeasts and moulds in 1g		*Enterobacteriaceae* in 1g		*Escherichia coli* in 1g	
	6 m	12 m	6 m	12m	6 m	12m	6 m	12m
Bolewice	41. 500	29.000	20	10	4.000	100	<10	<10
Cedry W.	430.000	32.000	420	10	41.000	100	<10	<10
Plewiska	485.000	34.000	125	40	4.000	850	<10	<10
Słońsk	780.000	32.500	7.400	140	91.500	500	<10	<10
Wiry	240.000	27.500	245	10	7.500	240	<10	<10
Control Plewiska	357.500	45.000	130	20	1.200	70	<10	<10
Standard	10.000.000		100.000		-		100	

Conclusions

Thyme herb yield only from Słońsk was higher compared with the yield from conventional cultivation. The quality of thyme herb from organic cultivation (essential oil, macro- and microelements content, microbiological purity) was high but not higher than the one from conventional cultivation. Thyme cultivar 'Słoneczko' is suitable for both organic and conventional cultivations.

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Amaranth farming: Rural sustainable livelihood of the future?

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Key words: Poverty, amaranth, sustainable livelihoods, value chain.

Abstract

Though amaranth has been studied intensively for its exceptional nutritional properties, little has been reported about its capacity for fighting poverty, securing food supplies, turning migrations, or its impact on the environment and the prospect for improvement of living conditions of those farmers cultivating amaranth. This paper addresses possibilities and limitations that Mexican small-scale farmers are facing to enhance sustainable livelihoods in the amaranth value chain. The study reveals that amaranth, as an alternative crop and livelihood, is perhaps one of the most complete endogenous natural resources that small-scale farmers have to combat the above-mentioned problems. The study identified several local and regional barriers for increasing the level of farming, production, processing and consumption. A striking and paradoxical limitation is the monopolization practices developed by some of the associations in relation to knowledge and technology transfer, seeds distribution and contact to potential national and foreign buyers.

Introduction

The rural areas of Mexico are hosting 60.7% of the country's extreme poor. Currently 25% of the Mexican population is undernourished, most of them are children from 0-5 years old (CONAPO 2006). The rural poor live mainly in the central and southern regions of Mexico, which have witnessed massive migration, economic instability, environment degradation and paradoxically, most of the small-scale organic farmers are currently located here, and that includes *the farming of amaranth too*. So why, when amaranth has been suggested as an alternative crop by The Food and Agriculture Organization of the UN to combat poverty and undernourishment 30 years ago, do the farmers still suffer from these problems? Our study (Bjarklev 2007) discusses the following question: What are the possibilities and limitations that small-scale farmers in Mexico are facing to enhance sustainable livelihoods in the amaranth value chain? We defined sustainable livelihoods as "the capabilities, assets (*capitals*) and activities for means of living. A livelihood is sustainable, when it can recover from stress and shocks and can maintain and enhance its capabilities and assets both now and in the future, while not undermining the natural resource base" (Carney 1998).

Materials and methods

The study was based on the Sustainable Livelihoods approach (Dalal-Clyton 2003), Value Chain and Clusters theories (Porter 2000). On that basis we constructed the analytical model shown in Figure 1. We analysed the context of each of the links of the amaranth value chain. These are supported by five types of *capitals*: human, financial, economic, natural and social, that either limit or enhance the capacity for development of each link of the value chain. The dimensions of sustainability are

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given by the enhancement or reduction of the capitals possessed by the actors. We conducted 25 in-depth individual interviews with actors involved in the Mexican amaranth value chain, 17 of which were tape recorded. We selected two cases in Central region of Mexico that traditionally cultivate amaranth: Sociedad Mexicana de Amaranto (conventional farming) and Quali (organic farming), both promoting the cultivation of amaranth as an alternative crop and livelihood for small-scale farmers. Our focus in this paper will be on Quali. Quali is an umbrella cooperative formed by non-farmer members from an NGO called Alternativas, but includes persons with specific knowledge about amaranth seeds and growing cuttings, processing and sale of amaranth.

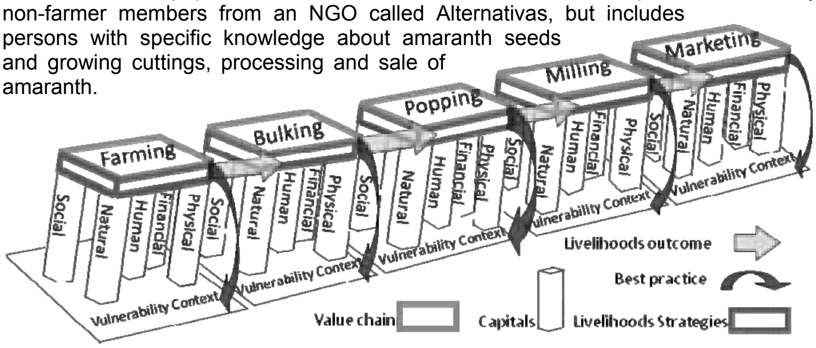

Figure 1: Schematic links in a value chain based on sustainability dimensions.

Though the intention was to get in direct contact with the small-scale farmers associated to this cooperatives, and although the cooperatives had agreed to that beforehand, the representative of both associations deliberately did all to avoid direct contact with the farmers associated. Due to the rejection of establishing contact with the associated small-scale farmers, interviews were conducted with 6 small-scale amaranth farmers that did not belong to these cooperatives in Puebla, Tlaxcala and Mexico City. In the Mexican value chain we also talked to small-scale manufacturers and small-scale sellers, representatives and researchers from Mexican State institutions, as the latter have regular contact with the mentioned cooperatives. In Europe we interviewed whole dealers, Kaffeklubben (a Danish fair trade consumer association) and CARITAS Denmark. Derived from the analytical model, we structured the project in five main sections as follows:

What it is the amaranth farmer's current contextual situation? The small-scale farmers conserve a huge diversity of amaranth varieties and, therefore, one of their main resources is the biodiversity. They also conserve traditional indigenous knowledge about farming the land and it opens possibilities for an easy adoption of *organic farming* principles and thereby possibilities for export to the EU market. However, the lack of infrastructure to capture rainwater and information on when and how to optimally irrigate amaranth is limiting its cultivation and not least prospects for increased yield. Quali representatives expressed that the organization has an extensive experience on these issues; however, the results are not published. The small-scale farmers' main complaint in the region, where Quali operates, was the lack of water for irrigation. Amaranth tolerates droughts, saline soils, and half of the water required to produce maize and wheat. This makes amaranth perhaps one the most valuable natural capitals for small-scale farmers in the central and southern region of Mexico, but the monopolization of knowledge by the cooperative limits its use.

What are small-scale farmers' main strengths and limitations? Though the representative of the cooperatives claimed to possess considerable knowledge about certification, technology, processing, marketing, and export, this knowledge is centralized and distributed unevenly. Sociedad Mexicana del Amaranto has made efforts to communicate its results, but mainly through the Internet reaching only the already well-established farmers. Quali *does not publish* its results and according to government institutions even its associated members (the small-scale farmers) have difficulty accessing knowledge and information about amaranth farming. Quali does not allow its associated small-scale farmers to self commercialise amaranth products (not even locally) and the organic certification does not follow the farmer, if he/she decides to be independent of Quali. According to the interviews with Quali's representative, the economic benefits derived from the sale of amaranth are not allocated directly to the associated farmers neither are they involved in taking decisions on the processing and trading links. The explanation was that associated farmers *are not part of the cooperative as owners or co-owners*. As a paradox, the results of this investigation indicate that farmers that are organized in producer cooperatives but independent of the mentioned associations *seem to* have better and direct access to *physical* and *financial* capitals. The interview with the Agricultural Secretariat in Mexico revealed that small-scale farmers access to *financial capital* is very limited, as the government programmes are directed to the agro-industry, because the literacy level, the lack of access to the Internet, and the variety of languages spoken by small-scale farmers, and not least because credits are directed mainly to the processing and trade link but not to the farming level. As such the government programmes work in favour of the cooperatives to become the channel for small-scale farmers to potentially capture part of the subsidies allocated for amaranth.

What strategies where adopted and how where they implemented? The support from the Mexican Government to research centres or universities is very restricted - therefore the potential for transfer of knowledge to the small-scale farmers is limited. The main actors involved in the amaranth value chain in Mexico have been cooperatives or similar organizations focusing on the bulking of amaranth seeds, the processing and marketing of amaranth. The field study revealed that the cooperatives monopolize the knowledge about appropriate farming techniques (labelled the technological package by one of the cooperatives), certification and financial funding of projects related to marketing amaranth. The interviews with Mexican research institutes and government agencies indicated that Quali does not even distribute or share knowledge and experience among their own associated members, not to mention other cooperatives or local or regional research institutes. Similarly, the international cooperation is monopolized by a few organizations.

What are the main limitations and possibilities in the amaranth chain? The study revealed that the Mexican amaranth production is characterized by being controlled by national cooperatives. Lately, international companies have begun to penetrate the national amaranth value chain by establishing contact with Mexican small-scale farmers to set up a global amaranth value chain. One of these initiatives has been curbed by the dominant cooperative Quali who controls most of the national amaranth chain. Quali has made it impossible for external actors to get in contact with the small-scale amaranth farmers. According to the European dealers, the fact that the contact needs to be done through these cooperatives is linked to the fact that there is not a register elsewhere to find the small-scale organic amaranth farmers. Mexican small-scale farmers that have tried to expand the Mexican amaranth chain have experienced difficulty in accessing the European markets due to the high standards on labelling, product information and quality control. There are many potential branches in which the amaranth production can be diversified (e.g., oil or milk). The diversification and the conservation of the already existing ones *depend on a sure and sufficient supply of seeds*. In this relation, the small-scale farmers confront a series of limitations such as: low yields due to limited research and information about crop varieties and techniques, and an ineffective distribution of already improved varieties due to monopolized practices of the mentioned cooperatives. These practices undermine the small scale farmers' social capital. The interviewees voiced that they felt betrayed by the cooperatives and had difficulty in trusting any such organization.

Where can changes be made and what can be done to enhance small-scale farmers capitals in the amaranth value chain? The amaranth production chain may today be characterized as producer-driven, since there is little consumer knowledge about amaranth. Besides there are no amaranth consumer associations in the national market – or in the EU market. The existence of such associations could secure the amaranth small-scale farmers more influence in the value chain. Taking into account cluster theories, revealed that the Mexican government is currently focusing on the processing phase. However, targeting the *farming phase* and in particular the small-scale farmers should be given priority in order to support the whole farmers' influence on the amaranth value chain.

Conclusions

Initiatives that support the small-scale farmers active participation in the cooperatives are vital for ensuring the fair distribution of knowledge and ensuring consumers more information about amaranth and small-scale amaranth farmer's welfare. The monopolistic practices favoured by the cooperatives in the amaranth value chain are actually setting the strongest barrier for expanding the amaranth production and for furthering a sustainable livelihood for small-scale amaranth farmers. Consumers' associations both at the national and even more important in the European markets could reverse this pattern if they demand a more active and tangible participation of the small-scale farmers associated to cooperatives controlling the national amaranth value chain. The Mexican government could play a more active role supporting small-scale livelihoods by setting higher demands to cooperatives in order to include effectively small-scale farmers as real partners or co-owners. Considering the whole value chain: from *farming* to the final consumers, and not only the manufacturing process, is vital for furthering sustainable livelihood in amaranth.

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Organic vegetable production

Mineralization of lupine seed meal and seedlings used as N fertilizer in organic vegetable production

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Key words: C:N, lupine seedlings, lupine seed meal, N mineralization, organic fertilizer

Abstract

Seeds of grain legumes are currently discussed as N fertilizer in organic vegetable production. They can be produced by the farmers themselves and applied in well controlled amounts flexibly in time and space. Most research investigating the N mineralization of grain legume seeds was carried out using coarsely milled seeds. We hypothesized that seed germination alters the chemical composition leading to a higher N release compared to seed meal. In a pot experiment the C:N ratio of lupine seeds was shown to decrease noticeably within the first two weeks after sowing. After an incubation period of 1300°Cd net N mineralization was significantly higher for the lupine seedlings compared to the seed meal and close relationships between N mineralization and C:N ratio were found. In field experiments with white cabbage, carried out in 2005 and 2006, similar relationships were found but sowing followed by an early incorporation of seedlings after 12 and 13 days showed an N supply similar to the seed meal treatment only. Strong priming effects, mainly caused by the lupine seed meal, are discussed to be a possible reason. Late incorporation after 42 and 37 days resulted in significantly lower N supply and cabbage yield.

Introduction

Since organic vegetable production systems mainly lack livestock, manure is not available as N source. Legumes as N fixing crops have the potential to contribute significant amounts of N to the following vegetable crop and hence play a major role in organic vegetable crop rotations. Unfortunately, all traditional legume systems have in common that neither the amount of N fixed nor the time course of mineralization can be influenced satisfactorily, making it hard to fit the N demand of the following vegetable crop. The use of grain legume seeds as N fertilizer, which can be produced by the farmers themselves and which can be applied in well controlled amounts flexibly in time and space, can overcome this problem. However, reviewing comparative studies on animal- and plant-derived N fertilizers, Laber (2003) summarized that grain legume seeds generally showed lower N mineralization rates than animal products or pomace derived from castor beans. Differences between the N mineralization of faba bean, lupine and pea seed meals were shown to depend on their total N content or C:N ratio (Stadler et al. 2006).

As an alternative to the seed application as coarse meal, sowings with a correspondingly high plant density can be established and incorporated after a short period. During seed germination, energy is mobilized from reserves by respiration processes, resulting in the release of considerable amounts of CO_2 and consequently in a lowered C:N ratio. This would suggest a higher N mineralization of young

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seedlings compared to milled seeds. Hence, pot and field experiments had been carried out to investigate whether the N utilization of grain legume seeds used for fertilization can be significantly increased by sowing compared to the application as coarse seed meal.

Materials and methods

Lupine seeds were sown in pots at densities of 2440 seeds m^{-2} corresponding to 173 kg N ha^{-1}. After 8, 13, 18, 22 and 27 days seedlings were cut and mixed with the respective soils they developed in before. The obtained growth stages ranged from the cotyledon stage (8 days) to the six-leaf stage (27 days). A coarse seed meal treatment (CM) and an unamended control were established as references. The soils were adjacently incubated at 10 and 20°C and kept at a water holding capacity of 70% gravimetrically. Soil mineral N content was determined 0, 15, 38 and 65 days after incorporation.

Field experiments were carried out in 2005 and 2006 using white cabbage as test crop. They were located on organically managed fields at the Research Station in Ruthe, situated 15 km south of Hannover, Germany (52°14' N, 9°48' E) on a loess loam soil. Lupine seeds were applied in amounts of 3.8 t ha^{-1} corresponding to 180 kg N ha^{-1} as a dense sowing with either a short or long developmental period until incorporation or as seed meal. The dense sowing treatment with a short developmental time (DS-S) was given 13 and 12 days to germinate and grow, whereas the long time dense sowing treatment (DS-L) was incorporated 42 and 37 after sowing in 2005 and 2006, respectively.

Net N mineralization was calculated as difference between the amounts of N mineralized from amended and unamended control soils. A single first-order kinetics model was fitted to the data to quantify maximum net N mineralization. The C:N ratio of the seedling biomass was adjusted by taking non-recovered amounts of seed coat C and N into account. Since seed germination was partly low in the field, an additional adjustment, assuming C and N contents of lupine seed meal for the fraction of non-germinated seeds, was carried out. Statistical significance between treatments was assessed by analysis of variance followed by Tukey's HSD-test at $p \leq 0.05$.

Results and Discussion

In the pot experiment the C:N ratio was shown to decrease during germination within the first two weeks after sowing. With expansion of the first leaf pair and the corresponding increase in photosynthetic activity, the C:N ratio began to raise but stayed below the initial seed C:N ratio of 8.8 until the end of the experiment. Soil mineral N uptake by the seedlings started 10 days after sowing and caused negative values for net N mineralization at incorporation date (Figure). However, after an incubation period of 1300°Cd net N mineralization of seed meal was significantly lower compared to the lupine seedlings. Within the seedling stages N mineralization was found to be in the inverse order of seedling growing time, being highest for the youngest lupine plants incorporated already after 8 days. Maximum net N mineralization was strongly correlated with the adjusted C:N ratio of lupine seedlings and seed meal.

Under field conditions net N mineralization rates higher than 100% were recorded 39 and 33 days after incorporation in 2005 and 2006, respectively, indicating a strong interaction between the decomposing lupine biomass and soil organic matter.

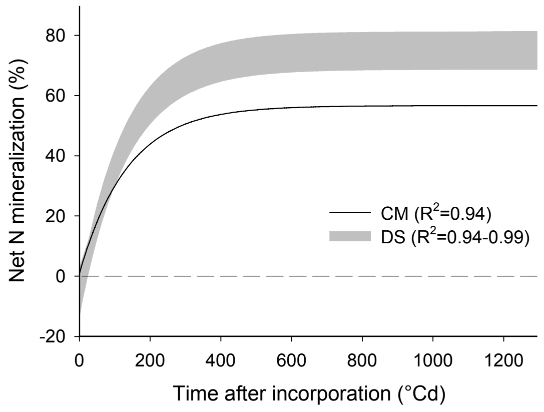

Figure 1: Time course of net N mineralization of lupine seed meal (CM) and seedlings (DS) in the pot experiment as derived from the single first-order kinetics model.

The grey area covers the range of mineralization time courses of the five DS-treatments.

According to Kuzyakov et al. (2000), this interaction is denoted as "positive real priming effect". Since mineralization rates were found to be within the expected range at following sampling dates, it was hypothesized that this short-term effect was not influencing medium-term net N mineralization. Thus, first sampling dates of both years were excluded, when fitting the first-order kinetics model to the field experimental data.

Despite the occurrence of strong priming effects in the field shortly after incorporation, the relationships between the maximum net N mineralization and C:N ratio of pot and field experiment were noticeably alike. Consequently, the DS-S treatment was expected to show a higher total N supply than CM. However, this was not the case. In both years there were no significant differences in total N supply between DS-S and CM and consequently not in cabbage yield (Tab.). This was partly caused by a low germination rate of lupine seeds, particularly in 2005. Furthermore, a positive influence of the priming effect, which was strongest for the CM treatment in both years, on total N supply could not be ruled out completely and might explain the tendency of an even higher N supply of the CM treatment in 2005. This finding is underlined by results from Müller and von Fragstein und Niemsdorff (2006a,b), who

Tab. 1: C:N ratio of incorporated lupine seed meal (CM), short time (DS-S) and long time lupine sowings (DS-L), resulting total N supply and cabbage yield

Year		CM	DS-S	DS-L
2005	C:N	8.6	8.1[1]	9.5[1]
	Total N supply[2] ($kg\ ha^{-1}$)	308 a	267 b	257 b
	Yield ($t\ ha^{-1}$)	56.1 a	54.2 a	47.2 b
2006	C:N	8.6	7.0[1]	10.9[1]
	Total N supply[2] ($kg\ ha^{-1}$)	395 a	404 a	343 b
	Yield ($t\ ha^{-1}$)	68.4 a	69.2 a	61.5 b

Significant differences between treatments are denoted by different letters (HSD, $p \leq 0.05$).

[1] Adjusted for non-recovered seed coat biomass and non-germinated seeds
[2] Sum of total amount of N in cabbage plants and residual soil mineral N (0-120 cm) at harvest

calculated N recovery percentages greater than 100% of mineralizing lupine seed meal when considering soil mineral N, microbial N and K_2SO_4-extractable organic N both under controlled and field conditions. However, an extension of lupine seedling growing time to 42 and 37 days (DS-L) resulted in significantly lowered cabbage yield (Tab.). This is in accordance with the results of the pot experiment in which net N mineralization was found to be in the inverse order of seedling growing time.

Conclusions

From the results can be concluded that lupine seedlings with even a more favourable chemical composition for decomposition do not necessarily show a higher net N mineralization than coarse seed meal. Priming effects can be expected to play a considerable role in lupine seed meal and seedling decomposition. Nevertheless, from the farmers' point of view, sowing can be an attractive alternative to seed meal application, since the milling procedure can be skipped and the N utilization of both systems had been shown to be similar, as far as lupine seedlings are incorporated in an early stage.

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Use of biodegradable mulching in vegetable production

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Keywords: soil mulching, thermoplastic starch, implementation, BIOMASS project.

Abstract

Trials were carried out in Liguria during three years (2004-2006) to evaluate the use of innovative starch based bioplastics for soil mulching. All trials carried out in open field as well as in greenhouse on different vegetable crops demonstrated the effectiveness of biodegradable films in controlling weeds and in increasing yield. The use of biodegradable mulching films found application in integrated production regulations set up by the regional authority and it is potentially adoptable in an organic farming context.

Introduction

Biodegradable mulching films represent a good alternative to herbicides or other chemicals for soil disinfestation, particularly when used just for weed control, being especially useful in organic farming (Minuto *et al*., 2002). Mater-Bi materials, produced by the Italian company Novamont Spa, have been introduced for several applications due to their different available processing systems, mechanical and physical properties and permeability to water. Mater-Bi materials are biodegradable, according to the European standards (Bastioli, 1997, 1998) and they can be industrially processed and produced by means of traditional film blowing and casting equipment (Thunwall *et al*., 2007). They have been adopted in the framework of demonstrative activities promoted by the European project LIFE04 ENV/IT/463 "BIOMASS" focused on the promotion of the substitution of existing non-biodegradable polymers with new biodegradable starched based plastics.

Materials and methods

Trials were carried out both in greenhouse and in open field in Liguria (La Spezia and Albenga locations); trial locations in La Spezia are certified for organic production. The behaviour of Mater-Bi films (NF 803/P - 12, 15 and 18 μm thickness) were compared to non biodegradable black polyethylene film (PE) (40 μm thickness). All films were laid both manually and mechanically and tested at least three times on different crops. The crops were managed following the cultural techniques commonly adopted by growers. Water was distributed through drip irrigation system. A complete randomised block design with 3 or 4 replicates of 25 m^2 to 300 m^2 each was applied. Data regarding behaviour of films during the crop cycle, mulching effect, crop yield, degree of degradation in the soil and climate condition were collected. In all demonstrative and experimental plots the effects of mulching films were evaluated counting the

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number of weeds/m^2 and, in some cases, the fresh weight (g/m^2) of aerial parts. The quantity (g/m^2) of biodegradable film on the surface of the soil and in the soil was evaluated 14 days after rototilling. All data were statistically analysed using Duncan's multiple range test (P=0.05). A comparison between costs of PE and biodegradable films was also calculated.

Results

Main results about trials carried out on tomato, lettuce, zucchini and Brussels sprouts are presented. Good results in terms of weed control and % of soil covered were obtained with 12 and 15 μm thick films designed for short crop cycles (from 3 to 5 months) (Table 1 and 2).

Tab. 1: Percentage of mulched soil, degradation of mulching film and effect on weeds of biodegradable and PE films on tomato^ crop grown under plastic tunnel [Sarzana (SP), March – September 2006].

Mulching film – thickness (μm)	% of mulched soil at						Degradation index of film at the end of the crop				Weeds at the end of the crop			
	25/04		02/07		12/09		film upon the soil °		buried film °°		number/m^2		Kg/m^2	
NF 803/P – 12	100	a*	90	a	85	a	7.3	b	3.6	c	3.0	a	0.4	a
NF 803/P – 15	100	a	90	a	85	a	8.4	a	6.6	b	0.9	a	0.2	a
PE black – 50	100	a	100	a	100	a	9.0	a	9.0	a	0.0	a	0.0	a
Bare soil	-		-		-		-		-		39.0	b	5.4	b

^Randomized blocks with 3 replications; Cultivar of tomato: "Pera d'Abruzzo"; density of cultivation: 6 plants/m^2; mulched surface/plot: 300 m^2; water supply: drip irrigation; film drawing up: mechanized; soil texture: silt (>90%); soil pH: 7.0. * Values followed by the same letter do not significantly differ according to Duncan's multiple range test (P=0.05). ° Degradation index of the film upon the soil (1=0% of mulched soil till 9=100% of mulched soil) and of the buried film (°°).

Tab. 2: Efficacy of different mulching films on tomato, zucchini and lettuce^ yield at the end of growing cycle [Sarzana (SP), March – November 2006].

Mulching film – thickness (□m)	Tomato °				Zucchini °°		Lettuce °°	
	Kg/plant		N° fruits/ plant		Kg/plant		Kg/m^2	
NF 803/P – 12	4.2	a*	13.3	a	4.5	a	278.0	a
NF 803/P – 15	4.8	a	14.2	a	4.6	a	296.6	a
PE black – 50	4.7	a	13.7	a	4.3	a	310.0	a
Bare soil	2.9	b	12.7	b	2.1	b	78.0	b

^Randomized blocks with 3 replications; mulched surface/plot: 300 m^2; water supply: drip irrigation; film drawing up: mechanized; soil structure: silt (>90%); soil pH: 7.0. *See table 1. ° Plastic tunnel, Cultivar "Pera d'Abruzzo", 6 plants/m^2 (march-september, 2006); °° Open field, Cultivar "Ibis", 2 plants/m^2 (may-august, 2006); °°° Plastic tunnel, Cultivar "Lollo verde", 20 plants/m^2 (September-november, 2006).

During the growing cycle only a limited degradation was observed, with tears and visible degradation particularly located in the buried parts. The residues of biodegradable film observed on the soil surface (g/m^2) immediately before rototilling, compared with the weight of new films, indicated that the degradation process of the material was already started. The same evaluation carried out 14 days after rototilling sieving the soil up to 20 cm depth confirmed the almost complete degradation of the film (Table 3).

Tab. 3: Film residues at the end of crop cycle of some vegetable crops (open field, winter-spring, Albenga 2005).

Mulching film –	New film	Tomato				Brussels sprouts				Lettuce			
thickness (□m)	(g/m²)	residues of film at the end of the crop cycle (g/m²)											
		upon soil°		in the soil^		upon soil°		in the soil^		upon soil°		in the soil^	
NF803 – 18	25.0	8.3	b*	0.6	b	4.0	b	2.2	b	7.8	a	0.9	b
NF803 – 15	22.9	7.4	a	0.4	a	2.2	a	1.2	b	7.0	a	0.7	b
NF803 – 12	15.3	7.2	a	0.2	a	1.3	a	0.1	a	7.0	a	0.2	a
PE black – 50	n.a.**	n.a.	-	n.a.	-	n.a.	-	n.a.	-	n.a.	-	n.a.	-
Bare soil		-	-	-	-	-	-	-	-	-	-	-	-

° g/m² of film residues upon soil before rototilling; ^ g/m² of film residues in the soil (evaluated sieving the soil up to 20 cm depth) 14 days after rototilling; * see table 1; ** because of technical and environmental reasons PE was not incorporated in the soil.

Tab. 4: Comparison between the costs of biodegradable films and conventional PE (being equal the application costs).

Characteristic of the film	PE	Mater-Bi films	
Thickness (µm)	45	15	12
average weight (Kg/ha)	450	180	140
Cost of the product (€/ha)	639	900	700
Cost difference (€/ha) (base: PE)	-	261	61
Cost difference (%) (base: PE)	-	40,85	9,55
Average removal cost (€/ha)	120	0	0
Average disposal cost (€/ha)	50	0	0
Overall cost of the product (€/ha)	809	900	700
Overall cost difference (%) (base: PE)	-	11,25	-12,11

Crop yield was not influenced by the different thickness of the mulching films and significantly differed from the yield obtained on bare soil due to high weed competition (Table 2). No differences in terms of film behaviour were observed between manually or mechanically laid films. Costs of biodegradable films (12 and 15 µm thick) including product, removal and disposal costs, proved to be comparable with the ones of conventional PE (Table 4).

Discussion

The results obtained testing different formulations of biodegradable films were generally encouraging and similar to those achieved by normal black PE. The same film behaviour was observed even on other crops which were grown during trials such as artichoke, garlic, onion, sweet pepper, water melon, eggplant and strawberry (data not shown). Thanks to their characteristics biodegradable films could mulch almost completely the soil during the crop cycle as well as standard PE assuring a constant control towards weeds and maintaining an accurate level of moisture in the soil. During application, mechanically laid films must be let free to rotate without any brakes in order to avoid stretching and consequent film thinning. No particular concerns are related to manual application. Biodegradable films proved also to be able to increase crop yield and quality and they are worth being used at the same extent of traditional films in consideration of the fact that even their cost is comparable when costs related to plants, removal and disposal of traditional films are taken in consideration. The evaluation of the percentage of mulched soil at the end of the crop along with crop yield suggests that an efficient weed control can be achieved as long as the film totally covers the soil during the major part of the crop cycle.

Conclusions

The major concern on biodegradable films in agriculture is primarily due to the effects of ageing and degradation during the growing cycle for long lasting applications, when premature breakings of the films can limit their applications. At this regards other researches demonstrated that well produced biodegradable films perform in a way comparable to the corresponding PE films (Briassoulis, 2007). Results demonstrated the effectiveness of biodegradable films manufactured using Mater-Bi films against weeds. Tested films appeared to be easily adapted during different seasons, in open field and under greenhouse conditions, being able to substitute conventional PE films for short crop duration. The revision of integrated production protocols and a further implementations of regulations at a regional level is expected to enhance a wider adoption of biodegradable films for the control of weeds without resorting chemical inputs, so stressing their capability to be used even for organic production.

Acknowledgments

The authors would like to thank all partners involved in the project: Assobagni, Comune di Celle Ligure, Coop. Fratellanza Agricola and Coop. Ortofrutticola.

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Japanese organic tomato intercropped with living turfgrass mulch

Xu, H.L.[1], Ma, G.[1], Shah, R.P.[2] & Qin, F.F.[1]

Key words: blight, IMP, intercropping, living mulch, organic, VAM, tomato, turfgrass

Abstract

Stripe cultivation of crops with turfgrass as living mulch has been adopted in orchard systems and proved effective in disease control and fruit quality improvement. However, no research has tried turfgrass as living mulch for field vegetable crops. In the present study, field tomato was stripe-cultivated with Kentucky blue grass and showed high resistance against leaf blights resulting in improved fruit yield and quality. Lower nitrate concentration in tomato leaves stripe-cultivated with turfgrass might be one of the reasons for decreased risk of fungal infection. Turfgrass is alive with high activity throughout the year and the root is colonized and mutually benefiting from each other with mycorrhizae. The mycorrhizal colonization was high in turfgrass root, and also much higher in roots of tomato plants with turfgrass as living mulch than in the tomato plants without turfgrass. This might be another reason for decreased infection risk of fungi. In conclusion, as a living mulch, an annually ever living turfgrass root system with mycorrhizae colonized, making a living soil and improving soil conditions, avoided the infection by soil-borne pathogens in tomato plants that are stripe-cultivated with turfgrass.

Introduction

Organic agriculture seeks to use nature as the model for system design. Nature consistently integrates the plants and animals into a diverse landscape. However, monoculture in conventional agriculture has greatly reduced biodiversity by a limited selection of crop plants and animals. Therefore, a major tenet of organic agriculture is to create and maintain biodiversity since beneficial relationships exist between species within a community. Intercropping, mix-cropping or stripe cultivation among different crops or between crops and grasses or green manure plants is one of the efforts made on the restoration of the natural biodiversity. In addition to a healthy crop from the beneficial relations among species, another reason to grow two or more crops together is the improvement in productivity per unit of land. Recently, another kind of stripe cultivation, the main crop into a living mulch crop such as forage grasses, has been adopted in both IPM and organic systems. Succeeded cases include the cereal crops or vegetables (Frank, 2004) into clovers and other grasses to control pests. For a long time, living mulch or so-called sod culture has been adopted to orchard systems and proved effective in disease control and fruit quality improvement (Vossen and Ingals, 2007). The living grass mulch under the fruit trees is relatively permanent and it is also called permanent sod floor. In contrast, the living mulch adopted to crop systems is not permanent and in many cases it is an annual or perennial grown just for one year. Although legumes such as clovers have been tried in research, few cases have used the relatively permanent turfgrass as living mulch for field vegetable crops. Therefore, in the present study, field tomato was intercropped with Kentucky

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blue grass and the tomato leaf blight infection and also the root mycorhhizal colonization were examined.

Materials and methods

Seeds of Kentucky blue grass (*Poa pratensis* L.) were sown in October and mowed next spring into a normal turf. A band 30 cm wide was ploughed with the green aboveground part of the turfgrass upside down into the soil. The turf green band left was 90 cm wide and enough for the mower to pass through. In the control, the whole plot was ploughed clearly. In both grass and control plots, a biofertilizer with N-P-K concentrations of 58-30-20 mg kg^{-1} was applied at the rate of 200 g m^{-2} on the total land basis. The biofertilizer was fermented using oil mill sludge, rice bran and fish meal mixed with EM, a microbial inoculant, as the starter (Xu, 2006). Seedlings of tomato (*Lypercosicon esculentum* L. cv. Momotaro & cv. Chika) were transplanted into the cleared band on May 20 with an interval of 60 cm between plants (Fig. 1). The grass residuals mowed off from the turf were used for mulch on the soil surface in the cleared band.

The net photosynthetic rate (P_N) in the upper 5th leaf was measured at different photosynthetic photon flux (i) with the light response curve modelled by $P_N = P_C\,(1\text{-}e^{-Ki}) - R_D$, where P_C was the photosynthetic capacity; R_D dark respiration; K time constant; and Y_Q the maximum quantum yield shown as $Y_Q = KP_C$. Disease index for leaf blight was estimated as Index = ∑(Number of infected leaves to a certain degree × Degree constant)×100/(total leaf number × highest degree constant). The degree was scored from 0 (no symptom) through 1 (12.5% of the leaf area was infected), 2 (25%), 3 (50%) and 4 (75%) to 5 (completely infected). Roots of turfgrass and tomato were sampled and examined under microscope for the presence of mycorrhizae (AM) after cleaned with 2.5% of KOH, acidified in 1% of HCl and stained in 0.05% of aniline blue in lactoglycerol (Koske and Gemma, 1989). AM colonization was estimated in three scales: Poor —only mycelia present; Moderate —mycelia and vesicles present; and Abundant —mycelia, vesicles and arbuscules present. Root segments (n=80) were collected from the root system of a sample plant. The soils samples were collected from the upper 20 cm soil layer, air dried and ground to pass through a 2-mm sieve. Measurements were conducted for EC (1:5 H_2O, EC Meter, CM-30G, TOA), pH (1:2.5 H_2O, pH Meter F-21, HORIBA), extractable ions such as Ca, K, Mg and Na (Atomic Spectrophotometer, SHIMADZU, U-2000, HITACHI), the total C and total N (CN CORDER, MT-700, YANACO, Japan) and inorganic nitrogen and phosphorus (colorimetric method).

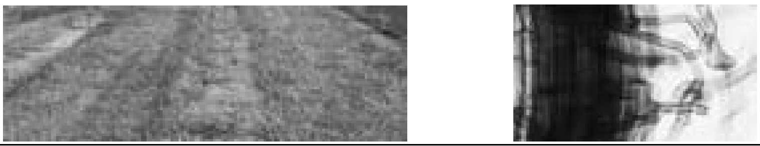

Figure 1: Tomatoes in turfgrass (Left) and mycorrhizae colonized in turfgrass root (Right)

Results

Both varieties of the field tomato intercropped into turf Kentucky blue grass showed high resistance to phytophthora and other leaf blights and improvements in leaf fruit yield and quality (Table 1) and photosynthetic activities at the later growth stages (Table 2). The nitrate concentration was lower in both the soil and leaves of tomato plants intercropped with grass (Table 3) and consequently decreased the risk of fungal infection (Table 1). Turfgrass is alive throughout the year and the root is colonized and mutually benefiting with mycorrhizae and other rhizosphere microorganisms. As shown in Table 3, the mycorrhizal colonization was high in turfgrass roots, and also much higher in roots of tomato plants intercropped with turfgrass than in the tomato plants without turfgrass intercropping. Although soil nutrient conditions were also improved, the disease avoidance was the critical factor for the high fruit yield of tomatoes in the turfgrass plots. The infection by leaf blight (*Alternaria solani* and *Fusarium oxysporum f.sp. licopersici* race 2) was much less severe in tomato plants intercropped with turfgrass than plants in control plot. In conclusion, as living mulch, the annually-ever living turfgrass root system with mycorrhizae colonized, making a living soil and improving soil conditions, avoided the leaf infection by soil-borne pathogens in tomato plants that were intercropped with turfgrass.

Tab. 1: Fruit yield and leaf blight infection of tomato plants with turfgrass as living mulch in comparison with tomato plants in control. (n=30)

Plot	cv. Momotaro: Yield (g/pl)	Numb (fr/pl)	Size (g/fr)	Mark. (%)	Disease (%) Early	Disease (%) Late	cv. Chika: Yield (g/pl)	Numb (fr/pl)	Size (g/fr)	Mark. (%)	Disease (%) Early	Disease (%) Late
Turf	4853**	32.5 **	149*	95**	6 **	16**	3759**	289**	13^{ns}	98^{ns}	2**	15**
CK	2429	18.9	128	46	44	81	1586	131	12	95	34	75

* significant for P<0.05; ** significant for P<0.01

Tab. 2: Photosynthetic activities of tomato plants with turfgrass as living mulch in comparison with tomato plants in control. (n=9)

Plot	cv. Momotaro: P_C (µmol m^{-2} s^{-1}) Early	P_C Later	R_D (µmol m^{-2} s^{-1}) Early	R_D Later	Y_Q (mol mol^{-1}) Early	Y_Q Later	cv. Chika: P_C (µmol m^{-2} s^{-1}) Early	P_C Later	R_D (µmol m^{-2} s^{-1}) Early	R_D Later	Y_Q (mol mol^{-1}) Early	Y_Q Later
Turf	30.4^{ns}	25.7**	4.1^{ns}	3.3^{ns}	0.0721*	0.0758**	32.7^{ns}	29.6**	4.7^{ns}	3.2*	0.0895^{ns}	0.0817**
CK	31.9	16.1	4.3	3.6	0.0784	0.0475	33.2	15.7	5.0	2.7	0.0889	0.0578

Tab. 3: Soil nutrition and mycorrhizal colonization in the plot of tomato in turf living mulch in comparison with tomato plants in control. (n=15)

Variable	Tomato in Control	Tomato in turfgrass	Turfgrass
pH	6.22□0.15	6.40□0.20	6.79□0.08
EC (dS m^{-1})	0.15□0.04	0.06□0.01	0.05□0.02
Na (mg kg^{-1})	54.6□14.8	32.0□15.1	34.9□17.5
K (mg kg^{-1})	874.9□57.2	601.8□30.4	541.6□99.9
Ca (mg kg^{-1})	2927.7□91.4	3181.7□84.1	3361.8□8.1
Mg (mg kg^{-1})	695.2□81.9	574.9□46.5	507.0□38.1
CEC (cmol kg^{-1})	22.16□0.65	21.65□0.55	24.18□0.73
P_2O_5 (mg kg^{-1})	226.8□33.0	171.6□2.05	128.9□36.9
NH_4-N (mg kg^{-1})	6.4□4.0	1.9□0.1	12.9□5.4
NO_3-N (mg kg^{-1})	40.7□20.8	14.0□2.3	17.0□10.1
Total N (%)	5.29□0.16	5.21□0.32	-
Total C (%)	0.44□0.02	0.43□0.04	-
C-N ratio	0.08□0.00	0.08□0.00	-
AM infected root (%)	9.33□4.33	18.33□5.33	32.67□2.67
Poor	3.33□2.33	6.33□2.33	12.67□1.33
Moderate	1.67□0.67	4.00□2.00	10.33□0.67
Abundant	4.33□1.67	8.00□2.00	9.67□1.67

Discussion

In Organic Agriculture, benefits of crop diversity are recognized, for example, planting mixtures or stripes of different crops in the field. In addition to a healthy crop from the beneficial relation among species, another reason to grow two or more crops together is the improvement in productivity per unit of land. However, the living mulch of turfgrass in this study differs from the common intercropping in three aspects: 1) the turfgrass is not the crop for harvest although it can be mowed and collected for forage; 2) the turfgrass is relatively permanent in comparison to annual crops; and 3) the microbial ecosystem in the rhizosphere is relatively stable because of the ever-alive root system. Instead of demand for productivity, the technique of living turf mulch is expected to avoid diseases, whereby a reasonable fruit yield is ensured in the organic field tomato production. The turfgrass absorbs the excessive N, if any, and excessive supply of N to tomato plants is avoided. This might be one reason for disease avoidance. Another reason for the disease avoidance is the microbial biodiversity in the rhizosphere that is maintained by the abundance of mycorrhizal colonization. Mycorrhizae colonize the turfgrass root with high density and the density is much higher than in roots of tomato plants without turf intercropping. Turfgrass adapts to hot and cold weathers and the roots are alive throughout the year, mutually benefiting from each other with mycorrhizae and other rhizosphere microbes. Moreover, the field biodiversity was also improved because turf grass grew between tomato plants and the naked soil was mulched with grass residuals. In the whole field no soil was naked and the tomato leaves never met the soil even after a heavy rain, whereby the plants were expected to be protected from being infected by the soil-born pathogens. There was no space and light competitive impact on tomato plants because the turf grass was mowed frequently and tomato plants were much taller than turfgrass. Turfgrass competed in nutrition, especially the N nutrition, with tomato plants. Therefore, enough nutrition from the organic fertilizer must be ensured. Usually, application of organic fertilizer is concentrated and localized near the tomato plants, although the rate is not really high on the total land basis. This high rate of localized fertilization will endanger the tomato seedlings to diseases that are usually caused by excessive N nutrition. If enough fertilization is not ensured, tomato plants may suffer malnutrition in the later growth periods. A proper fertilization rate and a sustainable organic fertilizer are necessary for the tomato plants intercropped into turfgrass. No any problem is induced from the water competition between turfgrass and tomato because the annual rainfall was around 2000 mm and only one or two times of sprinkle irrigation was needed. Turfgrass helps excessive water drain after heavy rains. More investment for the turf mower may be needed but the farmer can benefit from the harvested grass, which can be used as animal forage. In conclusion, using turfgrass as living mulch is a possible alternative way to avoid disease in organic field tomato production.

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Organic Methods for Control of Root Rot in Pea and Spinach in Northeastern U.S.

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Keywords: root rot, organic disease control

Abstract

The root rot disease complex is a limiting factor in organic production of cool season crops. This study aimed to increase seedling stands of peas and spinach by altering the seed environment such that the growing conditions of the seeds were favored over those of the pathogens. We compared treatments of raised (ridged) seed beds, dairy and vermicompost troughs, transplanting, and a biocontrol soil drench. Of the methods tested, transplanting provided the most reliable and best crop stands for both seasons (p=0.05) Since this method relies on the biological resistance the plants develop naturally with age, this method could prove applicable across many climates and other crops which are threatened by root rot.

Introduction

Root rot, seed rot, and damping off collectively represent a detrimental disease complex (hence referred to as root rot) which affects many vegetable crops. Root rot is marked by poor seedling emergence; infected seeds are soft, mushy and quickly deteriorate. In this study the pathogens identified were Pythium spp, Fusarium spp. and Rhizoctonia solani. The host crops in this study are spinach (Spinacia oleracea) and pea (Pisum sativum).

Conventional management of root rot relies on fungicidal seed treatments or, in severe infestations, methyl bromide fumigation. However, these treatments are not permitted in certified organic crops. Organic growers have few options for overcoming the detrimental effects of a root rot infestation. For many growers in the northeast U.S. obtaining a marketable crop of either peas or spinach can be nearly impossible due to the poor stands caused by root rot.

Peas and spinach share similar environmental growth conditions as root rot pathogens. Creating a seed bed which favors growth of the seed over that of the pathogen can be accomplished by exploiting the slight differences in the optimum growing conditions of the plants over that of the pathogens. Two important environmental factors which impact soil fungi are soil temperature and moisture, with the latter having greater potential influence on the severity of the disease. Kumar et al. (1999) have shown that the pathogens are more destructive at lower temperatures and higher moisture. Cultural management and techniques should therefore be geared towards creating higher temperatures and lower moisture environments than found in normal field conditions. Our objective was to compare ridge and furrow planting; compost amendments; a commercially available, certified organic soil

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drench; and transplanting as methods to establish these favorable environmental conditions, thus improving crop stands.

Ridge planting (Hodges, 2003) refers to planting seeds in a raised seedbed created during tillage. Another manipulation of the seed bed is to plant seeds in a furrow or trough of compost. By forming a physical barrier around the seed exudates, the compost environment may allow seedlings to develop beyond susceptibility of the pathogen (Mandelbaum Hadar, 1990). Additionally, the increase of antagonistic bacteria from the compost may suppress pathogen growth (Sullivan, 2004). It is well documented that mature composts contain a wealth of microbial populations (Boehm et al., 1993), although variation between types and batches of compost creates inconsistencies (Sullivan, 2004). We evaluated a locally-made dairy manure compost and commercially-produced vermicompost (from earthworm castings). The next treatment was the use of transplants. Seedlings are grown in flats of sterile media (usually 10-14 days, or until seedling shows 3-4 sets of true leaves) to mature beyond the most vulnerable stage of susceptibility to the seed rot pathogens. The seedlings are then transplanted into the field. We were able to compare the change in time and labour necessary for this by using records and data from a previous study (Childers, 2005). Finally, we evaluated a commercially available soil drench of Trichoderma harzianum as an antagonist to root rot pathogens. This product is registered for suppression of root rots in organic agriculture.

Materials and methods

All research was conducted at the West Virginia University Organic Research Farm located in Morgantown, WV, USA. The farm has been certified organic since 2003; all research complies with USDA organic standards. Spinach (Spinacia oleracea 'Whale F1') and garden pea (Pisum sativum 'Oregon Giant') seeds were used in all experiments. A 15.2-by- 7.6m plot, prone to root rot disease, was tilled and prepared for planting in fall 2006, spring 2007, and fall 2007. Eight treatments with three replicates each were established in a completely randomized design.

Treatments 1-4) Compost troughs (dairy manure compost and vermicompost, each at 2 rates): The planting rows were excavated of field soil and the trough was filled with either dairy manure compost (from WVU dairy research farms) or vermicompost (UNCO Industries, Racine, WI) at two rates: 1,967 cm3 compost m-1 or 3,387 cm3 m-1, referred to as Low and High respectively. The seeds were planted into the compost troughs such seeds were encased within the compost and had no contact with the field soil. 5-6) Ridge planting: In a prepared bed, the field soil was mounded to create a convex-shaped seed bed. Two different heights of the ridge bed (7.5 cm and 15 cm) were compared. 7) Transplanting: Seeds were sown in flats using organic growing media (made with WVU dairy compost, peat, and perlite) and allowed to develop for 10-14 days before being placed in the field (at the same time as seeds in the other treatments were sown). Both pea and spinach were transplanted as clumped groups containing 5-7 seedlings in each clump. 8) Control: Seeds were sown using traditional planting methods placing seeds directly into level rows.

Each treatment row (containing peas) was 1.2 m in length. Peas were planted 5 cm deep, 5 cm apart. Rows containing spinach were 60 cm long with seeds sown 3 mm deep, 5 cm apart. Seedling emergence/survival was recorded at 10, 15 and 21 days after planting. Soil moisture and temperature measurements were recorded continuously from the time of planting until the final field observation (21 days) with WatchDog data loggers (model 400, Spectrum Technology, East-Plainfield, IL). In fall

2007 we compared a commercially available organic soil drench, Root Guardian Biofungicide (Trichoderma harzianum, Gardens Alive, Lawrenceburg, IN), transplanting, and a control for their effect on seed emergence. Seeds were sown into the field and Root Guardian was applied as a soil drench at the recommended rate of 12 ml/L immediately after planting. The transplanting and control treatments were as described above.

Tab. 1: Mean emergence (%) of spinach and peas after 21 days in fall 2006 and spring 2007

	Fall-Spinach	Spring-Spinach	Fall-Peas	Spring-Peas
Transplant	95 a	90 a	99.1 a	93 a
Control	0 c	4.3 b	11.4 d	10.3 bc
Vermicompost-High	43.3 b	2.6 b	27.7 bc	8.6 c
Ridge-15cm	2.5 c	6 b	15.9 cd	16.6 bc
Dairy-High	3.3 c	1.6 b	19.6 bcd	31.3 b
Vermicompost-Low	29.1	5.3 b	39.2 b	8 c
Ridge-7.5cm	1.6 c	7.6 b	16.4 bcd	20.3 bc
Dairy-Low	6.6 c	8.6 b	15.9 bcd	21 bc

* Means separated by Tukey-Kramers HSD. P<0.05

Results

Transplanting of both pea and spinach resulted in survival rates nearing 100% for both years (Fig.1-4). Spinach emergence was greater (P = 0.05) in plots with high vermicompost than controls in 2006, but not in 2007. None of the other treatments differed significantly from the control in either year (Fig. 1 and 2). Pea emergence in plots with the high dairy compost treatment was greater (P = 0.05) than in controls or the high ridge treatment in 2006, but these differences were not significant in 2007 (Fig. 3 and 4). Pea emergence in the low vermicompost treatment was greater (P=0.05) than in controls in 2006, but the high vermicompost treatment did not differ from controls in 2006, and both vermicompost treatments resulted in the lowest pea emergence in 2007. In the fall 2007 experiment with Root Guardian, the transplanting treatment resulted in the highest plant (pea and spinach) survival (data not shown). No significant differences were observed between the Root Guardian treatment and the control. Temperature and moisture sensors were placed in only one replicate of each treatment, so statistical comparisons are not possible (data not shown); however no consistent correlations occurred between treatments or seasons and stand emergence for either crop.

Conclusions

Despite anecdotal evidence suggesting that improving drainage by planting seeds on a ridge will help in controlling root rot, we concluded that the differences in soil moisture or temperature between ridge plantings and the control did not significantly impact crop stands in our silt loam soil. Interestingly, the volume of compost made no difference in the results associated with the treatments, which we think illustrates the tenacity of the pathogens to migrate considerable distances in the rhizosphere to reach sprouting seeds. The pathogen population may be too overwhelming for an effective antagonistic suppression to take place. The inconsistent results between the two seasons demonstrated that these methods are unpredictable in resulting in an improved seed stand. This may be due to a significant interaction between climate and treatment that needs to be explored in more detail. We found the soil drench, Root Guardian, to be an ineffective treatment, as it was not statistically different from the control. We recognize the possibility of a seasonal interaction, and thus we will repeat the experiment with Root Guardian in spring 2008.

Finally, due to the overwhelming success of the transplanting method, small scale growers whose fields show poor stands of peas and spinach due to root rot are recommended to follow this technique. Though this method increased our planting time/labor by 25% we felt that this could be reduced by the efficiency of a larger scale farm operation. Moreover the additional time and labor was justified by the insurance of not losing crops to root rot. The minimal cost inputs created by the flats and media could be distributed over many seasons.

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Effects of shading on root and shoot development of melon (*Cucubrita pepo)* transplants in conventional and organic float system nurseries

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Key words: organic float system, conventional float system, shade, melon transplants.

Abstract

Float system is a common technique of tobacco and vegetables transplant production. We evaluated the shade effect on the roots and shoots development for two float systems surgeries (CV:conventional and ORG:organic) on melon transplants. The shade had differently influenced the development of the roots and shoots of the two float systems surgeries. Roots fresh weight and surface was significant higher under shade for organic transplants and significant lower under shade for conventional transplants. Hence, shoots fresh weight and surface was significant higher under shade for organic as well as conventional transplants. Because of the described differences in roots development, the transplants which were produced in the organic float system nursery had better quality under shade in contrast to those produced in conventional float system nursery which had better quality under light. The quality of transplants is related to their behaviour during the transplanting process, their resistance to the transplanting stress and their survival in the field.

Introduction

Conventional melon seedling production can be labour intensive. The float system may be a less labour-intensive alternative. Float system technology is used widely to produce tobacco transplants in greenhouse, but it is scarcely used for horticulture crops. Potential advantages may include lower production costs, more efficient use of water and nutrients, reduced foliar and root disease levels and elimination of nutrient leaching to groundwater below the greenhouse. However, if nutrient levels are not carefully managed, seedling can grow in very little time, resulting to tall, leggy and low quality transplants (Leal, 2001; Rideout and Overstreet, 2003).

Materials and methods

The experiments were conducted at the greenhouse of a Tobacco Research Station in West Greece, (Lat: 38°36´, Long: 21°21´, alt: 24m). Each experiment was set up according to a split-plot design, and two basins (dimension 110x90 cm and capacity 200 lt) at each one of the three replications were used.

Four polystyrene float trays consisted of 198 cells each (17 cm^3 volume cell) were placed inside each basin. Each cell was filled with substrate mixture (peat: perlite, 1:1) and sown with melon seed, *Cucubrita pepo* vs *galia F1*. In order to create shade,

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special curtain used, which allowed only 30% of light to get through. This curtain covered two of the four trays.

The first basin was managed by means of the conventional (common) technique (CV); with water-soluble fertilization, 150 g of Fytosrpint (19-19-19) by Fytothepriki Co. and two fungicides, 10 ml Previcur (i.e. propamocarb) by Bayer Crop Science and 10 gr Derosal (i.e. carbedazim) by Syngenta.

The second basin (ORG), followed the EU organic guidelines; with organic water-soluble fertilizer, 100 ml Fish–Fert (2-4-0.5, and other trace elements) by Humofert Co. and 10 ml by Trichomic (*Trichoderma sp.*) by Trichodex-Spain Co.

The estimation of LSD for means comparisons was accomplished by using the statistical program "SPSS".

Results and Discussion

The Leaves Surface (L.S.) and Fresh Weight of Shoots (F.W.S.) had a different direction in the experiment. The shade influenced L.S. of organic and conventional transplants the same and they were significant higher than those in light. The same had been noticed in the values of F.W.S. (Table 1).

On the other hand the values of Fresh Weight Root (F.W.R) and Root Surface (R.S.) of the ORG were smaller where the shade was significantly higher than those in light. In the CT basins the values of R.S. was significant lower than those in light (Table 1).

Tab. 11: Effects of the shade in two float systems (CV and ORG) on plant parameters of melon. (LSD values ($p<0.05$) are also shown).

	R.S. ($mm^2.plant^{-1}$)			L.S. ($mm^2.plant^{-1}$)		
	CV	ORG	$LSD_{5\%}$	CV	ORG	$LSD_{5\%}$
shade	864.85	735.5	45.32	5298.85	1846.55	1232
light	1126.033	625.55	27.44	4964.2	1559.57	1651
$LSD_{5\%}$	211	159		231	227	
	F.W.R. ($g.plant^{-1}$)			F.W.S. ($g.plant^{-1}$)		
	CV	ORG	$LSD_{5\%}$	CV	ORG	$LSD_{5\%}$
shade	0.58	0.51	0.19	4.55	1.36	2.11
light	0.85	0.41	0.22	4.17	1.05	2.76
$LSD_{5\%}$	0.32	0.22		0.34	0.29	

Conclusions

In our experiments, there was a clear evidence of root colonization by AM fungi in the ORG float system. A combination of phosphorus (Mader, 2000) and Trichoderma organic form (type) as well as fungicide absence is responsible for the recorded root colonization.

The effect of the shade on transplants R.S. and F.W.S. was significant lower in CV float system nursery and higher in float system nursery. On the contrary, the effect of the shade on fresh weight and surface of transplants shoots was significant higher in both float systems. The roots behaviour, in the ORG float, under shade was due to the better management of N in the plant. The roots followed the development of the shoot in order to maintain plants' balance. This provided better behaviour of the transplants during transplanting process, as well as their resistance to the transplanting stress and their survival in the field. (Anthony S. D. and Douglass F.J. (2005))

On the other hand this balance did not appear at the CV float system nursery. The absence of light decreased the root development. Probably roots of conventional basins have no assistant factors to reduce shade effect like mycorrhiza or small N concentration in the water solution.

Our results shown, that ORG float system was responsible for a higher quality of the transplants under shade. In conclusion, a combination of higher root development and lower shoot elongation resulted in creating transplants of a higher quality, compared to that of the CV float system.

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Crop protection and soil fertility in organic okra cultivation in Mauritius

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Key words: *Abelmoschus esculentus, Allium cepa, Azadirachta indica*, pests, NPK, soil health, organic.

Abstract

Okra was grown in organic and conventional systems. The organic plots included an intercrop system, using onion in alternate rows. Well-decomposed manure was used as a soil amendment, and mulching was done with cane straw. A bird net prevented damage by birds to seeds. Neem extract was applied as and when needed based on economic threshold values of important pests. Parameters studied included plant height, leaf area index, soil pH, soil NPK, and yield and quality of harvested okra fruits. Okra was grown in the conventional plots in a monocrop system, fertilised with synthetic NPK fertilisers, and sprayed with synthetic pesticides. Comparison of soil, plant and yield parameters showed that leaf area index, plant height (from week 10) and fruit yield and quality were higher in the organic system compared to the conventional system, while pest damage was equal in the two systems. Soil pH and phosphorus levels were lower in the organic plots, while available nitrogen and potassium were higher in the organic plots.

Introduction

Organic production has been identified as a high value-added activity for niche markets by the Government of Mauritius in its Non-Sugar Sector Strategy Plan (2003-2007) and its Strategic Options in Crop Diversification and Livestock Sector Plan (2007-2015). Although Mauritius has a number of attributes that makes it a good candidate for developing organic production (Facknath and Lalljee, 2001), organic agriculture has not really taken off in the country. Research on organic farming so far has been restricted to investigating methods for pest control and soil fertility management.

The long crop cycle of okra (6 months) has been used as a reason for the unsuitability of this crop in organic cultivation in Mauritius, mainly because of the higher risk of pests and diseases and difficulties of plant nutrition management. However, preliminary studies (Facknath, unpubl.) have shown that with the help of plant allelochemicals (either in the form of extracted plant sprays and/ or the plant grown as an intercrop) and appropriate soil amendments, okra can be grown organically.

Onion (*Allium cepa*) allelochemicals repel aphids (Elwell and Mass, 1995) and leafminers (Facknath, unpubl), while neem (*Azadirachta indica*) compounds have strong antifeedant, growth regulating, and pesticidal activity on a range of insects and mite pests (e.g. Isman, 2000). The weed control effect of mulching is well documented (e.g. Reijntjes et al., 1995). Composted manure can provide the necessary plant nutrients.

Materials and methods

Okra was grown in organic and conventional plots (all plots had been left fallow for 5 years prior to the experiment) in a completely randomised design with 8 replicates of 14.4 m^2 each, and a distance of 3 m between sub plots. Following a germination test, okra (cv. Piton) seeds were planted at the rate of 5 seeds per 20 x 20 x 15 cm hole. In the organic plot, onion was grown as an intercrop.

In the organic plot, well-decomposed manure was applied at planting, while in the conventional plot, the recommended rates of ammonium sulphate, simple superphosphate and potassium sulphate were applied. Irrigation in all plots was carried out using a drip system. Bird net placed over the plots until germination prevented damage by birds. Thinning to one plant per hole was done in all plots. Folimat was sprayed in the conventional plot to control insect pests, and top dressing with ammonium sulphate was carried out as recommended (Anon, 1994). In the organic plot, cane straw mulch was used to suppress weeds. Soil and plants from both organic and conventional plots were analysed for pH, leaf area index, and levels of NPK. Available nitrogen was determined by the Markham's Distillation method; available phosphorus was determined by the Modified Truog's method, and available potassium by flame photometry. Incidence of pests was recorded in all plots, as was yield of okra. Yield was measured in terms of quantity as well as quality of fruits harvested. Data was transformed and subjected to analysis of variance. Means were separated using LSD at 5% level of probability.

Results

Tab. 1: Mean (± se) leaf area index for organic and conventionally grown okra plants

Treatment	7 weeks	9 weeks	12 weeks
Organic	259.9 ± 24.3 a*	471.4 ± 32.8 a	687.1 ± 55.8 a
Conventional	135.3 ± 14.0 b	457. 9 ± 37.1 a	530.6 ± 39.5 b

* significant for P<0.05 within a column

Tab. 2: Mean (± se) height of organic and conventionally grown okra plants

Treatment	5 weeks	8 weeks	10 weeks	15 weeks
Organic	16.6 ± 0.9 a	30.2 ± 0.9 a	50.0 ± 3.8 a	76.8 ± 2.3 a
Conventional	13.3 ± 1.1 a	25.2 ± 1.2 a	38.8 ± 1.2 b	62.5 ± 4.5 b

* significant for P<0.05 within a column

Tab. 3: Mean (± se) number of aphids in organic and conventionally grown okra plants

Treatment	Before spraying	2 days after spraying
Organic	403.9 ± 22.2 a	2.0 ± 0.8 a
Conventional	597.8 ± 31.0 b	1.9 ± 0.5 a

* significant for P<0.05 within a column

Tab. 4: Mean (± se) pH of soil in organic and conventional okra plots

Treatment	Prior to planting	Middle of crop cycle	Post harvest
Organic	6.6 ± 0.09 a	5.7 ± 0.03 a	5.7 ± 0.03 a
Conventional	6.6 ± 0.09 a	6.0 ± 0.05 b	6.2 ± 0.08 b

* significant for P<0.05 within a column

Tab. 5: Mean (± se) level of nitrogen (%) in soil in organic and conventional okra plots

Treatment	Prior to planting	Middle of crop cycle	Post harvest
Organic	0.05 ± 0.0009 a	0.06 ± 0.0003 a	0.06 ± 0.0005 a
Conventional	0.05 ± 0.0009 a	0.04 ± 0.0003 b	0.05 ± 0.0008 b

* significant for P<0.05 within a column

Tab. 6: Mean (± se) level of phosphorus (ppm) in soil in organic and conventional okra plots

Treatment	Prior to planting	Middle of crop cycle	Post harvest
Organic	506 ± 1.14 a	600 ± 0.94 a	650 ± 1.25 a
Conventional	506 ± 1.14 a	820 ± 0.94 b	855 ± 0.47 b

* significant for P<0.05 within a column

Tab. 7: Mean (± se) level of potassium (ppm) in soil in organic and conventional okra plots

Treatment	Prior to planting	Middle of crop cycle	Post harvest
Organic	590 ± 1.41 a	650 ± 1.25 a	600 ± 1.25 a
Conventional	590 ± 1.41 a	585 ± 2.49 b	565 ± 0.94 b

* significant for P<0.05 within a column

Tab. 8: Quality of okra fruits from organic and conventionally-grown plants

Treatment	Grade A (kg)	Grade B (kg)	Grade C (kg)
Organic	11.01	5.39	3.20
Conventional	8.03	3.77	2.03

* significant for P<0.05 within a column

The following can be deduced from this experiment :

Leaf area index, plant height (from week 10), and fruit yield and quality were higher in the organic system compared to the conventional system.

Level of pest incidence was similar in the organic and conventional systems.

Soil pH and phosphorus levels were lower in the organic plots, while available nitrogen and potassium were higher in the organic plots.

Total yield of okra fruits, in terms of weight, was higher in the organic plots than in conventional ones ($F = 14.23$; df=1; $p < 0.01$).

Discussion

In the conventional plots, the presence of aphid and leafminer damage required the application of pesticides, while in the organic plots there were significantly fewer pests. The neem extract was as effective as the synthetic insecticide in controlling pest attack. Allelochemicals released by the onion intercrop in the organic plots may be the reason for fewer pests being observed in these plots. Furthermore, organic fertilisers build up resistance against pests in plants (van Emden, 1997; Stoll, 1988), and this could also explain the lower pest incidence. The higher levels of nitrogen in the soil could have contributed to the larger leaf area and greater plant height, which in turn would mean greater photosynthetic capacity and better growth of plants. Although earlier studies have shown that higher nitrogen content in soil can lead to higher incidence of leafminer damage (Facknath and Lalljee, 2005), this was not observed in the present study, perhaps due to the repellent property of onion allelochemicals.

Conclusions

Organic practices were found to be better than organic ones, in terms of both crop yield and soil health. With the well-known environmental and health benefits of organic agriculture, farmers in Mauritius should be encouraged to shift to organic systems of production.

Acknowledgments

The authors express their gratitude to Mr. G. de Fontenay, Manager of the Verger Agricole de Labourdonnais for all field facilities provided.

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Research Needs in Organic Vegetable Production Systems in Tropical Countries With a Focus on Asia

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Key words: soil fertility, crop nutrition, superior variety, pest control, natural resources

Abstract

Well-managed organic vegetable production systems (OVPS) can provide food security and healthy diets for humans, while being less harmful to the environment and more efficient in natural resource use. However, most OVPS research is carried out in developed countries, mainly under temperate or subtropical climatic conditions. Institutionalized research in organic farming in most tropical countries appears to be relatively new, and it is not a significant focus for the International Agricultural Research Centers. Tropical farmers in Asia producing vegetables organically, whether by design or default, must overcome significant challenges organic growers in temperate climates seldom face, including a lack of suitable varieties, heavy rainfall and the year-round presence of pests. According to our online literature survey, tomato is the vegetable most commonly researched in organic farming, followed by lettuce, carrot and cucumber; we found little research on crops important to tropical Asia, such as eggplant, chili pepper, different cucurbits such as gourds, and locally important indigenous vegetables. To improve and promote OVPS in tropical countries, institutional research is needed to identify and develop vegetable varieties, alternative crop protection and management methods better suited to the tropics.

Introduction

In tropical Asia, vegetables are an integral part of the diets of many people, providing the essential micronutrients vital to human health and development. While conventional vegetable production has generated income for Asia's many small-scale farmers, consumer concerns about synthetic pesticide residues have led to a greater demand for 'safer' organically produced vegetables (UN, 2003). Although there are constraints, the potential exists for smallholders to further increase their incomes by producing vegetables organically. For example, according to Pai (2006), there were 914 certified organic farms in Taiwan in 2006, covering an area of 1,442 hectares. The area of organic rice was largest with 746.4 hectares followed by organic vegetables with 372.7 hectares. However, in terms of production value, organic vegetables (NTD 249 million or USD7.55 million) were more important than organic rice (NTD158 million or USD4.78 million), or any other organically produced crop in Taiwan. This relationship is also true for other countries in the tropics/subtropics such as Thailand (Danuwat, 2007).

To participate in this expanding market, Asia's organic farmers – including traditional farmers who are "organic by default" because they cannot afford chemical inputs – need help to increase yields and improve the quality of their produce. Research should focus on the development of superior, disease-resistant vegetable varieties, safe botanical pesticides and crop management techniques specific to the tropics.

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Organic production constraints in tropical countries

According to an electronic survey by Stoll (2003) lowland vegetable production is the predominant form of organic vegetable cultivation in the tropics, followed by upland vegetable cultivation. Vegetable farmers in tropical and subtropical countries are confronted with a range of production constraints including climatic stress (heat, seasonal drought, heavy rainfall, floods, and tropical cyclones) and the year-round prevalence of insect pests and diseases (UN, 2003). Poor soil fertility, low-quality seed, and a lack of varieties adapted to these conditions further complicate organic vegetable production. Successful organic vegetable production requires a minimum level of key inputs, but in most tropical countries organic input markets are poorly developed. Weak linkages persist between vegetable producers and their input suppliers and produce markets. Traditional farmers considered to be 'organic by default' often lack basic agricultural equipment, have limited access to credit, must expend a significant amount of labor to satisfy their daily basic needs, and may not have access to education and information (Freyer, 2007).

Lack of research on tropical organic production

A simple literature search using internationally available databases shows that tomato is the most commonly researched vegetable in organic farming systems, followed by lettuce, carrot and cucumber (Table 1, column two).

Tab. 1: Number of records returned when entering keywords related to organic vegetable production

Key words entered	Records returned CAB-Abstracts + (AGRICOLA, AGRIS) [1)]	Records returned CAB-Abstracts only[2)] (without 'organic' in front, vegetable name only)
Organic tomato	27 + (9) = 36	32,536
Organic lettuce	16 + (3) = 19	7,255
Organic carrot	9 + (2) = 11	5,684
Organic cucumber	8 + (1) = 9	11,411
Organic onion	7 + (1) = 8	7,349
Organic pepper	5 + (0) = 5	9,026
Organic bean	5 + (0) = 5	25,192
Organic pea	5 + (0) = 5	16,740
Organic cabbage	5 + (0) = 5	9,374
Organic broccoli	4 + (1) = 5	2,847

(Databases AGRICOLA 1984 – September 2007, CAB-Abstracts 1989 – September 2007, AGRIS 1975 – June 2007, accessed 8 November 2007)

1) The same records already returned in CAB-Abstracts not included to avoid duplicate records

2) The database CAB-Abstracts was used only in order to avoid duplicate records

Note: if potato would have been considered to be a vegetable, tomato would be just the second most important vegetable crop in organic vegetable research.

Organic vegetable research is only a small subset of overall vegetable research – most of which has been done in developed countries under temperate and subtropical climatic conditions (Table 1, column three). Very few records related to organic vegetable production in tropical countries appeared in our search. For example, in the search for “organic tomato” production only four records were returned from tropical countries (three from Brazil and one from India). The FAO report ‘Organic Agriculture and Food Security’ states that there is almost no organic agricultural research taking place in most developing countries. Even in developed countries allocations to organic farming do not exceed one percent of total agricultural research budgets (Scialabba EL-Hage, 2007).

A focus for future research

To promote and improve organic farming in tropical Asia research efforts should focus on crops important to the region, including eggplant (brinjal), chili pepper, and different cucurbits such as gourds, etc. Some indigenous vegetables may be more suited to regional OVPS than introduced ‘exotic’ vegetables because of their adaptation to tropical environments, and often good tolerance of pests, diseases and low soil fertility.

Research into plant protection strategies based on a combination of preventive and direct methods will help organic vegetable producers to better manage their crops. Preventive methods such as crop rotation and maintaining soil fertility enhance the vigor and health of crop plants (UN, 2003). Soil-borne diseases and insect pests such as flea beetle (Phyllotreta spp.) are in general very difficult to manage. We found in tropical Taiwan that it is extremely difficult to control small sucking insect pests (often virus vectors) such as white flies (e.g. Bemisia tabaci), aphids (e.g. Myzus persicae) and melon fruit fly (Dacus cucurbitae) in the open field without nets. In contrast, larvae of several important Lepidoptera such as Spodoptera spp., Leucinodes orbonalis, Plutella xylostella, and Helicoverpa armigera can be controlled relatively easily with Bacillus thuringiensis (Bt) foliar applications, provided the larvae are small and remain exposed on leaves and stems. Fungal diseases are difficult to control in organic farming due to a lack of effective fungicides (Aini et al., 2005), particularly if copper and sulfur products are omitted or not available. Therefore, the most important research need in organic (and conventional) farming is to manage plant diseases through the development of disease-resistant or tolerant varieties (Aini et al., 2005).

Botanical pesticides offer a fertile area for research. More than 1,000 plants with potential applications in crop protection have yet to be investigated in detail (Prakash & Rao, 1997). Field experiments are needed to confirm the abilities of the most promising candidates observed in laboratory studies. The efficacy, human and environmental toxicity, and mode of action of most home-made botanical pesticides remain to be studied. Research should consider aspects influencing their efficacy, such as optimized extraction methods, use of natural additives such as alcohol, and target pests in relation to their vegetable host plants, as well as phytotoxicity and the effect on non-target beneficial organisms.

Research in soil fertility and plant nutrition management is needed to ensure the most effective use of limited resources such as phosphorus, and to provide the best management options for stressed soils affected by salinity, acidification, low organic matter content or nutrient depletion (eg. Grenz & Sauerborn, 2007). Being able to produce effectively under low fertility conditions may become more common (Juroszek et al., 2008) due to increasing land degradation and soil nutrient depletion as well as the expected depletion of sources of high-grade phosphate fertilizers this century (Runge-Metzger, 1995). Breeding of modern varieties is conducted mostly under high-input situations and has missed out on exploiting genetic differences expressed at low levels of inputs (Ceccarelli, 1996). Lammerts van Bueren (2002) pointed out that for very low yield-level environments, selection in 'low-input' systems is necessary. For instance Moura et al. (2001) found in a pot experiment a large variation in the phosphorus (P) efficiency of 10 tested sweet pepper lines, suggesting that genetic improvement programs aimed at increasing this characteristic in sweet pepper could be successful. In addition to breeding P-efficient vegetable varieties to cope with expanding low-fertility situations, other approaches such as the use of microbes for enhancing P-availability, improved technologies to use low-grade phosphate rocks, and extraction and recycling of 'safe' P from organic resources such as waste water and solid waste should be considered (Grenz & Sauerborn, 2007).

To conclude, more institutionalized research in organic agriculture and horticulture is needed to improve and promote organic farming systems in tropical countries.

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"Aurora Tropical": a model of Ecological Horticulture, Case studies of 11 Onion and Shallot cultivars

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Key words: semi-arid climate, tropic, alliums, vegetable, sustainable

Abstract

A proposal is presented for a model programme of ecological horticulture which could contribute to improved vegetable crop production and biodiversity in tropical agroecosystems. Each step of the model "Aurora Tropical" was successfully applied for producing pesticide-free onions and shallots in semiarid conditions of Venezuela and for comparing simultaneously growth and productivity of 11 cultivars. The model steps include a good knowledge of the vegetable crop, market, soil/substrate, irrigation water, climate, microclimate, companion crops and the current and indigenous horticultural technologies. Also, the proposal recognizes the distinction between agriculture and horticulture in tropical environments. Growth and yield results indicate that the onion cultivars Americana, Cimarron and H10020 were the top performers for leaf area, bulb diameter and yield. Furthermore, the red shallot 10026 showed the highest total soluble solids and dry matter content, and also a good relative yield. Shallots (from true seed) and other local and exotic vegetables have a great potential in tropical environments.

Introduction

In tropical areas, sun's rays striking the ground intense and continuously, means a faster and more diverse growing season year-round for plants, animals, microorganisms, and humans. These regions cover approximately 40 % of the world's land area and are home to a large proportion of the world's total population and to most of the world's poor, undernourished and deprived inhabitants (Lal, 2000).

The common features of farming communities in many tropical locations include infertile acid soils, low organic matter content, steep slopes, high risk of erosion, a warm, humid climate, economically-poor farm families, many minority ethnic groups, high population growth, and poor infrastructure (Craswell and Lefroy, 2001). Additionally, most assessments indicate that climate change will have negative effects on agriculture and forestry in the tropics (Zhao et al., 2005). Notwithstanding these constraints, some farmers all over the tropics find it is profitable to diversify from agricultural into mainly horticultural crops. In recent years, the supply of fruits and vegetables has increased continuously on a global scale; much of this growth has been concentrated in Latin America and China (Weinberger and Lumpkin, 2005). Unfortunately, vegetable production systems in the tropics and elsewhere are mostly intensive, and this approach has been identified as one of the largest contributors to the loss of biodiversity and natural resource degradation (Weinberger and Lumpkin, 2005). Thus, there is an urgent need for the development and implementation of

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ecological vegetable production systems to mitigate tropical degradation. In this context, the aim of this research is to propose an ecological model named "Aurora Tropical" for sustainable vegetable production in tropical areas and to apply and test it in the production of onions *(Allium cepa* L.) and shallot cultivars (*Allium cepa* L. *Aggregatum* Group) in the Quibor valley of Lara state, Venezuela.

Materials and methods

As a model of ecological horticulture, Aurora Tropical integrates current and indigenous knowledge from various agricultural systems including local, modern, integrated, organic agriculture and agroecology, permaculture and agroforestry, adapting all to the tropical regions. Table 1 shows the 6 steps followed by the model and their applications for producing onions and shallots in tropical conditions.

Results and Discussion

Table 2 shows the results of a trial comparing growth, yields and postharvest quality of 9 onion cultivars and 1 shallot cultivar. A second shallot cultivar (100026 Hazera Seeds, Israel), did not survive after transplanting. This cultivar may not have been appropriate for this region and/or transplanting season. The integrated model Aurora Tropical proved to be very effective, producing good quality, pesticide-free onions and shallots under tropical conditions. Each step had an interesting response. For example, companion cropping was a very useful technique, mainly intercropping with sunflowers. Results from Jones and Gillett (2005), indicate that sunflowers indeed attract and play host to numerous beneficial insects in a vegetable agroecosystem. This is a very important finding, as we know that almost all vegetable crop production in tropical countries follows the conventional system, whereby production activities are the largest users of plant protection products, since most of these crops are rather susceptible to pest and climatological hazards. As vegetables are often traded and consumed in fresh form, biological contamination, pesticide and heavy metal residues and waste products are also very serious issues (Weinberger and Lumpkin, 2005), especially in tropical conditions. Research done in Venezuela and Peru supports this concern (Pierre and Betancourt, 2007; Yucra et al., 2006).

As shown in Table 2, the onion cultivar Americana was the top performer for leaf area, bulb diameter and yield, followed by Cimarron and H10020. However, this cultivar showed a high thicknecking percentage (data not shown) which negatively affects keeping quality and market. The red shallot showed the highest total soluble solids and dry matter content, and gave a relatively high yield. Shallots are not a well known vegetable crop in Latin American countries. In fact, this is the first experiment with shallots in Venezuela. Nevertheless, in Asian and African countries, the shallot is an economically important crop and much more in demand than common onion, because of its pungent flavour, culinary value and high adaptability to tropical and subtropical conditions. For example, in Vietnam, shallots are sold in every market all over the country, as fresh green or dry bulbs. For dietary consumption, it is used as a vegetable, spice, pickle or as medicine to reduce fever and cure wounds (Phuong et al., 2006).

Tab. 1: Steps of the ecological model "Aurora Tropical" and its application for producing onions and shallots in semiarid tropical conditions of Venezuela

Step	Application
1. Crop, Market, Climate, soil/substrate and water: Historical and current analyses of these resources (quality and quantity) are compulsory	Onions and shallots for trading as fresh produce direct to the local market. Climate: first peak of the humid season (May to September), at the "Hacienda El Tunal" in Quibor valley, Lara state, Venezuela (lat. 9º 57´ N). Soil: Previous analyses see Ramirez, (2002). A clay loam soil with low organic matter and high phosphorus and potassium content was used. Water. The electric conductivity (EC) of the irrigation water was 0.7 dS m^{-1} and the pH 7.
2. Sowing/transplanting season and system: according to the vegetable crop, market, climate, soil/substrate and irrigation water.	Onion and shallot seeds were sown in plug flats of 288 cells (5 seeds per cell) on 20 April 2006. On 27 May, the seedlings were transplanted in six rows with 15 and 10 cm between rows and plants respectively on a raised, shaped, standard vegetable bed (1 m wide).
3. Vegetable cultivar: productive genetic material adapted to the local area, sowing season and tolerant to main local constraints is necessary.	Growth, development, yield, postharvest quality and adaptation (mainly to day length) of 11 hybrids (8 onions, 2 shallots) and 1 onion open pollinated (OP), were compared using a complete randomised block design with 5 replications (55 plots, each 6 m long). All cultivars were certified short-day materials.
4. Companion crops: mainly plants well known as hosts of beneficial insects. These crops are chosen in relation to the main vegetable crop, sowing season and main pests limiting the main crop.	On 27 May, crops of carrot, vegetable and herb mixture (parsley, coriander, beet, fennel, alfalfa, carrot, and basil), soy, and the outer crop of sunflower were directly sown on individual beds (1 m wide and 30 m long). These crops were completely surrounding the main crop (onions and shallots) as a core frame. Carrots were located just next to the main crop. According to Stoll (2000), mixed cropping of carrots and onions contributes to a reduction of the thrips populations (the main onion pest locally and worldwide).
5. Horticultural technologies: A key factor. It means picking and using the appropriate and adapted technologies (indigenous or modern), such as an integrated tillage, irrigation system, fertilization and pest management (IPM) among others. All technologies are used for "preventing" and not for curing.	Main and companion crops were drip irrigated and organically fertilized (10 ton ha^{-1} of "Tunal Compost" from a mix of cattle, chicken and pig manures). Moreover, main crops were mineral fertigated (only using 155 kg ha^{-1} of Nitrogen and 50 kg ha^{-1} of Potassium). Regarding IPM, roots of onion and shallot seedlings were soaked in a mixed solution of trichoderma and humus. This solution was also foliar applied. Diseases were managed with preventive foliar application of copper, sulphate, and organic pesticides. Meanwhile, insects were controlled by using natural repellent solutions (neem, basil, garlic, etc.). Also, insect pests on the coloured plastic traps (yellow, blue and white) and crops were monitored. Hand weeding was undertaken as needed.
6. Harvest, postharvest and complementary steps.	When most onion cultivars were harvested (112 days after transplanting), bulb yields and postharvest quality were recorded. After sorting by size and skin colour, the produce was sold at the local growers market, labelled as an ecological product. During the application of the model, there were guided visits, open field days, workshops, cookery demonstrations, etc., at the experimental plot.

Conclusions

Aurora Tropical could become a useful tool for producing sound vegetables in tropical regions which still rely on an agriculture-based economy and are classified as developing countries. It is crucial to point out the big distinction between horticulture and agriculture under tropical conditions. The selection of the precise vegetable cultivar for the current season, companion crops and other adapted horticultural technologies are very useful skills for breaking down the monoculture structure, promoting biodiversity, providing pest and weed control benefits, reducing erosion, and improving water infiltration, among others. Shallots and other adapted crops have a great potential for producing and developing new markets in tropical areas.

Tab. 2: Growth, yields and postharvest quality of 9 onions and 1 shallot short-day cultivars applying the ecological model Aurora Tropical

Cultivar	Origin	Skin colour	Leaf area* (cm^2 $plant^{-1}$)	Bulb diam.* (cm)	Yields* (kg ha^{-1})	TSS* (ºBrix)	Dry matter (%)*
H. Sequoia	Nunh. Chile	Yellow	100bc	4.7abc	22797bc	5.54de	4.0cd
H. 10020	Haz. S. Israel	Red	115b	5.1ab	28153b	7.02bc	4.6bc
H. Cimarron	Nunh. Chile	Yellow	117b	5.2ab	26368b	5.01de	3.6d
H. 10000	Haz. S. Israel	Yellow	63cde	4.1cde	12223cde	4.81de	3.5d
OP Reina438	Paim. S. Italy	Yellow	86bcde	4.7abc	17029bcde	4.88de	3.6d
H. 1478	Haz. S. Israel	Yellow	39e	3.5e	5768e	5.11de	3.4d
H. 1297	Haz. S. Israel	Yellow	48de	3.6de	7828e	4.35e	3.3d
H 10026, Sh.	Haz. S. Israel	Red	97bc	4.3bcde	18677c	10.83a	7.0a
H. Americana	Seminis USA	Yellow	164a	5.3a	35020a	7.34b	4.9b
H. 10021	Haz. S. Israel	Red	69cde	4.4bcd	14420cde	6.01cd	4.0cd

* Means followed by the same letter are not significantly different by Duncan test at the 0.05 level. H.: hybrid, OP: open pollinated, Sh.: Shallot, TSS: total soluble solids, Nunh: Nunhems, Haz: Hazera Seeds, Paim: Paimer seeds.

Acknowledgments

This research was funded by the CDCHT – UCLA (014-AG-2004), Alimentos el Tunal C.A. and FUNDACEBOLLA. We would like to thank all suppliers of irrigation systems, fertilizers, organic pesticides, seeds, etc. Dr. Ramirez-Guerrero is truly grateful for the SIDA-SUS Program “Sustainable Agriculture in an Environmental Perspective” and Svalöf Consulting AB from Sweden. The authors thank Dr. Julia Wright (HDRA, UK), Dr. Lesley Currah (Currah Consultancy, UK) and ISOFAR evaluators for comments and suggestions for the English revision.

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Change in the weed seed bank during the first four years of a five-course crop rotation with organically grown vegetables

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Keywords: weed seed bank, red clover, yellow sweetclover , vegetables, crop rotation

Abstract

In a five-course rotation with organic vegetables (white cabbage, carrot and onion) the weed seed bank was reduced the year after two continuous years with red clover, mainly because of mowing and no soil cultivation the second year red clover. The year after the weedy yellow sweetclover the weed seed bank increased.

Introduction

The weed observations were an integrated part of the project 'Optimum crop rotation for secure organic vegetable production', started in 2002 at Bioforsk Arable Crops – Landvik, in the southern part of Norway. The project has focused on different N-sufficient crop rotation systems on a clay rich soil. Of five production years two have been used for green manure fertilisation with legumes. Our results have shown that the systems provide abundant levels of nitrogen for white cabbage, carrots and onions.

The soil seed bank is recognized as the primary source of annual weeds in arable land. The majority of seeds entering the seed bank come from annual weeds growing in the fields. The size of the seed bank reflects past and present field management (Cavers & Benoit, 1989). Albrect (2005) found that the number of weed seeds increased at sites with low crop cover and high density of weed plants at the soil surface. Winter cereals, sunflowers and lupins increased for example the weed seed bank by 30-40%. Grass-clover mixtures, however, reduced the seed bank by 39%. In an organic farmed six-course rotation investigation in Norway, the seed bank was reduced from a maxiumum of 17600 m^{-2} to a minimum of 7200 seeds m^{-2} after three years with perennial grass-clover ley (Sjursen, 2001).

The main objective of the present study was to evaluate the effect of two years with a N-fixing clover crop on the weed seed bank, either two continuous years with red clover or two alternating years with yellow sweetclover.

Materials and methods

The investigated area had four different fields with three replicates. Two of them had this rotation: Red clover, red clover, white cabbage, onion, followed by a last year with carrot. Two other fields had this rotation: yellow sweet clover (ribbed meliot), white cabbage, yellow sweet clover, onion and carrot. The plot size was 8 x 15 m. Soil samples down to 0.20 m for weed seed investigations were taken each year before

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the growing season started (around 25th of April). The seed number analysis were carried out by the seedling emergence method described by Sjursen (2001). Number of emerged weeds on the soil surface were counted in a frame 0,5 x 0,5 m (clover crops) or 0,1 x 1,0 m (vegetable crops) during the end of June – beginning of July. The fields were weed managed by common organic methods, like flaming before planting/sowing, inter-row hoing/ploughing, and manual weeding in vegetables, and two-three times mowing in clover leys.

Results

The weed seed bank in the whole investigated area increased the first three years by 11% from about 28000 to 31000 seeds m^{-2}, and was redused by 7% to 29000 seeds m^{-2} the fourth year. 23 weed species occurred in the seed bank. The most frequent species were *Spergula arvensis* L., *Filaginella uliginosum* (L.) Opiz., *Poa annua* L., *Capsella bursa-pastoris* (L.) *Medicus*, *Chamomilla suaveolens* (Pursch) Rydb. and *Stellaria media* (L.) Vill.

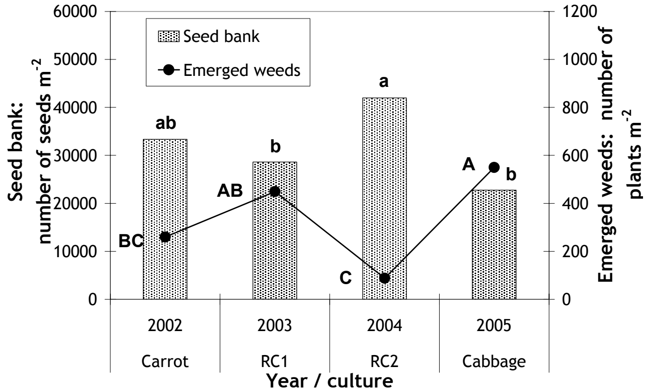

Figure 1: Weed seed bank in the soil (left hand y-axis) and emerged weeds (right hand y-axis) during two continuous years with red clover (RC1 and RC2) in rotation with carrot and white cabbage. Onion is the fifth year. Values with the same letter (lower case or upper case) are not significantly different at $p \leq 0.05$ (n = 6).

The same species were most frequent among the emerged species. The seed bank increased after one year with red clover, but was reduced after the second year of clover (figure 1 and 2). The seed bank increased the year after yellow sweetclover (figure 3 and 4). The density of emerged weed plants was high in the first year with red clover (figure 1 and 2) and in yellow sweetclover (figure 3 and 4).

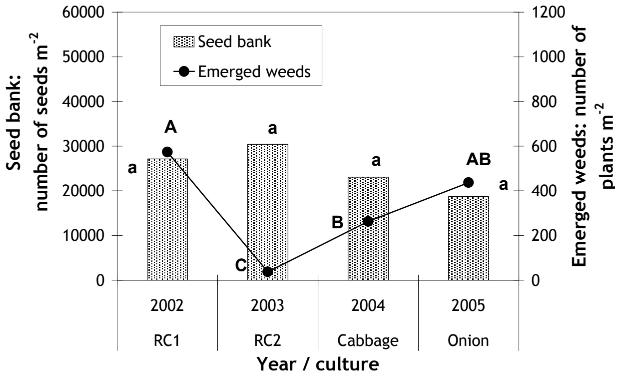

Figure 2: Weed seed bank in the soil (left hand y-axis) and emerged weeds (right hand y-axis) during two continuous years with red clover (RC1 and RC2) in rotation with carrot and onion. Carrot is the fifth year. See figure 1 for statistics.

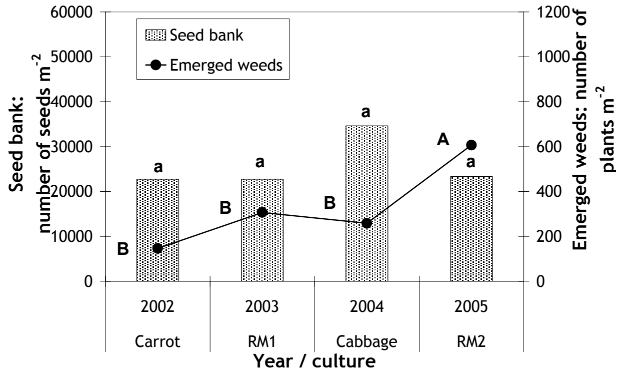

Figure 3: Weed seed bank in the soil (left hand y-axis) and emerged weeds (right hand y-axis) during two alternating years with yellow sweetclover (RM1 and RM2) in rotation with carrot and onion. Onion is the fifth year. See figure 1 for statistics.

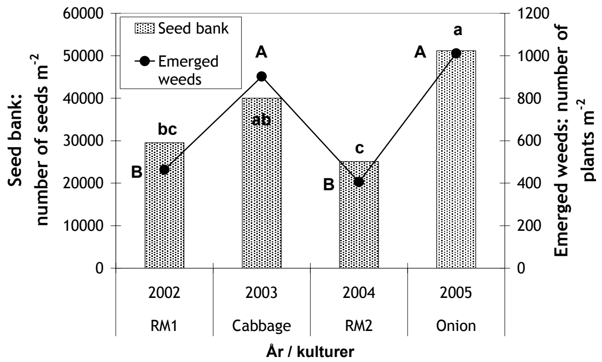

Figure 4: Weed seed bank in the soil (left hand y-axis) and emerged weeds (right hand y-axis) during two split-up years with ribbed meliot (RM1 and RM2) in rotation with white cabbage and onion. Carrot is the fifth year. See figure 1 for statistics.

Discussion and conclusions

The results show that there are a close relation between the emerged weed plants at the soil surface and the seed bank the following year. The red clover was mowed two-three times the second year. This resulted in low emergence of annual weeds, and reduced seed bank the following year (figure 1 and 2), in accordance with the investigations by Sjursen (2001) and Albrecht (2005). This effect was not seen in yellow sweetclover. There was a tendency of weed seed bank reduction the year after white cabbage, which can be explained by the strong competition by the fast-growing cabbage leaves and the manual weeding. This effect was not seen the year after carrot and onion, which is known as low-competitive crops. Teasdale et al. (2004) force the importance for organic farmers to minimize opportunities for rapid buildup of the seed bank.

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Changes in mineral content and CO_2 release from organic greenhouse soils incubated under two different temperatures and moisture conditions

Pepin, S.[1], Dorais, M.[2], Gruyer, N.[3] & Ménard, C.[4]

Key words: soil respiration; moisture content; biological activity; soil temperature

Abstract

In organic greenhouse vegetable productions, the turnover rate of organic amendments may be a limiting factor for optimal crop productivity and quality. Hence, we determined the mineralization potential of several organic greenhouse soils maintained at two temperatures (17, 23□C) and water potentials (–35, –250 mbars). Replicate cores of structurally intact soils were collected in plastic cylinders, saturated with water and adjusted to the appropriate matric potential. Additional soil samples were sieved, placed in glass jars and incubated under the same treatment conditions. Soil nutrients, gas concentration (O_2, CO_2, N_2O) and microbial activity (CO_2 release) were measured over a 25-week period during aerobic incubation. Large variations in nutrient and organic matter content were observed among intact soil samples. CO_2 efflux declined exponentially with time, decreases being most apparent in soils having high organic matter content. An increase in temperature lead to enhanced soil respiration rates, mainly during the first weeks of incubation. Overall, mineralization rates were only slightly affected by moisture level or temperature. Gas diffusion, and thus soil biological activity, may be momentarily hindered during frequent irrigations. Yet, our findings indicate that in general matric potentials of –35 and –250 mbars both result in similar mineralization rates in these soils.

Introduction

The foundation of organic farming is based on soil biological activity, which depends on soil properties (C/N, % organic matter, pH, O_2), cultural practices (fertilization, amendment, crop rotation, tillage, irrigation) and environmental factors such as temperature and soil moisture (Dorais, 2008). Although the growing conditions can easily be controlled in a greenhouse, the turnover of organic amendments for organically-grown vegetable crops may become a limiting factor for optimal crop productivity and product quality. Indeed, nutrient requirement of greenhouse tomato crops is higher than that of field tomato crops, with yield being up to 10 times greater in greenhouse crops than field crops (Heuvelink & Dorais, 2005). Soil texture and structure, as well as temperature and moisture may all affect the activity of soil microorganisms and hence, the mineralization rate of organic matter in the soil (Angers & Carter 1996; Schjønning *et al*. 1999; Thomsen *et al*. 1999). For instance, pore size distribution and total porosity both impact on soil organic C mineralization by

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[3] As in 1

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influencing soil moisture availability for microbes (Yoo *et al*. 2006). Irrigation management is thus a key factor to optimize soil biological activity. A better understanding of mineralization processes under different greenhouse growing conditions is important for optimizing crop nutrient supply, while minimizing losses to the environment (i.e. to the groundwater). The objective of the present study was to determine the mineralization potential of several organic greenhouse soils maintained at two temperatures and two soil water potentials.

Materials and methods

An incubation experiment was conducted using two temperatures (17°C, 23°C), two soil matric potentials (–35 mbars, –250 mbars = field capacity) and five incubation periods (1, 4, 8, 16 and 24 weeks). Three replicate 196-cm^3 cores of structurally intact soil (0–10 cm depth; 5-cm diam. cylinders) per treatment and time period were collected from five organically managed greenhouse soils in 2006 (n=300; Table 1). Soil samples were first saturated with distilled water, then adjusted to matric potentials of –35 and –250 mbars using a tension-plate assembly and a pressure-plate apparatus. Based on soil water release characteristics, these two matric potentials resulted in a mean (±SD) water-filled pore space of 80% (±6%) and 68% (±5%), respectively. Additional samples (n=240) were collected, saturated and brought to the appropriate matric potential, then sieved through a 6-mm mesh and placed in sealed glass jars. Cylinders and glass jars were placed into two growth chambers under constant temperature in completely randomized blocks (n=3). Soil samples were weighed once a week and distilled water was added when necessary to compensate for water loss. Samples were rotated weekly both within and between chambers to minimize chamber effects. Microbial activity (CO_2 efflux) was measured in larger soil samples (~900 cm^3) at 4 to 8-week intervals using a portable gas exchange system (model LI-6400, Li-Cor) and a Soil CO_2 Flux Chamber. Three cylinders and glass jars from each soil and treatment were sampled at the end of each incubation period to determine water-extractable minerals (K, P, Mg, Ca, Na, etc.; readily available to plants) and KCl-extractable inorganic nitrogen (NO_3, NH_4). Soil organic matter content was determined using the Walkley-Black method (for mineral soil) or the loss by ignition method (for soil having >20% organic matter). Mean changes in nutrient content were analyzed using an ANOVA with soil type, temperature, matric potential and incubation period as fixed factor effects. All statistical analyses were computed using *SAS* v.8.2 (SAS Institute, Cary, NC) with a level of significance of $P < 0.05$.

Results and Discussion

From our glass jar trials, we observed a significant increase in nutrient contents of soil samples during the 24-week incubation period (Table 1) and a corresponding decrease in organic matter (data not shown), thus suggesting microbial activity. Similar trends were obtained with intact soil cores, but a greater variability was observed due soil heterogeneity within the greenhouse. Microbial activity was also inferred from soil respiration measurements. CO_2 release from incubated samples declined with time (Figure 1). As expected, CO_2 fluxes were greater at 23°C than at 17°C in all types of soil (P<0.01). However, soil matric potential had no significant effect on CO_2 efflux (data not shown). There were no statistical differences in nutrient and organic matter contents between the different types of containers, hence similar soil respiration rates were assumed.

There was a significant effect of incubation temperature on the mineralization of NO_3 in sandy loams (Figure 2; P<0.05), and a consistent trend of increasing nutrient content with temperature in most soils, except for NH_4 and K in OS~20, and P content in general. Matric potential (i.e. moisture) had no consistent effect on nutrient change over a 24-wk period (Figure 2). Further, we did not detect any significant effect of moisture and temperature on Mehlich-3 extractable micro- and macro-nutrients (data not shown). This was partly due to high soil greenhouse variability in nutrient content and thus, between intact soil cores.

Tab. 1: Changes in nutrient content of organically managed greenhouse soils after a 24-week incubation period.

Textural class	Cultivation time	Organic matter	Changes in nutrient content (mg kg^{-1} soil day^{-1})			
	(years)	(OM, %)	NO_3	NH_4	K	P
Sandy loam (SL)	1	4.9	0.77*	–0.09	0.08*	0.0035*
Sandy loam (SL)	2	6.3	3.38*	0.31*	0.13*	0.0068*
Loam (L)	4	8.5	4.82*	0.29	0.22*	0.0043*
Loam (L)	~15	11.3	1.77	<0.01	–0.01	0.0360*
Organic soil (OS)	~20	33.4	5.33*	0.44*	0.82	–0.1101*

NOTE: a soil is considered organic when the content of organic matter > 20%. Cultivation time refers to the number of consecutive years a crop was organically produced on the same soil. * indicates a significant ($P \leq 0.05$) change in nutrient content between week 1 and week 24.

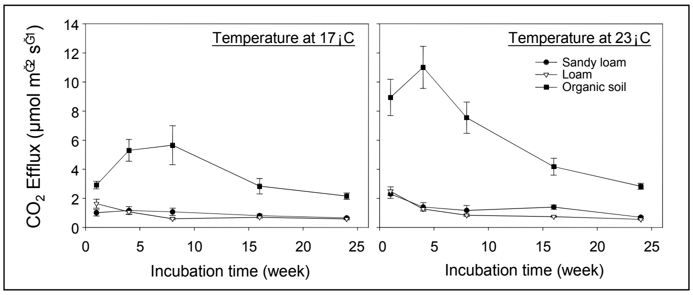

Figure 1: Relationship between incubation time and soil respiration for three types of organically cultivated soil (sandy loam 1-year, loam 15-years, and organic soil 20-years) exposed to two different soil temperatures

Conclusions

Based on our results and studied soils, we conclude that increasing greenhouse soil temperature from 17°C to 23°C would significantly enhance soil respiration rates, particularly during the first few months. However, mineralization rates in intact soil cores were only slightly increased by higher soil temperature or lower moisture content. Since gas diffusion and soil biological activity may be momentarily hindered during frequent irrigations (required by vegetable greenhouse crops), soil moisture conditions close to field capacity should improve the turnover of soil organic matter. Yet, similar changes in nutrient contents were observed in soil samples incubated during 24 weeks at matric potentials of –35 vs. –250 mbars. Enhanced turnover of organic amendments and release of plant available nutrients may be possible by further improving air-filled porosity (lower matric potential, i.e. drier soil) or by stimulating the activity of soil microflora and fauna.

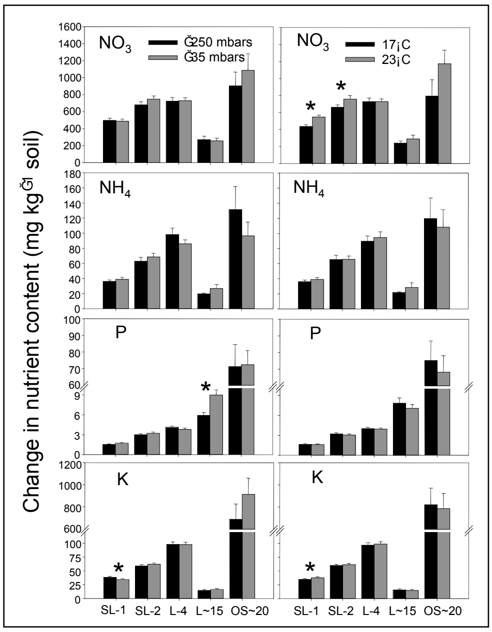

Figure 2: Mean changes (±SE) in nutrient contents of soil samples maintained at two temperature and matric potentials over a 24-wk incubation period

Acknowledgments

We thank le Conseil des recherches en pêche et en agroalimentaire du Québec for its financial support (project no. 405058), and Serres Jardins-Nature, Serres Naturo and Ferme des Ruisseaux for providing soil samples. We are grateful to A. Charles, F. Fournier, C. Halde, M. Karimi Youch, G. Laroche and V. Lavoie for their assistance with soil analysis.

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Plant traits affecting thrips resistance in cabbage

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Keywords: *Brassica oleracea* var *capitata*; *Thrips tabaci*

Abstract

The development of thrips populations and thrips damage in 15 cabbage varieties was monitored in two years of field experiments in the Netherlands.. A number of morphological and physiological plant traits were also measured. The most important factors leading to a low level of thrips damage were late development of a compact head, a low Brix value and a high amount of leaf wax. Two open-pollinated cabbage varieties with low and high susceptibility to thrips damage were crossed in both reciprocal combinations. The resulting F1 populations were intermediate for susceptibility to thrips damage.

Introduction

Cabbage is one of the main field crops grown by organic farmers in the Netherlands. When cabbage is cultivated for storage, it is usually harvested around mid-October. This type of cabbage crop may be severely damaged by thrips (*Thrips tabaci*). Thrips damage can already appear in August, but the thrips population on the plants and the more severe symptoms develop mostly during September and October. Also during cold storage symptoms continue to develop. In conventional cultivation chemical treatments may be used to control thrips damage, but as the insects are protected within the developing head this is not always effective. In organic farming no effective natural crop protection is available.

The damage caused by thrips is due to the symptoms that develop after feeding, which are small callus-like growths (warts) that will turn brownish after some time. Although the presence of the insects themselves, and the direct yield loss due to feeding are not important, the induced symptoms necessitate the removal of the outer leaf layers before marketing. This increases labour costs and reduces marketable yield (North & Shelton, 1986; Fail & Penzes, 2004).

Among modern cabbage varieties, large differences are known to occur in the susceptibility to thrips damage (a.o. Shelton et al, 1983). It is not clear whether these differences are due to resistance (affecting the thrips population in the plant) or to tolerance (affecting the development of symptoms upon thrips feeding). Further, not much is known about plant traits affecting the resistance or tolerance to thrips. This research is aimed at elucidating these points.

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Materials and methods

Plant material and cultivation

In 2005, ten cabbage accessions with varying scores for thrips damage, wax layer, earliness of heading and of maturity were obtained from the Centre of Genetic Resources of the Netherlands (open-pollinated varieties) and from seed companies (F1 hybrids). Seedlings were transplanted to plugs at 2 weeks after sowing and planted in the field at 6 weeks.

In 2006, 13 accessions were grown, including 5 F1 varieties that had not been tested in 2005 and two reciprocal F1 combinations between two OP varieties with high and low susceptibility to thrips damage.

In both years, all accessions were planted end May. In 2005, four accessions were planted also mid-June. The experiments were replicated in two fields, one in Wageningen and one in Zwaagdijk. Both fields were laid out in three blocks, each with one plot per accession/plant date and 45 plants per plot. Cultivation was according to organic farming regulations.

Evaluation of traits, thrips population and damage

At four dates (early August, early and late September, and early or mid-October) three plants per plot were evaluated a.o. for head circumference, leaf thickness, developmental stage, head compactness and leaf wax (visual grading). Heads were halved longitudinally. One half was peeled, the total number of adult thrips were counted, and the thrips damage (affected leaf area and size of warts) graded visually; the three other halves from each plot were pooled and ground, and analyzed for Brix (Atago N-20 refractometer) as an indication of sugar content.

Statistical analysis

Data were transformed where necessary to obtain uniform residual variances. This involved logarithmic transformation of developmental stage and of thrips damage scores; for other traits no transformation was necessary. Next averages (of transformed values if necessary) were calculated per plot. All ANOVA analyses and correlations were based on plot means, and carried out in Genstat 8.

Results and Discussion

Development in time

At the first harvest date in both years, most plants had barely started to form a head. Only a few thrips were found in the entire experiment and no damage was observed. During the next three harvests all heads grew and matured. Differences in maturity and compactness were clearly evident at the earlier harvests but became less pronounced at the last harvests. For leaf thickness and Brix no clear trends were observed. Leaf wax was lower at the first harvest than at the next three harvests.

Effect of planting date

In 2005, four of the accessions were sown and planted at two dates. For developmental stage, size and compactness, large differences between the two planting dates were observed during the earlier harvests, which decreased towards the last harvest date. No clear effects on leaf wax or leaf thickness were observed, while the Brix values were slightly lower in heads from the late planting. The number of thrips was considerably smaller, and the damage slightly smaller in the late planting, with exception of the highly resistant cultivar Galaxy F1 which showed no consistent differences between the planting dates.

Location effects

In each year separately we observed significant differences between the two locations for many of the measured traits, and within the same year these differences were more or less consistent between harvests. For example, in 2005 the cabbages grew and matured faster and became larger at Wageningen than at Zwaagdijk, leaves were thicker and had more wax at Zwaagdijk and thrips damage was generally higher in Wageningen. However, these location differences were not consistent between the two years, indicating that transient effects such as weather and nutrition were more important than the locations themselves.

Genotypic effects

The varieties showed a large variation for all traits studied, as was expected from the selection criteria. Based on earlier observations and information from breeders and growers, the F1-hybrid varieties Slawdena and Bartolo were selected as highly susceptible standards and Galaxy as a resistant standard. These varieties performed as expected, while the other test material showed a full range of responses, at some harvests even extending beyond the susceptible and/or resistant varieties (*e.g.* Figure 1) Thrips population and damage were highly correlated, especially at the two late harvest dates of both years (R ranging from 0.86 to 0.91), in line with the observations of Stoner & Shelton (1986). There were no varieties with a remarkably low damage in relation to the number of thrips, as would be expected if low thrips damage were caused by small plant responses to feeding rather than by reduced thrips population development. This indicates that among the tested accessions, resistance rather than tolerance is the cause of the observed differences in thrips damage.

Correlations between plant traits and thrips damage

Thrips damage and thrips numbers in the last two harvests were positively correlated. Both were also positively correlated with Brix, and with compactness and developmental stage in the first two harvests. This indicates that a cabbage head with tightly packed leaves early in the season leads to higher thrips populations; presumably because the insects are sheltered against predators. These results are at variance with those of Shelton et al (1983) who could not attribute varietal differences in thrips damage to dry-matter quality or to date of maturity. This may be due to the different sets of varieties tested, or to differences in climate or thrips populations between the test locations.

Further, a large amount of leaf surface wax was shown to be negatively correlated with thrips damage and thrips population size, indicating that wax gives some protection against thrips. No relation was found with head size. Contrary to earlier indications from growers, we also found no clear relation between leaf thickness and thrips population or damage.

Inheritance of resistance to thrips damage

Open-pollinated varieties Langendijker Bewaar (resistant) and Bewama (susceptible) were crossed reciprocally, and the two reciprocal F1's were tested together with the parental varieties and st,andards in the 2006 experiments. At the later two harvests, when the thrips damage was well established, and at both locations the two reciprocal

F1's showed thrips damage intermediate between that of the parental varieties (Figure 1). This is in contrast to the results of Stoner et al (1986) who observed dominance for susceptibility. The discrepancy may be due to the different cross combinations and/or to the observation scale. The inheritance will be studied further in an F2 / F3-line population derived from our crosses.

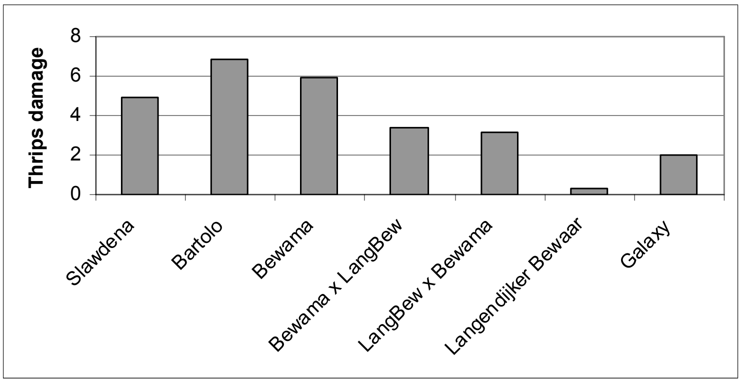

Figure 1. Thrips damage means for two reciprocal F1's between varieties Bewama (susceptible) and Langendijker Bewaar (resistant) in comparison with the parents and standard varieties Slawdena and Bartolo (susceptible) and Galaxy (resistant)

Conclusions

Thrips damage and thrips population size were found to be highly correlated, and no varieties were found with high thrips numbers but low damage. This indicates that resistance rather than tolerance is the dominating factor affecting thrips damage.

Important plant traits that limit thrips damage are the late formation of a compact head, a low dry matter content and a high amount of leaf surface wax.

Highly resistant and susceptible OP varieties were identified. F1's of crosses made between those varieties showed an intermediate level of resistance.

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Increasing Cultivar Diversity of Processing Tomato under Large Scale Organic Production in California

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Key words: cultivar mixtures, plasticity, interaction, cover crop

Abstract

At an organic farm in California, higher plant diversity was hypothesized to enhance ecosystem functions and services. Plant diversity was manipulated temporally and spatially: mustard cover crop vs. no cover crop (fallow) in winter, and mixtures with one (farmer's best choice), three, or five processing tomato cultivars in summer. Soil N, soil microbial biomass, crop nutrient uptake, canopy light interception, disease, GHG emissions and biomass were measured. Results show that the mustard cover crop reduced soil nitrate (NO_3^-) in winter and also during the tomato crop, which was associated with decreased growth and canopy development. All cultivar mixtures had fairly similar yield and shoot biomass. The 'choice cultivar' (i.e. farmer's best choice) showed plasticity depending on the mixture, tending to have higher biomass production in mixtures. This study shows the complexity of cultivar-mixture interactions. To achieve the greatest benefit for ecosystem functions in organic farming, mixtures require greater understanding of cultivar plasticity and phenological and physiological trait diversity.

Introduction

Cultivar mixtures have been studied primarily for increasing yields (Burton et al., 1992) and disease control (Mundt, 2002), but other ecological processes have not been adequately evaluated. Cultivar mixtures may potentially provide a strong benefit for ecosystem functions in organic systems because of their limited management options and dependence on on-farm resources. Interaction among cultivars, and the effects of surrounding environment, may stimulate genotypic responses that could maximize the potential performance of a cultivar.

Mixtures are increasingly important in the framework of sustainable agriculture. Examples include rice in China (Meung et al., 2003), winter wheat in USA (Gallandt et al., 2001), and barley in the German Democratic Republic (Finckh et al., 2000). Even so, difficulties in managing cultivar mixtures can often be overestimated. Cultivar selection for mixtures depends on characteristics such agronomic compatibility, genotypic diversity (Mundt, 2002), high yields, and marketability. The number of genotypes in a cultivar mixture tends to be three (Mundt, 2002).

The central question of this study was: Why choose a cultivar mixture instead of a monoculture in an organic agroecosystem? It was hypothesized that increasing plant diversity may increase ecosystem functioning. A diverse tomato community may better use available nutrients, water and light resources. Some mixtures may perform similarly in different environments (yield stability). Cultivar differences in allocation and

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growth, including plasticity responses in different mixtures, may help to increase resource use and yield stability, and decrease N loss due to complementarities in root system development, depths, and N needs.

The main objectives of this study were: to measure the effects on phenotypic, nutrient uptake, and yield response of a 'choice cultivar' (i.e. farmer's best choice) when interacting in three different tomato communities, and thus on yield stability; to assess the effects of tomato community composition on resource utilization and its response to the surrounding environment, i.e., disease pressure and abiotic stress, using indicator variables; and to examine, at the ecosystem level, the effects of soil N availability on tomato communities.

Materials and methods

Our study involved participatory research with a 14-year organic processing tomato grower at a 44 ha organic certified farm in Yolo County, California (California Certified Organic Farmers http://www.ccof.org/). His main commodities were processing tomatoes and oats as hay, as well as a fall/winter cover crop. Processing tomatoes were grown every other year on alternating fields using conventional tillage, and were furrow irrigated during the processing tomato crop, i.e., spring and summer season.

Two different sets of environmental conditions were established prior to tomato planting: winter fallow and mustard cover crop, i.e., main plot treatments of 16x9 m, each with 6 beds. Three cultivar mixtures as subplot treatments of 5x9 m with 6 beds utilized processing tomato cultivars that had the following characteristics: high yielding and currently marketable, grown commercially with similar amounts and timing of inputs, mid-maturity varieties, i.e., ~125 days from planting to harvest, and fruit quality that met industry standards. Subplot treatments consisted of the 'choice cultivar' grown by the farmer in the entire field (1 cv); a mixture of the 'choice cultivar' plus two more cultivars used by the same farmer on other of his fields (3 cv); and these three cultivars plus two more that were currently used by other organic growers in California for a total of 5 cultivars (5 cv). A completely randomized block design with a split-plot treatment structure was used. A total of eight blocks were established.

Soil sampling and measurements were as follows. Nitrate (NO_3^-) and ammonium (NH_4^+) by KCl extractions of field moist soil at three depths (0-15, 15-30 and 30-60 cm). Microbial biomass carbon (MBC) was analyzed for the 0-15 and 15-30 cm depths using the fumigation extraction method (Vance et al., 1987). Carbon dioxide (CO_2) and nitrous oxide (N_2O) gas emissions were sampled on the bed shoulder after irrigation events using closed, capped chambers for 30 min (Rolston, 1986). Biomass samplings for shoots and fruits of individual plants for the 'choice cultivar' and for the cultivar mixtures were done throughout the season. These samples were analyzed for N content by C/N combustion. Measurements of canopy light interception using a portable tube solarimeter with sensors for photosynthetically active radiation (PAR) and disease evaluation for *Sclerotium rolfsii* (Southern blight) were also performed intermittently.

Results

Yields were similar for all tomato cultivar treatments within each of the two winter treatments, with and without a cover crop. The vegetative growth of all cultivar mixtures performed better in winter fallow plots, e.g., canopy light interception and aboveground biomass were higher. Total N uptake (g N m^{-2}) tended to be lower in the winter mustard plots, and did not differ between cultivar mixtures and the 'choice cultivar' (Table 1). Plants lost to disease tended to be higher in winter mustard plots.

The ‘choice cultivar' (farmer’s best choice) had higher biomass productivity when in mixtures of 3 or 5 cultivars, at mid-season and in the N-limited winter mustard plots, e.g., its shoot and fruit biomass was highest in the 3 cv mixture at 75 DAP in the winter mustard plots. By the end of the season, however, similar yields for harvestable tomatoes were found in the 'choice cultivar' in the three tomato mixtures.

Inorganic N was more available in winter fallow plots. The winter mustard cover crop decreased N availability from prior to cover crop incorporation through tomato harvest, and it generally increased soil microbial biomass (significant only at 7 days after planting (DAP), suggesting higher microbial activity. CO_2 and N_2O emissions were generally similar in the tomato cultivar treatments, but CO_2 emissions were initially higher in the winter mustard plots. CO_2 emissions in the fallow plot were higher for the monoculture in the last two spot samplings, and N_2O emissions were variable with a tendency of the 5 cv mixture to be higher in winter fallow plots.

Tab. 1. Light interception, aboveground biomass, harvest index and N uptake at early and mid crop season and harvest time for processing tomato mixtures in California. Data shown for cover crop mainplots and cultivar mixtures (cv).

DAP^	Variables	Cover crop treatment		Winter fallow plots			Winter mustard plots		
		Fallow *	Mustard	1cv	3cv	5cv	1cv	3cv	5cv
35 DAP	PAR** intercepted (%)	19.54 ± 1.05 a	15.27 ± 0.94 b	21.56 ± 1.20	18.51 ± 1.85	18.55 ± 2.25	15.47 ± 1.89	14.88 ± 1.50	15.47 ± 1.68
69 DAP	PAR intercepted (%)	45.64 ± 1.04 a	38.52 ± 1.34 b	46.07 ± 1.43	45.63 ± 2.18	45.20 ± 1.96	38.75 ± 1.54	39.86 ± 2.65	36.93 ± 2.76
95 DAP	PAR intercepted (%)	46.83 ± 1.18 a	42.57 ± 1.26 b	48.05 ± 2.61	46.38 ± 1.61	46.07 ± 2.00	45.05 ± 1.88 x	39.99 ± 2.23 y	42.67 ± 2.29 xy
39 DAP	Shoot biomass (g m $^{-2}$)	70.43 ± 6.82	53.83 ± 4.71	71.61 ± 9.80	73.98 ± 11.60	65.69 ± 16.41	68.12 ± 3.76 x	48.97 ± 8.49 xy	44.39 ± 7.21 y
75 DAP	Shoot biomass (g m $^{-2}$)	245.68 ± 17.42	275.38 ± 19.74	251.00 ± 21.15	249.80 ± 42.01	236.30 ± 32.86	222.11 ± 35.10 x	323.86 ± 27.00 y	280.17 ± 24.28 xy
111 DAP	Shoot biomass (g m $^{-2}$)	293.62 ± 9.25	273.75 ± 13.16	274.04 ± 17.37	292.02 ± 15.04	310.55 ± 14.33	302.44 ± 29.23	262.06 ± 21.95	256.77 ± 13.88
75 DAP	Fruit biomass (g m $^{-2}$)	122.20 ± 12.55	126.31 ± 13.78	135.57 ± 22.62	123.43 ± 16.15	107.59 ± 28.77	99.96 ± 23.15 x	163.04 ± 28.14 y	115.93 ± 6.60 xy
111 DAP	Total fruit (g m $^{-2}$)	351.86 ± 15.36 a	251.94 ± 15.12 b	365.84 ± 29.75	351.84 ± 23.77	337.89 ± 28.65	269.49 ± 35.61	233.99 ± 18.64	252.33 ± 23.40
111 DAP	Harvestable fruit (g m^{-2})	234.45 ± 14.75 a	161.98 ± 15.56 b	240.75 ± 26.06	232.80 ± 26.90	229.81 ± 27.06	185.68 ± 38.69	146.77 ± 20.08	153.49 ± 19.03
111 DAP	Harvest index	0.36 ± 0.02 a	0.30 ± 0.01 b	0.37 ± 0.03	0.37 ± 0.02	0.35 ± 0.03	0.31 ± 0.04	0.29 ± 0.02	0.30 ± 0.02
111 DAP	Aboveground N (g N m^{-2})	11.53 ± 0.38	9.57 ± 0.38	11.56 ± 0.71	11.86 ± 0.61	11.19 ± 0.81	9.83 ± 0.70	9.06 ± 0.83	9.82 ± 0.52

^ Days after transplanting; ** PAR, photosynthetically active radiation; * Different letters indicate statistical differences using the Tukey test.

Discussion

Cultivar mixtures showed little difference compared to the 'choice cultivar' alone, in terms of any of the variables that were measured: yield, vegetative biomass, canopy light interception, and disease. These results imply that the cultivars are fairly similar in terms of response to abiotic and biotic environmental conditions. In fact, the breeding lines for processing tomatoes in California are from the same genetic stocks, and have specific genes that adapt them to the machine harvest of processing tomatoes, e.g., similarly early flowering times, determinate growth, and compact canopies (Jones et al., 2007). Breeding programs in California have developed cultivars that are high performers as monocultures, and thus have selected the highest yielding cultivar rather than the best cultivar mixture. Results suggest potential benefits if mixtures are formed with cultivars that complement and maximize their performance when interacting with each other, e.g., the grower’s ‘choice cultivar’ showed early benefits in vegetative growth in mixtures. Overall mixture productivity might increase if environmental stress had been greater.

The winter mustard cover crop did not benefit tomato production and decreased N availability, probably because of the high microbial activity that immobilized N early in the tomato growing season. While N leaching potential was reduced, this came at the cost of lowered productivity. Also the late, rainy spring forced the grower to delay the incorporation of the winter mustard crop, and the maturity of the plants may have been a factor in increasing N immobilization potential.

Conclusions

Cultivar interactions, their complementarity or competitiveness in a mixture, may potentially provide benefits for ecosystem functions on organic farms. Cultivars of such a mixture would likely perform better in a mixture than in monoculture. In such a situation, cultivars would be expected to have greater trait variation than is presently found in mainstream California processing tomatoes. In addition, phenological and physiological trait diversity of a cultivar mixture must be incorporated into management practices, e.g., nutrient management, irrigation, and harvest time. This study shows the difficulty of grouping together a set of cultivars that as a mixture can enhance ecosystem functions and benefit organic systems. Improving mixtures for multifunctional benefits will require better understanding of functional traits (Balvanera et al., 2006), and testing many combinations of diverse assemblages, so that the highest yielding mixture can be selected in comparison to the highest yielding monoculture (Cardinale et al., 2006).

Acknowledgments

This research was supported by USDA OERI grant 2004-51106-02242 to L. Jackson.

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Plant breeding

Possibilities for breeding to improve responsiveness to arbuscular mycorrhizal fungi in onion

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Key words: Onion, *Allium cepa* L., arbuscular mycorrhizal fungi, low input farming, *Allium fistulosum, Allium roylei*

Abstract

Arbuscular mycorrhizal fungi (AMF) play an important role in the uptake of nutrients and water from soil. However, some crops, for example onion, Allium cepa L., have a poorly developed root system. As a result, onion plants need a lot of fertiliser for growth, and they are sensitive to drought. The aim of this project is to study the beneficial effects of mycorrhizal fungi on the growth and development of Allium species and to determine whether it is possible to improve onions for mycorrhizal responsiveness by breeding. Variation among Allium species indicated that selection and thus breeding for high responsiveness to AMF is possible. Two years of experiments with genotypes of a population segregating for mycorrhiza responsiveness indicated that increase in dry matter may be a more reliable trait than responsiveness.

Introduction

Arbuscular mycorrhizal fungi (AMF) are fungi that occur naturally in soil. They play an important role in plant growth since they contribute to the uptake of nutrients and water from soils (Ryan and Graham, 2002). Onion (*Allium cepa* L.) is an important vegetable crop worldwide, but one of the major challenges in onion cultivation is to provide the plants with sufficient nutrients (Brewster, 1994). Large amounts of fertiliser are needed, but, because of the poorly developed root system (Portas, 1973), much of the applied nutrient is not used. For low-input systems, plants have to be good nutrient scavengers. Therefore, productivity and stability of onion production in such systems can be particularly problematic (Greenwood et al, 1982).

Two ways were studied to improve the uptake of water and nutrients in onions. The first was to improve the root system. A wild relative of onion, *Allium fistulosum* L., is known for its extensive root system. Genes from *A. fistulosum* can be introgressed into onion germplasm via a bridge cross with *Allium roylei* (Khrustaleva & Kik 2000). De Melo (2003) used this population to study the genetic basis of the root system of *A. fistulosum* and concluded that it should be relatively easy to improve the root system of onion through breeding. A second and complementary approach is the use of arbuscular mycorrhizal fungi (AMF). From earlier studies, it is known that onion plants can associate with AMF (Stribley, 1990; Charron et al., 2001). For example, the application of AMF in greenhouse experiments using organically managed soils

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resulted in yield increases of *Allium fistulosum* between 50 and 60% and a comparable increase in number of stem born roots (De Melo, 2003).

The aim of the present research was to study the beneficial effects of arbuscular mycorrhizal fungi on the growth and development of *Allium* species, and to determine whether it is possible to improve onions for mycorrhizal responsiveness by means of breeding.

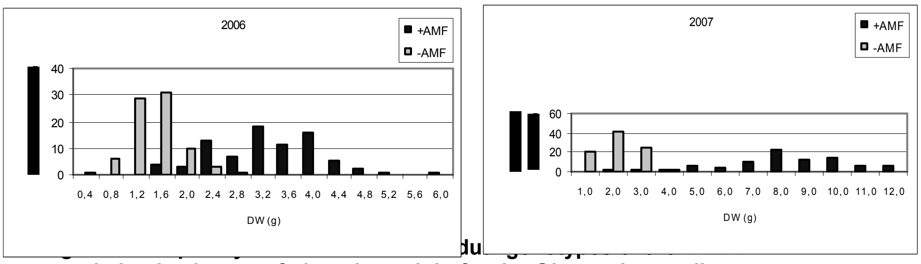
Materials and methods

A tri-hybrid population was developed as described by Khrustaleva and Kik (1998). First, *Allium roylei* (RR) was crossed to *A. fistulosum* (FF). A specific RF genotype was chosen as pollen donor in a cross with onion (CC). Subsequently, a population of *A. cepa x (A. roylei x A. fistulosum)* was built (referred to as CCxRF), each genotype carrying a set of *A. cepa* chromosomes and a set of an *A. roylei - A. fistulosum* combination. AMF species *Glomus intraradices,* was kindly provided by Dr. Y. Kapulnik, Volcani Centre Israel.

Experiments were carried out in 2006 and 2007 in a climate-controlled greenhouse (day/night 22/17 °C), using the population, the parental species and the RF-hybrid. Each genotype was multiplied vegetatively, and transferred to individual pots containing a mixture of sterilized clay soil, sand and perlite (6:1:1, v/v/v). AMF was added to the plant hole just before transplanting. Per genotype, six replications were used with AMF (treated plants) and six with sterilized AMF (control plants, NM). After five weeks, AMF-colonization was quantified using the grid method (Brundrett *et al.* 1996). Colonization ranged from 30-40% in the AMF treatment, and no mycorrhiza was observed in roots of control plants. Plants were harvested thirteen weeks after transplantation. During their growth, and also at harvest, several characteristics of the plants were measured, including total fresh and dry weight, and their partitioning into leaves, bulb or stem, and roots. The number of leaves, stems, and roots was also recorded, as well as plant height. AMF responsiveness was calculated as the increase in plant height or weight compared to the non-mycorrhiza treatment: $(W_{AMF} - W_{NM})/W_{NM} * 100$. Responsiveness was considered significant when the AMF and control treatment were statistically different ($p<0.05$). In this paper only results for plant dry weight are considered.

Results and Discussion

AMF had a significant effect on plant dry weight of the tri-hybrid population (Figure 1). In 2006, the dry weight of the non-mycorrhizal control varied between 0.4 and 2.8 g per plant, whereas plants with mycorrhiza had weights up to 6 g. In 2007, weights were higher. Control plants had weights up to 5 g, whereas the mycorrhiza-inoculated plants weighted up to 12 g. The frequency distribution of individual genotypes of the tri-hybrid population for their responsiveness to AMF with respect to dry weight, demonstrated variation, from plants that had no or little response to AMF, to plants that responded to 400 % in 2006 and even >1000% in 2007 (Figure 2).



population in classes of plant dry weight for the *Glomus intraradices* treatment (AMF) and the control.

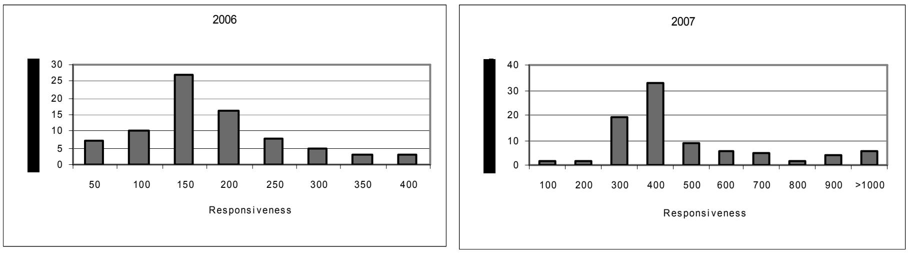


Figure 2: Frequency distribution of responsiveness of individual genotypes of the CCxRF population in plant dry weight to *Glomus intraradices* (see text for calculation).

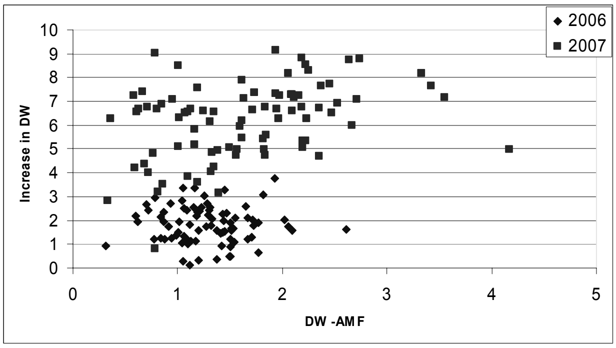


Figure 3: Absolute increase in dry weight in genotypes of a population when grown under AMF compared to the non-mycorrhizal control (DW –AMF).

Examining plant sizes however, it was obvious that responsiveness was influenced largely by the size of the non-inoculated control plants. Variation in soil type and amount of nutrients available will influence the growth of the non-inoculated control plants. We started to question ourselves whether or not selection for high responsiveness (as it is defined now) will result in a situation that is truly ideal for organic farmers: or that a better approach would be first to select plants that perform relatively well under poor conditions and then select plants that profit more from colonisation by AMF than other plants. For that reason, the absolute increase in dry weight of the genotypes was analysed. Results show that there is variation in dry weight among plants grown under mycorrhizal conditions as well as variation in absolute increase in dry weight (Figure 3). This is an indication that not all genotypes respond similarly to the presence of mycorrhizal fungi indicating that selection for absolute response should be possible.

Based on these results, the next step will be the analysis of the genetic basis of reaction to the presence of mycorrhizal fungi in the CCxRF population by QTL mapping. Clarification of the genetic basis may help in identifying onion cultivars more suited for low input farming. In addition, plants will be transplanted into organic fields and grown under high and low input conditions to study both the rooting system and their growth in the field. The reason for this is that we expect to find not only traits to improve the rooting system but also to improve the mycorrhizal responsiveness from the crosses between *A. fistulosum* and onion.

Acknowledgments

This work is funded by the Dutch Ministry of Agriculture, Nature and Food quality as part of Programme 388-II Breeding for Organic Farming. The first author thanks the Alban Programme of the EU, PDT-Uruguay, and the NFP for financial support.

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Response of old, new and organically bred winter wheat cultivars in different farming systems: concept and experimental layout in the DOK field trial

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Key words: Organic farming, organic breeding, winter wheat cultivars, arbuscular mycorrhizal fungi, nutrient acquisition potential

Abstract

Organic farmers often use winter wheat (Triticum aestivum L.) cultivars that have been bred under conventional high-input conditions. We test the hypothesis, whether old and organically bred cultivars are better adapted to low-input conditions through a better functioning of the symbiosis with arbuscular mycorrhizal fungi (AMF). Our aim is to assess the nutrient acquisition potential of old, new and organically bred winter wheat cultivars and to identify the role of AMF for nutrient uptake and growth. In October 2006, an experiment with 10 wheat cultivars was superimposed to all four field replicates of the DOK long-term experiment, comprising four different treatments with increasing nutrient input: unfertilized, biodynamic low and moderate intensity and conventional mineral system. Growth and harvest parameters such as plant density and length, growth habit, plant health, yield and grain quality will be assessed. Shoot and root samples were taken at tillering and flowering to analyse nitrogen and phosphorus content and AMF root colonization. In this paper, the current state of literature findings in the field of organic breeding is summarized and the experimental setup for variety testing in an existing long-term trial is outlined.

Introduction

Organic farmers often use the same wheat cultivars as conventional farmers. Most of these cultivars have been bred under and for high input conditions. In organic farming systems these cultivars cannot perform to the full extent of their high genetic potential because organic soils frequently do not deliver enough nutrients and fertilizers are limited. Better nutrient uptake efficiency would be of great value for organic farms and conventional farms producing under low-input conditions.

Nitrogen (N) and phosphorus (P) are usually the most limiting macro-elements in organic farming. A large part of P in soils is secluded in minerals and organic compounds, or heavily absorbed, and the supply of soil-N by mineralization is limited. The AMF symbiosis can positively influence plant growth and health. AMF are known to be strongly affected by the concentrations of soluble nutrients, specifically P, and plant genotype. This suggests a suppression of the AMF symbiosis with wheat cultivars obtained in selection programmes under high-input conditions. In addition,

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physiology and rooting of such cultivars may be adapted to high soil nutrient content. New cultivars may have a negative influence on AMF root-colonisation due to resistance introduced against fungal root pathogens.

In the current project we will test, whether old and organically bred wheat cultivars are better adapted to low-input conditions than conventionally bred cultivars through a better functioning of the AMF symbiosis. The aim is to assess nutrient acquisition potential and to identify the role of AMF on nutrient uptake and growth.

Review of the Science

Symbiotic relationships of wheat and AMF can play an important role for growth and productivity. There is clear evidence, that AMF colonization is affected by nutrient supply and AMF infection potential of the soil, as it has been shown in pot trials for P (Zhu et al., 2001). Highest values for shoot and root weights of wheat were measured for inoculated treatments in a pot trial with a soil low in P (Rubio et al., 2003). AMF symbiosis can lead to an increased uptake of P by plants. AMF hyphae could contribute up to 50-80% of total plant P-uptake in pot trials with wheat (Li et al., 2006).

AMF occurrence and diversity shows a strong dependence on the land use management. AMF root colonization in the DOK-trial decreased with increasing farming intensity. Colonization was highest in the unfertilized control and 30-60% higher in the organic than in the conventional farming systems. Similar results were found in additional pot experiments with field soils from the DOK-trial (Mäder et al., 2000). The results agree with Covacevich et al. (2007), where AMF colonization was highest in plants receiving no annual P supply compared to plants grown at elevated nutrient levels. Native AMF could contribute considerably to the P-uptake of field grown wheat, even at typical soil fertility levels (Schweiger et al., 1999). Oehl et al. (2003) compared the influence of low-, moderate- and high-input conditions on AMF occurrence and diversity. Numbers of spores were highest under low- and moderate conditions. A shift in the AMF diversity could be shown with highest species numbers in the organic field, which was part of the DOK-trial. Results from the DOK-trial also showed that older wheat varieties might have a higher capacity to take up P: Grains of an old wheat variety had a distinctly higher P-content than grains of two recently released varieties, suggesting wheat x variety x AMF interactions (Mäder et al. 2007).

Wheat yield worldwide increased rapidly, especially during the second half of the last century due to an increased use of chemical fertilizers, and pesticides (Ceccarelli, 1996) and the introduction of semi-dwarf cultivars (Manske et al., 2002). Wheat breeding was targeting the improvement of nutrient use efficiency; especially of N and P. Little is known about the influence of the nutrient level during breeding on the performance of cultivars under low- and high-input conditions. Brancourt-Hulmel et al. (2005) assessed the efficiency of low- *vs.* high-input selection environments to improve wheat for low-input conditions. They concluded, that breeding programmes targeting low-input environments should include low-input selection environments to maximise selection gains. Results in barley could show a genotype x environment interaction. High-yielding lines selected in high-yielding environments showed lower yields on farmers' fields (Ceccarelli et al., 1996). Wheat cultivars differ in their ability to form AMF symbiosis (Hetrick et al., 1995). There is evidence that wheat cultivars bred before 1900 and the beginning of the intensive chemical fertilization were more responsive to AMF than modern cultivars (Hetrick et al., 1992). Hetrick et al. (1996) found a relationship between AMF root colonization and biomass only in responsive wheat cultivars. Average yield of wheat during 21 years was only 20 % lower in the organic systems of the DOK-trial depending on the variety (Mäder et al., 2007). This supports the hypothesis of a cultivar x AMF symbiosis x farming system interaction.

Materials and methods

A field trial experiment with 10 wheat cultivars was performed in the DOK-trial with organic and conventional land use management (Mäder et al., 2002). Two organic systems (BIODYN 1 and 2), a conventional system (CONMIN) and an unfertilized control plot (NOFERT) were included, differing mainly with respect to fertilization strategy and the concept of plant protection management. The organic systems stand for mixed farms with arable land and livestock, CONMIN for a stockless conventional system. Level of fertilization increased gradually from NOFERT to BIODYN 1, BIODYN 2 and CONMIN. This concept may show a correlation between AMF symbiosis and the level of fertilization. The field experiment is designed as a randomized block with four replicates. Wheat cultivars were sown in October 2006.

Winter wheat cultivar experiment in the DOK trial and selected varieties

Ten subplots with winter wheat cultivars were sown in each DOK-plot (5 m x 20 m) in the described four treatments and in all four replicates, resulting in 160 subplots (3 m x 1 m). Plots of BIODYN 1 were adjacent to BIODYN 2, plots of NOFERT adjacent to CONMIN. Cultivars were sown marginal in each plot, with five subplots at the inner and the outer side, with a border of 0.50 m between two cultivars. Sowing density was 420 seeds m^{-2} according to the usual local level. Cultivars with different breeding history were chosen for the field trial:

- Old cultivars: Rouge de Bordeaux (France, 1840), Mont Calme 245 (Switzerland, 1926), Probus (Switzerland, 1948)
- Conventionally bred cultivars: Titlis (Switzerland, 1996), Antonius (Austria, 2003), Caphorn, (France, 2001), DI 9714 (France, not registered)
- Organically bred cultivars: Scaro (Switzerland, 2006), Sandomir (Germany, not registered, Composite Cross Population (Great Britain, not registered)

Except for the composite cross population (CCP), they had to be of bread wheat quality and suitable for the growing conditions in Therwil (Basel, Switzerland). By including four Swiss cultivars (one in each breeding group) it will be possible to trace the development of cultivars with a similar genetic background, adapted to the local conditions in Switzerland during the last century. The field experiment aims to observe different agronomic growth and harvest parameters, nutrient uptake and the occurrence of AMF symbiosis during the growing season. At the beginning of the experiment, soil parameters were analysed and the number of AMF spores were counted. Samples of roots (soil core Ø 4 cm, 20 cm deep) and shoots were taken at tillering and flowering to measure nutrient uptake and for AMF assessments. During the growing season plant density was counted, plant length measured, plant growth stages, pests and diseases were recorded. Harvest took place at the end of July. We are now working on the analysis of the harvest samples: Yield of grain and straw, thousand seed weight and hectolitre weight will be measured. Additional following quality parameters of the grain will be measured: falling number, quantity and quality of protein (Zeleny). Furthermore we will analyse macro-and micro-nutrients in shoots, grain and straw to trace the relocation of nutrients. Analysis of harvest parameters showed the same ranking of yields for all varieties and treatments, whereby conventionally bred varieties had the highest yields. No statistical interaction between varieties x treatments was found (2-way ANOVA). On the meeting we will present agronomic performance of the varieties and selected quality parameters.

Acknowledgments

This study is financially supported by COST Switzerland (COST-Action 860; SUSVAR: Sustainable low-input cereal production: required varietal characteristics and crop diversity).

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Does regional organic screening and breeding make sense? Experimental evidence from organic outdoor tomato breeding

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Key words: Organic breeding, tomato, *Phytophthora infestans*

Abstract

Does regional organic screening and breeding make sense? To answer this question we looked for experimental evidence in an organic outdoor tomato project. Potentially suitable varieties were collected, genotype x environment interactions were investigated and selection was carried out within three crosses at three farms in Central and Northern Germany. The resulting selections were compared at all farms. Screening within organic horticulture was the most important means of finding suitable varieties. After three years of evaluation, 71% of the 18 most successful varieties came from colleagues within organic horticulture. The analysis of the regional evaluation did not reveal strong interactions of varieties and locations. The rate of Phytophthora *(late blight) fruit infections significantly depended on the year, thus stressing the need for long-term evaluation. Site specific adaptation was partially observed for late blight infections and for yield. The main advantage of multilocational selection, however, was to make use of the selection potential at each farm. At Rhauderfehn, the farm with the highest level of* Phytophthora *infections, selection led to reduced fruit infection and extended harvest period. Selection at Ellingerode resulted in the highest yield. We recommend multilocational breeding approaches with frequent exchange of breeding material and data.*

Introduction

Within the organic agriculture movement, we are facing both chance and challenge to develop breeding approaches that are particularly suited for organic systems. Breeding for adaptation to site specific conditions on-farm or in-garden is the most discussed issue. It does present an alternative to breeding for general adaptation in breeding stations. Integrated in an organic outdoor tomato breeding project, we have chosen three approaches to answer the initial question. 1) We collected and evaluated potentially suitable varieties. 2) Genotype x environment interactions were investigated in the regional evaluation. 3) Selection was carried out within three crosses at three farms, and the resulting selections were compared.

On a global scale, tomato (*Lycopersicon esculentum* Mill.) is the most important vegetable (FAO 2007). In many areas production is limited by late blight (*Phytophthora infestans*) infections, particularly so in organic outdoor cropping.

Materials and methods

Regional evaluation was based on 3500 accessions. In close contact with genebanks, NGOs, seed trade and private seed savers, 92 varieties were selected for comparative trials at three organic farms in central and northwestern Germany. The number of va-

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rieties was reduced during 2003 to 2006. Some additional varieties with superior performance in a screening at one farm were included. Two replications with two plants (2006: 3x2) were grown per location. Layout and maintenance of the plots favoured *Phytophthora*-infections.

At the same farms selection for yield and *Phytophthora* field resistance was carried out within three crosses. In 2004 20 F5-progenies Celsior x Matina with 2x2 plants, 9 F3-progenies Golden Currant x Matina with 5 plants and 30 F2-plants Rote Murmel x Campari F1 were grown at each location. 3 to 11 individual plants per cross were selected. For the latter two crosses, selection was repeated in 2005. The comparison of all selections was carried out at each farm in three replications with two plants. Analysis of variance was calculated with PLABSTAT Version 2n (Utz 1997).

Results

In 2005, after two years of evaluation, 88% of the remaining 33 varieties had been provided by non-commercial sources, i.e. genebanks, NGOs and private seed savers. 71% of the most successful 18 varieties in the final year 2006 were originally maintained and recommended by seed savers and NGOs within organic horticulture.

In the regional evaluation, the varieties were the most important variance component for all traits (Table 1). Site specific adaptation, i.e. variety x location interaction, was of minor importance or absent. For fruit infection variety x year interactions were larger than variety x location interactions. Generally threefold interactions were high. The high heritability of *Phytophthora*-infections on leaves and fruits, and for yield confirmed the suitability of the experimental design.

Tab. 1: Variance components for late blight infections and yield

Years	Number of varieties	Variance components				Heritability
		Varieties	Varieties x Locations	Varieties x Years	Varieties x Locations x Years	
Leaf infection [1]						
2003-2004	44	1051**	0	266.8**	1053**	86.61
2003-2005	22	1588**	57.02	224.6**	605.0**	94.31
2003-2006	10	1772**	146.8*	76.85	629.5 [2]	96.11
2005-2006	17	1993**	206.3*	49.32	373.8 [2]	95.82
Fruit infection [1]						
2003-2004	44	969.8**	0	354.9**	1291**	81.74
2003-2005	22	1512**	74.31	653.9**	708.5**	85.86
2003-2006	10	784.7**	84.41+	429.4**	481.1 [2]	84.18
2005-2006	17	1284**	77.12	734.1**	483.4 [2]	74.15
Yield per plant in g						
2005-2006	17	73574**	0	0	186407 [2]	79.04

0 indicates negative estimates
1) Area under disease progressive curve
2) The estimate includes a part of the error and was not tested for significance
+, *, ** significant at the 0.10, 0.05, 0.01 probability level

Tab. 2: Influence of the selection site on the performance of three crosses at three farms

Test site	Selection site Schönhagen	Ellingerode	Rhauderfehn	Mean
Late blight leaf infection [1]				
Schönhagen	151.0	146.9	147.8	148.6
Ellingerode	151.1	143.4	163.2	152.6
Rhauderfehn	224.4	203.4	200.3	209.4
Mean	175.5	164.6	170.4	
Late blight fruit infection [1]				
Schönhagen	69.7	61.9	60.6	64.1
Ellingerode	74.5	71.3	72.3	72.7
Rhauderfehn	234.8	220.8	216.4	224.0
Mean	126.3	118.0	116.4	
Yield per plant until 15.10. in g				
Schönhagen	1227	1316	962	1168
Ellingerode	1718	2115	1491	1775
Rhauderfehn	560	648	574	594
Mean	1168	1360	1009	
Harvest period in days				
Schönhagen	71.6	73.7	75.1	73.5
Ellingerode	67.7	68.3	69.6	68.5
Rhauderfehn	46.7	47.6	52.6	49.0
Mean	62.0	63.2	65.8	

[1] Area under disease progressive curve

The selection Schönhagen suffered the heaviest infections with late blight (Table 2). Selection at Rhauderfehn led to the lowest level of fruit infections. Concerning both leaf and fruit infections the selections Ellingerode and Rhauderfehn revealed the best performance at their site of selection. Mean yield results were best for the selection Ellingerode. Selection at Rhauderfehn resulted in an extended harvest period. Site specific adaptation for yield was observed for one of the crosses (Table 3). The selections Schönhagen and Ellingerode of Golden Currant x Matina yielded best at their site of selection. Relative performance of the selection Rhauderfehn was improved at Rhauderfehn, but was outyielded by the selection Ellingerode. The test sites were characterized by a different yield level and different yield dynamics. Due to heavier infections with late blight, yield was reduced at Rhauderfehn and yield after 15.9. was very low.

Discussion and Conclusions

Screening within organic horticulture was the most important means to find suitable varieties. Observations in practical organic crop husbandry can be of major significance in the selection of genotypes for an organic breeding program.

The analysis of the regional evaluation did not reveal strong interactions of varieties and locations compared to genetic variance. We have to bear in mind, that the variation between the varieties included in the experiment was high. The data indicated that the ranking of varieties according to yield and late blight field resistance was basically the same at all locations. *Phytophthora* fruit infections depended significantly on the year, thus stressing the need for long-term evaluation.

Tab. 3: Influence of the selection site on the yield of Golden Currant x Matina at three farms

	Selection site			
Test site	Schönhagen	Ellingerode	Rhauderfehn	Mean
Yield per plant until 15.9. in g				
Schönhagen	677	576	393	549
Ellingerode	1024	1164	729	972
Rhauderfehn	848	1004	853	902
Mean	849	915	658	
Yield per plant until 15.10. in g				
Schönhagen	1697	1571	1225	1498
Ellingerode	2475	2920	1884	2426
Rhauderfehn	1019	1095	1037	1050
Mean	1730	1862	1382	

Divergent evolution of populations at different selection sites is a known phenomenon (Goldringer et al. 1998). We know that selection on farm can lead to site specific adaptation (Horneburg and Becker 2008), but experimental evidence is scarce. In the experiment presented here, specific adaptation was partially observed for late blight infections and for yield. The main advantage of multilocational selection, however, was the use of the selection potential at each farm. At Rhauder-fehn selection led to reduced fruit infection and extended harvest period, while selection at Ellingerode resulted in the highest yield. As a conclusion, we recommend multilocational breeding approaches with frequent exchange of breeding material and data.

Acknowledgments

Many thanks to the Rut- and Klaus-Bahlsen Foundation, the German Federal Organic Farming Scheme and our colleagues on farm!

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Organic wheat breeding

Wheat populations: population performance and stability in organic and non-organic environments

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Key words: winter wheat, organic, non-organic, mixtures, yield stability, populations

Abstract

Twenty winter wheat varieties were used as parents in a half diallel crossing programme for the production of wheat populations and physical mixtures that were then grown in field trials at two non-organic and two organic sites over three years in England. Yields of the populations and mixtures were compared with those of the relevant varieties grown as pure stands. In general, there was an improvement in yielding ability in the populations which was achieved while maintaining a high level of stability across environments. Potential improvements through selection or introduction of broader based populations are discussed.

Introduction

Rapidly increasing global climate change will amplify variability in crop performance unpredictably in all types of farming. Options for dealing with such changes will be limited by the increasing costs of oil-based inputs, both fuel and chemicals. For these reasons, we started a programme of population breeding in wheat based on Suneson's (1956) 'evolutionary breeding' in barley (Phillips & Wolfe, 2005; see also Goldringer *et al.,* 2006). The principle is to inter-cross in all combinations a number of varieties with different useful characteristics to generate a complex segregating population. This is then exposed to natural selection at field sites to allow adaptation. The objective is to generate a reservoir of genetic variation that can buffer the population against a wide range of environmental variation, more than would be possible in pedigree line varieties, or physical mixtures based on single genotypes.

The programme is based on twenty parent varieties that have expressed high yield and/or quality potential over many years and large areas, or that have contributed significantly to the pedigrees of such varieties. Field trials from 2004 to 2007 generated data on the performance of the varieties, their mixtures and their populations. Here, we summarise some key points concerning the performance of the populations and mixtures; the performance of the parents is considered in a second paper (Jones *et al.,* this Conference).

Materials and methods

The F2 progeny from the original crosses were divided into three groups, Yield (Y), Quality (Q) and Yield/Quality (YQ), with a further set that included hybrids with four naturally-occurring male sterile genotypes. The Yield populations were based on the nine varieties, Bezostaya, Buchan, Claire, Deben, HTL (High Tiller Line), Norman, Option, Tanker and Wembley. The Quality populations were based on the twelve varieties, Bezostaya, Cadenza, Hereward, Maris Widgeon, Mercia, Monopol, Pastiche,

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Renan, Renesansa, Soissons, Spark and Thatcher. The Yield/Quality populations contained the progeny from all crosses. Controls were provided by the parent varieties and by physical mixtures of the relevant parents. The variety Norman was excluded from the data because of seed stock problems. The populations, mixtures and parents were planted in randomised block field trials in the autumn of 2004, 2005 and 2006 at four sites in England. The sites comprised two organic (Sheepdrove, Berkshire and Wakelyns, Suffolk) and two non-organic (Metfield, Suffolk and Morley, Norfolk) sites. Each subsequent season, seed was harvested from the populations and mixtures and re-sown. In addition, population samples were switched between sites each year to increase the selection on them.

Assessments were made on a range of characters. Here, we report only on yield behaviour. Initial data analysis used univariate statistical methods to observe some of the patterns. Later analysis made use of the AMMI approach (Additive Main effects and Multiplicative Interactions; Ebdon and Gauch, 2002) with biplots.

Results

Performances of the populations, without or with male sterility, and the mixtures were compared with the relevant parent varieties both for yield and yield stability (Table 1).

Tab. 1: Yields of the Y, Q and YQ populations, without or with male sterility, and the mixtures, relative to the appropriate parent means. Values of less than 3% above or below 100 are unlikely to be significant.

	Non-Organic			Organic		
	Y	Q	YQ	Y	Q	YQ
Population	103	103	101	102	103	109
Population with male sterility	101	99	100	107	105	104
Mixture	105	104	103	100	105	105

Although the yield gains from the populations and mixtures are relatively modest for the three years, they are consistent, with the larger gains tending to occur under organic conditions, as expected. A further trend, which requires confirmation, is that under non-organic conditions, the mixtures tended to perform slightly better than the populations. This was reversed under organic conditions, with useful gains more evident from the populations. We assume that this difference under organic conditions was due to the greater genetic diversity in the populations compared with the mixtures. Under non-organic conditions, it may be that the amount of genetic variation in the populations is excessive in the sense that many genotypes fail to make a positive contribution in the controlled and more limited non-organic environment. From the initial AMMI (Additive Main effects and Multiplicative Interactions) analyses of the yield data, it was also encouraging to find from the IPCA-1 scores, that the populations and mixtures tended to show values close to zero, indicating that the recorded yield values were stable relative to the pure line varieties. One exception was the Q set under organic conditions, in which the populations and mixture had closely similar but relatively high scores. In 5 out of 6 comparisons, the populations showed greater stability than the mixtures, as expected, with the populations without male sterility having the most consistently low scores.

Tab. 2: IPCA-1 scores of the Y, Q and YQ populations, without or with male sterility, and the physical mixtures, relative to the appropriate parent means. The closer the score is to 0.0, the more stable the performance.

	Non-organic			Organic		
	Y	Q	YQ	Y	Q	YQ
Population	0.39	0.09	0.02	-0.07	0.47	0.04
Population with male sterility	0.21	0.21	-0.03	-0.23	0.4	-0.08
Mixture	0.16	-0.15	-0.05	0.45	0.49	0.5

Under non-organic conditions, the yields of the YQ populations and mixture were intermediate between those of the Y group (highest) and the Q group (lowest), as expected. Interestingly, under organic conditions, the yields of the YQ populations and mixture were equal to those of the Y group, which may have been due to greater buffering capacity in the YQ material. This was also reflected in a general tendency for the YQ group to be more stable than both the Y and Q groups.

It had been expected that over the three years of trials (F4 - F6) there would have been a trend in population performance either in terms of yield or yield stability. From the data analysed so far, however, there is no such evidence: population advantage in yield and stability appears to be similar in each year. Some time-related trend was expected also for the mixtures since the seed for each year came from the mixture harvested at the end of the previous season, but, again, there was no obvious effect.

One important trend arose from population samples of YQ which were exchanged between sites at the end of each year. Populations were either exchanged between sites within a farming system (organic or non-organic), or between farming systems. Where the exchange involved different farming systems, there was no change in yield in either direction. However, when populations were exchanged within a system there was a trend towards increasing yield in all cases. Within non-organic systems the yield increased either from 92% to 103% of the parent mean after three years or from 100% to 107%. Within organic systems, the yield increased either from 96% to 107% of the control or from 99% to 129%.

Discussion

In broad terms, the trials confirmed the hypothesis that composite cross populations of a range of wheat varieties, together with mixtures of the same varieties, should perform at least as well if not better than the means of the varieties involved, grown as pure stands. In practice there was a consistent improvement in yield, particularly for populations that were exposed to more than one site within a farming system. Furthermore, the mixtures and particularly the populations were stable in performance, tracking the yields of the relevant parent means. In other words, for the risk averse farmer (and particularly the organic farmer), the use of these populations and mixtures presents a more practical and safe strategy than growing the whole range of parent varieties. Furthermore, such a strategy would be as good as growing pure stands of a more limited range of the parent varieties chosen for their higher average, but often less stable, yields.

However, this raises several questions. First, what happens if the future includes greater environmental variation? In our view, the populations would still provide the best strategy for risk avoidance, based on their inherent genetic variation and their observed performance when grown at different sites. This is confirmed from the observation that a sample of the YQ population grown in Hungary produced a low yield in that first year because the severe winter conditions killed a considerable number of plants. However, the survivors were planted again in Hungary in the following autumn and yielded significantly more than local control varieties.

A second question relates to the detailed management of the populations. So far, they have not been subjected to any form of human selection. This will change from 2008 with a comparison of the effects of no direct selection versus hand selection against 'poor' genotypes versus mass selection against excessive height and small grains. Whether or not such 'interference' proves disadvantageous will probably depend on the severity of the applied selection rather than the particular form of selection.

A third question relates to the range of characteristics currently available in the populations. The parents used represent a wide range of successful genotypes from the Atlantic coast region of Europe. However, these genotypes gained their success over what will soon be recognised as a narrow range of environments as climate change develops. For the long term, we believe it is necessary to develop populations based on much wider genetic variation. In this context Kovacs (pers. comm.) suggests developing new lines of the parents and relatives of bread wheat which could then be inter-crossed to produce 'new' species and lines to form novel composite crosses. In our view, this approach merits serious consideration.

Conclusions

Field trials over three years under non-organic and organic farming systems enabled comparisons to be made of the performance of composite cross populations based on inter-crosses of high yield or high quality parents, or on all parents, against the appropriate mixtures and the parents grown as pure stands. The results so far indicate a satisfactory performance of the populations in terms of both yield and yield stability. The material should now be subjected both to directed selection and to a wider range of test environments to verify their potential ability to buffer the wheat crop against large variations in the growing environment.

Acknowledgments

Thanks to Defra, John Innes Centre and our collaborating farmers.

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Wheat populations: parental performance and stability in organic and non-organic environments

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Key words: winter wheat, organic, non-organic, yield stability, populations

Abstract

Twenty winter wheat varieties used as parents in a half diallel crossing programme for the production of wheat populations were grown in field trials at two organic and two non-organic sites over three years in England. Yields of the varieties between the two non-organic sites were highly correlated, but less so between the two organic sites and between the non-organic and organic sites. At the non-organic sites, most of the variation in yield (60%) was due to varietal differences, whereas, at the organic sites, it was due largely to the effects of environment (79%), and genotypic variation only accounted for 9%. More detailed analysis, using AMMI (Additive Main effects and Multiplicative Interaction), allowed stricter comparisons among individual varieties. With the exception of the variety Deben, different varieties performed well in terms of yield and stability in the two systems. In particular, Tanker performed well in the non-organic trials, but was below average under organic conditions, whereas Renan gave the reverse response. The results indicate the importance of specific trials for non-organic and organic variety performance evaluation.

Introduction

The rapidly increasing impact of global climate change will amplify variability in crop performance unpredictably in all types of farming. Options for dealing with such changes will be limited by the increasing costs of oil-based inputs; both fuel and chemicals.

For these reasons, we started a programme of population breeding in wheat based on Suneson's (1956) 'evolutionary breeding' in barley (Phillips & Wolfe, 2005). The principle is to inter-cross, in all combinations, a number of varieties with different useful characteristics so as to generate a complex segregating population. The population is then exposed to natural selection at field sites to allow adaptation. The objective is to generate a reservoir of genetic variation that can buffer the population against a wide range of environmental variation, more than would be possible in pedigree line varieties, or, indeed, physical mixtures based on single genotypes.

The programme is based on twenty parent varieties that have expressed high yield and/or quality potential over many years and large areas, or that have contributed significantly to the pedigrees of such varieties. Field trials from 2004 to 2007 generated data on the performance of the varieties, their mixtures and their populations. Here, we summarise some key points concerning the performance of the parents; this will be considered in relation to the mixtures and populations in a second paper (Wolfe et al., this conference).

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Materials and methods

The twenty winter wheat varieties were considered in three groups, Yield, Quality and Yield/Quality, corresponding to the three populations, Y, Q and YQ. The Yield group comprised nine varieties, Bezostaya, Buchan, Claire, Deben, HTL (High Tiller Line), Norman, Option, Tanker and Wembley. Unfortunately, Norman had to be eliminated from the field trials because of poor seed stocks. The Quality group comprised twelve varieties, Bezostaya, Cadenza, Hereward, Maris Widgeon, Mercia, Monopol, Pastiche, Renan, Renesansa, Soissons, Spark and Thatcher. The Yield/Quality group comprised all twenty varieties with the exception, again, of Norman. The nineteen winter wheat varieties were planted in randomised block field trials in the autumn of 2004, 2005 and 2006, together with the populations and mixtures, at four sites in England. The sites comprised two organic (Sheepdrove Organic Farm, Berkshire and Wakelyns Agroforestry, Suffolk) and two non-organic (Metfield Hall, close to Wakelyns Agroforestry, and Morley Agricultural Research Station, Norfolk) sites, both using high levels of synthetic inputs. Assessments were made on a range of characters from crop emergence through to yield and characteristics of harvested grain. Here, we report only on yield behaviour. Initial data analysis used univariate statistics to observe some of the patterns. Later analysis made use of the AMMI approach (Ebdon and Gauch, 2002) with biplots.

Results

In all trials, all varieties had higher grain yields under non-organic (9.41 t/ha) than organic conditions (5.31 t/ha, $P < 0.001$). However, a major difference between these overall values lay in the distribution of the sums of squares in ANOVA among genotype (G), environment (E: years and locations within farming systems) and G x E interaction (Table 1).

Tab. 1: Distribution of ANOVA sums of squares (percentage) among items G, E and G x E for the same 20 winter wheat varieties in organic and non-organic field trials.

System	G	E	G x E
Non-organic	60.4	26.2	13.4
Organic	9.4	79.3	11.3

This means that the non-organic approach of using synthetic materials to control the environment was relatively successful so that much of the variation observed was due to differences among the varieties, with relatively little due to environment or the interaction G x E. Conversely, under organic conditions, a large proportion of the variation observed was due to the impact of the environment with relatively little due to differences among varieties. Further, the G x E interaction, though small in absolute terms, was large relative to the G term, much more so than under non-organic conditions. These differences were responsible for the contrast in correlations among varieties in yield (or yield rank) at the two non-organic sites ($r = 0.94$) compared with the two organic sites ($r = 0.61$). Correlations values between non-organic and organic sites were highly variable ranging from $r = 0.36$ (significantly different at $P<0.05$) to $r = 0.75$.

AMMI allowed further exploration of these interactions in terms of relative values and stability of yield for individual varieties. In summary, the analyses showed that the same five varieties were consistently high yielding in all non-organic environments (Table 2), although the higher IPCA-1 scores for Option, Tanker and Claire, i.e. larger departures from the mean of 0.0, indicates less stability for these varieties than for Deben and Mercia. Under organic conditions, there was much greater variation in variety ranking across environments, with a different range of highest yielding varieties. Furthermore, the highest yielding varieties, Deben, Claire and Soissons, were less stable than Wembley and Renan.

Tab. 2: Mean yields (t/ha @ 15 % moisture content) and IPCA-1 score for the highest yielding of 20 varieties under non-organic and organic conditions.

Non-Organic			Organic		
Variety	**Mean yield**	**IPCA-1 score**	**Variety**	**Mean yield**	**IPCA-1 score**
Deben	11.25	0.0937	Deben	6.41	0.823
Mercia	11.18	-0.115	Claire	5.95	0.5067
Option	10.87	0.2119	Soissons	5.86	-0.4552
Tanker	10.78	0.3142	Wembley	5.78	-0.0232
Claire	10.42	-0.2832	Renan	5.72	-0.0951

The most extreme differentiation in performance between non-organic and organic conditions was expressed by the two varieties, Renan and Tanker (Table 3).

Tab. 3: Reversed performance of Renan and Tanker under Non-organic and Organic conditions.

	Non-Organic			Organic		
Variety	**Mean yield**	**IPCA-1**	**Average yield rank**	**Mean yield**	**IPCA-1**	**Average yield rank**
Renan	8.92	-0.2159	11	5.72	-0.0951	5
Tanker	10.78	0.3142	3	5.09	0.2215	16

Discussion

The objective of the reported trials was to provide a control background for the development of populations and physical mixtures derived from the variety set. However, the data generated provided a useful, comprehensive example of the performance of a disparate range of winter wheat varieties under non-organic and organic conditions. There were positive correlations between the performances of wheat varieties in both systems, but there were also important differences. The variation in performance is likely to predominantly be management system, but the environment, including soil conditions may also be contributing factors. The group of higher yielding varieties showed little overlap between systems although Deben was the highest across all environments. Even this exceptional variety was less stable under organic than non-organic conditions. Interestingly, the second best variety under non-organic conditions was an older variety, Mercia, which combines high yield with high quality (it declined in popularity during the mid-1990s and breeders rights were removed in 2002). A number of the varieties that gave stable yields under both farming systems were also low yielding. Several varieties showed some change of ranking in comparisons between different non-organic and organic trials. However, the most extreme and consistent was between Tanker, which performed well under non-organic but not under organic conditions, and Renan, which gave the opposite response. Further analysis of the data in terms of the measured growth characteristics may help to indicate the nature of these reversals. DNA marker analyses will also help to determine whether these varieties contribute differentially to the populations that include them as parents. Simple correlations of varietal performance across environments are clearly inadequate; analyses are needed that recognise stability and performance of the individuals involved. Using the AMMI analysis, the next stage will be to use the data collected on other aspects of variety performance. There are clear differences among varieties and systems in, for example, plant height and ground cover as well as in quality characteristics. Integrating these with the yield data will help to determine a more comprehensive view of how different varieties respond to different environments, and how these characteristics may contribute to the mixtures and populations based upon them. It should also be possible to analyse the impact of some features of the environment such as rainfall, temperature and sunshine hours. We expect to find that there are many different gene complexes and interactions involved and that single genes rarely have an identifiable, large and stable effect.

Conclusions

Positive correlations for yield performance between varieties grown under organic and non-organic conditions are often used to suggest that non-organic trials can indicate performance under organic conditions, eliminating the need for specialised trials. Such positive correlations were evident in the trials described above, but more detailed analysis at the level of the individual variety indicates that there may be numerous differences among varieties exposed to the two types of farming system, as well as the effect of the soil type and climate, in terms of both absolute yield and the ability to achieve that yield (stability). For this reason, we recommend separate trials for non-organic and organic production. However, we also recognise that generalisation can be dangerous in the sense that the observations summarised above were the result of the interaction of a particular set of winter wheat varieties grown in a particular set of circumstances, which is not repeatable. Indeed, it is also important to recognise that, with rising oil prices and increasing environmental variation, growing circumstances are likely to change rapidly, increasing the need to monitor performance of relevant germplasm in a changing world.

Acknowledgments

Thanks to Defra, John Innes Centre and our collaborating farmers.

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Breeding for nitrogen use efficiency in organic wheat systems

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Key words: nitrogen use efficiency, plant breeding, winter wheat, dryland systems

Abstract

Improving crop nitrogen use efficiency (NUE) is important to reducing the environmental impacts of agriculture, for both perennial and annual crops. This study tested winter wheat breeding lines developed in organic and conventional systems, historic wheat varieties and perennial wheat under organic management. There were significant differences among selection categories and among genotypes. However, standard methods of measuring NUE may not be appropriate when the breeding objectives are to reduce N use. Alternative methods of evaluating breeding materials, including regression analysis of grain protein deviation (GPD) and principal component analysis (PCA) were explored. GPD was not found to discriminate well between genotypes in this study, but PCA showed promise in examining the relationship among measured variables and among genotypes.

Introduction

Because organic and conventional systems differ significantly in terms of soil N cycling, traits needed for high NUE may also differ significantly. To improve NUE in organic systems, breeders must determine whether there is genetic variation for traits related to NUE and identify genotypes with traits that contribute to NUE. The goals of this study were to understand variation in N use among historic varieties, conventionally and organically bred annual wheat genotypes (conventional and organic lines, respectively, hereafter) and perennial wheat in an organic system. Conducting this study in an organic system provided information about genetic differences that can be used in to select for high NUE under conditions of relatively low available N. Breeding wheat with superior performance in organic systems will help wheat farmers transition to more sustainable fertility management.

Historic varieties were developed before synthetic N sources were available, so these varieties may be important sources of adaptive traits for organic N cycling. In perennial wheatgrass, natural selection has been acting on species in competitive prairie ecosystems where N is limited. Deep root systems and longer photosynthetic duration may indicate that perennials are more efficient at capturing and using N. It is also possible that modern varieties have important traits for N-uptake because increasing the harvest index (HI) requires plants to assimilate more N for and equivalent biomass as grain has higher protein concentration than straw. Breeders may have indirectly and inadvertently selected for improved N uptake along with HI (Sinclair, 1998).

Materials and methods

The study ran from 2005-2007 on transitional organic ground at Spillman Agronomy Farm in Pullman, WA (Spillman) and at Sara and Joe DeLong's certified organic farm

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in St. John, WA (the DeLong's). Wheat genotypes (selection categories) included six F5 lines each from our organic and conventional breeding programs, six historic varieties and a genetically diverse bulk population of perennial wheat. Organic lines were selected under USDA certified organic management practices. Conventional lines were selected under standard management, including seed treatments, synthetic fertilizers and herbicides, but no pesticides or growth regulators. Historic varieties were released before 1955, when the use of synthetic fertilizers became common in breeding programs and on farms. Check plots included the popular soft white winter wheat Madsen (Allan et al., 1989), and J99C0009, a Madsen derivative with foot rot resistance. Madsen is a parent of the organic lines and J99C0009 is a parent of the conventional lines. Foot rot was not evident in the experiment during either season.

At Spillman, the soil type is Palouse silt loam and at the DeLong's, the plots were on a Snow silt loam in 2005-2006 and on a Mondovi silt loam in 2006-2007. Annual average precipitation is 540 mm at Spillman, and 428 mm at the DeLong's. Most precipitation occurs during the fall and winter months, and summers are generally hot and dry. The experiment followed spring peas plowed under as a green manure each year at Spillman and at the DeLong's it followed fallow with hog manure in 2005-2006 and dry peas in 2006-2007. A 3.5 m^2 plot of each annual genotype and the perennial bulk was planted in a randomized complete block design (RCBD) with four replicates at each location. Spillman was fertilized with Perfect Blend 4-4-4 enhanced organic fertilizer (granulated poultry manure) each spring at a rate of 42 kg N ha^{-1}. No additional fertilizer was applied at the DeLong's due to higher soil N. The breeding program does not control diseases or insect pests to select resistant genotypes. Hand weeding was used to reduce and equalize weed pressure across blocks.

Soil samples were taken twice each year before planting and in the spring. Eight cores 2 m deep were taken in each field. Cores were divided into 6 segments to determine inorganic N and soil moisture. The gravimetric method was used for soil moisture content, and nitrate (NO_3^-) and ammonium (NH_4^+) were extracted using KCL (Keeney and Nelson, 1982) and analyzed with a flow injection analyzer (FIA, Lachat Instruments, Loveland, CO). Leaf chlorophyll content was measured using a chlorophyll meter (SPAD 502, Minolta Co, Japan). Readings were taken three times during the growing season. Five plants were chosen at random in each plot and four readings were taken along the youngest fully expanded leaf and averaged. Readings corresponded to plant growth stages of 8-9 leaves (SPAD1), pre-anthesis/anthesis (SPAD2), and post-anthesis (SPAD3). At maturity plants from a 0.6 m long segment of a row within each plot were cut at ground level. Total weight and grain weight of these samples were measured and HI was calculated as grain weight/total weight. Plots were harvested with a Wintersteiger plot combine, and grain was weighed for plot yield, then analyzed for protein content on a 12% moisture basis by near infrared (NIR) spectroscopy (Tecator Infratec 1226 Grain Analyzer, Foss, Eden Prairie, MN).

Analysis of covariance (ANCOVA) in SAS (SAS Institute, Cary, NC) was used to asses variation among and within selection categories for grain yield, grain %N, total grain N and total biomass. SPAD meter readings were used as quantitative covariates to test for significant correlations between SPAD readings and the dependent variables. The SPAD covariate was retained in the final model if significant. Regression and PCA analysis in SAS were used to determine the relationship between grain N components and other measured variables.

Results

It is apparent that there is significant genetic variation for traits related to N use in organic systems in this sample of genotypes. The check genotypes Madsen and J99C0009 had the best performance in terms of yield, biomass production and total grain N. The conventional lines were not significantly different from the checks. Comparisons among categories showed that the selection categories were all significantly different from each other in terms of yield, grain %N, total grain N and biomass production with the following exceptions. Organic was not significantly different from perennial for biomass production, and historic was not significantly different from perennial for total grain N or grain yield. Ranking the categories showed a definite pattern, with conventional being higher for grain yield, total grain N and biomass followed by organic, perennial and historic genotypes. For grain % N, the ranking was almost exactly reversed, with perennial followed by historic, organic, conventional and control genotypes. Regression analysis showed a negative relationship between grain %N and grain yield, but no genotypes were identified with significant GPD (large standardized residuals from this regression), possibly because most genotypes were soft white wheat and the number of locations and years in this study was limited.

In the PCA, the first three components explained over 60% of the variation in the data. Genotypes with high scores for PC1 are likely to have high yield, total grain N, straw yield and total biomass. Grain yield and grain %N were not strongly correlated to HI. In conventional systems, HI is often positively correlated with yield but in this case, good vegetative growth may increase weed competitiveness and may serve as an N source for developing grain when soil N supplies are exhausted.

Tab. 1: Ranking of selection categories for agronomic traits related to NUE

Grain yield	control = conventional > organic > perennial = historic
Grain %N	perennial > historic > organic > conventional > control
Total grain N	control = conventional > organic > perennial = historic
Biomass	control = conventional > organic = perennial > historic

> or < comparisons significant for P<0.05

Discussion

While historic varieties have desirable traits, as a group they had the lowest yield, total grain N and biomass production. Organically bred lines were lower yielding than the conventionally bred lines, but significantly better than the historic varieties. Because the organic lines were derived from crosses between Madsen and a historic variety, the fact that several were not significantly different than conventionally bred elite lines is encouraging, and further gains are expected from selection. Conventionally bred modern lines generally had the highest yields and total grain N, showing that it is useful to include these lines in breeding for organic systems, to take advantage of gains from selection over the past 50 years while incorporating traits from historic varieties that are important to organic systems. The comparisons that were not significantly different are also of interest. The perennial bulk population had the same total grain N as the historic lines and the same biomass as the organic. Although perennial wheat currently has lower yield, total grain N and biomass, it has a very short breeding history. With continued selection for yield, it is possible that perennial wheat will show progress similar to that observed in annual wheat, where modern varieties now exceed their historic counterparts. As high grain %N is not required in soft white wheat, lines able to yield well at lower grain %N may be advantageous in organic systems. If end-use and mineral nutritional quality do not suffer, using negative GPD as a selection criteria as well as yield under low N conditions could reduce grain N requirements. Interestingly, quality checks used by Oury et al. (2007) had negative GPD, so it appears that high protein with respect to yield is not necessarily an indicator of end-use quality. PCA was useful to visualize important sources of variation in the data and to discriminate among genotypes. Factor loadings and correlations among measured variables can asses redundancy in the data and measurements which are highly correlated to other variables or not well correlated to traits of interest may be eliminated. This method could be very useful to breeding programs when deciding which variables are of most importance in certain environments for breeding goals.

Conclusions

Standard methods of calculating NUE are predominantly based on grain yield. This may not be appropriate when other factors, such as crop environmental impact, are also considered. While grain yield is important, other traits contribute to NUE, and these traits may be more useful when attempting to increase NUE from an environmental as well as an economic perspective. Alternative methods of analysis, such as GPD or PCA, may be useful in analysing these other traits. While PCA cannot replace careful observation and selection, it may be a useful tool in identifying trends or genotypes that merit more detailed analysis and observation.

Acknowledgments

This work was funded by a National Science Foundation (USA) Graduate Research Fellowship and a Graduate Research Fellowship from The Land Institute (Salina, KS, USA). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation or The Land Institute. Thanks to Kerry Balow, Meg Gollnick and Steve Lyon for their advice and assistance on this project.

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Contribution to organic breeding programmes of wheat variety testing in organic farming in France

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Key words: variety, winter bread wheat, breeding, screening, organic farming.

Abstract

Bread winter wheat is one of the most important cash crops for French organic farmers. Nevertheless, most of varieties available on the market were bred for conventional farming systems (with high inputs of mineral fertilizers and chemicals for crop defense). In order to obtain correct levels of yield and quality, it is important i) to screen current varieties to find the best suited for organic conditions, and ii) to rapidly obtain suitable varieties that are specifically bred for organic farming conditions. Bread wheat variety trials under organic conditions have been coordinated since the year 2001, to centralize and evaluate results at national level. The ringtest not only aims to compare varieties, but also to support organic breeding, as it provides an opportunity to evaluate the ability of advanced lines bred for organic farming to meet the needs of farmers and millers for agronomic and quality traits. Trials are also used to study specific traits required for organic farming (such as weed competitiveness), so that they can become selection criteria in specific breeding programmes. In addition, protocols and results obtained in variety trials in organic farming give information to discuss about possibility of low input VCU testing (Value for Cultivation or Use).

Introduction

The acreage of bread wheat is considerable in French organic agriculture (about 30 000 ha in 2006). As bread wheat is the most important cash crop, the type of varieties organic farmers should be using is very important. That is why it is essential to assess wheat varieties in terms of their productivity and quality, and to assess stability across years and sites under French organic conditions. Varieties that are compared encompass modern varieties that are available on the seed market, but also new cultivars that are supposed to be more suitable for organic production, including lines from organic breeding. The coordination of wheat variety testing at national level has two main objectives: i) To determine relative performance of cereal varieties grown under organic conditions. This should improve productivity and quality of organic cereal production by identifying cultivars that are best suited to organic farming systems. ii) To provide information for organic breeding programmes in order to support them, as these trials give opportunity to evaluate the relative performance of advanced lines bred for organic farming, and to study specific traits (such as weed competitiveness) usually not used as selection criteria.

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Materials and methods

Considering that numerous wheat variety trials were conducted independently with no connection and only local evaluation of results, Technical Institute for Organic Farming (ITAB) proposed in 2001 to centralise results and evaluate them at national level, in order to coordinate methods and reduce costs. The first step was to apply the same protocol and to have common varieties in each trial. Furthermore, as very few baking tests were locally processed because of cost, they have been centralized and taken in charge by ITAB for the last three years. All trials, run on organic farms, use a randomised block design with either 3 or 4 replicates. Where possible, organically certified seed is used, otherwise conventionally produced untreated seed is used. The basic principle is to have diverse environmental conditions that reflect reality (farmers standard practises are generally applied[1]), in order to assess the ability of varieties to adapt to different constraints. Varieties assessed in the ringtest are conventional varieties with traits that are supposed to best fit organic constraints (i.e. a good response to low level of nutrients, a good competitive ability against weeds), foreign varieties (with priority to those specifically bred for organic agriculture), and advanced lines from French breeding programmes specifically for organic agriculture. Agronomic and quality parameters that are currently centralized at are: yield (t/ha) and proteins content (% -NIR method-) for all trials, and if available: specific weight (kg/hl), height (cm), ground cover, diseases notations, quality/bread-making data. As a result, for the last 5 years data of 20 to 30 wheat variety trials per year have been combined for yield and proteins content. As a large range of soil types and climatic conditions are concerned; these results are processed by large geographical areas (roughly: north, south, centre and west). Since last year, results on important traits such as height, diseases, test weight, and baking quality have also begun to be combined and evaluated at national level.

Results

Figure 1 gives an example of annual results for the Southern area: yield versus protein content. Besides, stability across sites is observed. The variety Saturnus, which has clearly higher protein content, has low and very variable yields across sites, whereas the variety Orpic, in the average for both yield and protein, appears to be very stable across all five sites.

In addition, there is an analysis of stability of results across years for both yield and protein content: for the 2 or 3 last years for most varieties, for the last 5 years for three of them. Results are similarly analyzed for the five main areas of France. Complemented by baking quality results (example in figure 3), these analyses are the base used to elaborate list of recommendations to organic farmers: the results are published each year, including long-term results over the years.

Within the ringtest, we include advanced lines bred for organic farming (cultivars from Lemaire-Deffontaines and INRA), in order to assess in different organic conditions their performances and compare them to current varieties. Two lines bred by INRA appear to be promising: both have yields among the more productive (see figure 2, lines are underlined), while their response to baking test is good (figure 3) and a nutrient analysis indicates good level of magnesium.

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[1] For fertilisation: N provided through crop rotation or manure, 30 to 60 kg/ha if direct fertilisers.

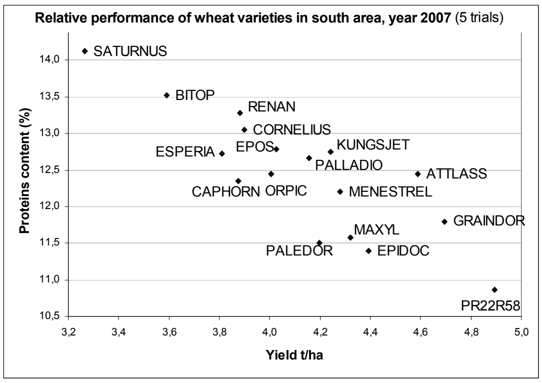

Figure 1: Relative performance of winter wheat varieties in south area, year 2007

In addition, measures of height and ground cover show good weed competitiveness. For this criteria, it is interesting to add that the network of organic wheat variety trials is used to study how to improve measurement of weed competitiveness, as it offers a large range of weed species found under different conditions of climate and soil.

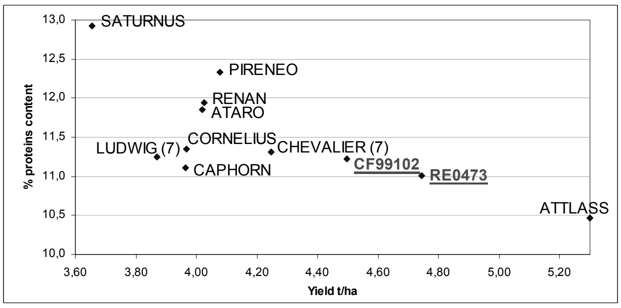

Figure 2: Relative performance (yield and proteins content) of 2 winter wheat lines bred for organic farming (results of 8 trials across France, year 2007).

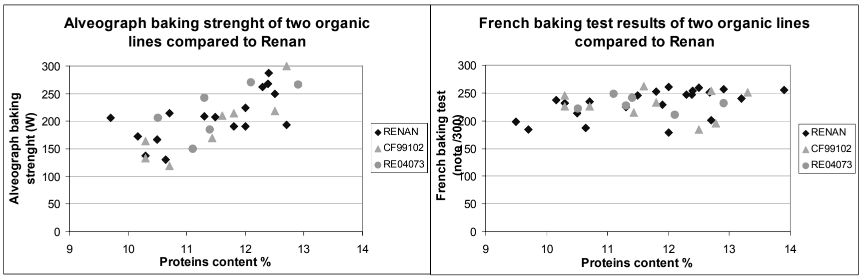

Figure 3: Baking quality results of 2 winter wheat lines bred for organic farming (samples from year 2004 to 2007).

Discussion

Currently, referent varieties such as Renan (a compromise between yield and proteins, with good baking quality), Attlass (for yield) or Saturnus (for proteins) perform relatively well from North to South. The results demonstrate that advanced lines bred for organic farming CF99102 and RE04073 perform well compared to current varieties with good levels of yield and ground cover; baking quality data are good up till now, but have yet to be completed for RE04073. According to those results, a proposition for official registration may be done next year.

In addition, it is important to underline that network gives large information to discuss about the possibility of low input VCU testing. As official VCU in France is conducted under conventional conditions, the network of variety trials in organic farming provides knowledge on i) reference varieties cultivated in organic farming and ii) assessment of weed competitiveness and specific baking quality required for organic bread making.

Conclusions

Organic farmers need bread wheat varieties suitable for both organic conditions (agronomic traits) and organic market demand (quality traits). Already in France some initiatives exist to set up specific organic breeding programs to meet the requirements for adapted genotypes. Besides screening of conventional varieties, a national network of variety trials in organic farming complements those breeding programs, as the network provides data on the performance of advanced lines and help to improve selection criteria. A problematic issue which needs more attention is the registration system, not being adapted to lines for very low input and organic conditions. Therefore another value of the national network could be to transform some of the trials into official VCU trials, or to be recognized as post-registration system for organic agriculture if VCU trials are eliminated. This still has to be discussed.

Acknowledgments

ONIGC has supported programme since 2003. We gratefully acknowledge all organisms and persons responsible of organic variety trials, which authorized us to use and process their results at national level, as well as farmers who entertained trials.

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Wheat trials networks for determining characters for organic breeding

Rolland, B.[1], Al Rifaï, M.[1], Bataillon, P.[1], Fontaine, L.[2], Gardet, O.[3] & Oury, F.X.[4]

Key words: plant breeding, organic farming, low inputs, pure lines, winter bread wheat

Abstract

The objectives of the French national institute of agronomy (INRA) cereals programme are to evaluate genetic material from breeding programmes for low input systems (high disease and lodging resistance, low seeding rate, good response to low level of nutrients, standard quality) including organic conditions.

The aim of the study is to define important agronomic characteristics of cultivar adapted to organic farming. Despite some relation with agronomical performances in low input system, weeds competitiveness, productivity and baking quality are specific in organic farming. Productivity and baking quality are linked to nutrient acquisition ability: nitrogen uptake and nitrogen-use-efficiency. The selection of new lines based on weed competition and N efficiency is necessary. Thus, we define an index selection method.

Introduction

To develop sustainable agriculture, INRA conducts projects in close relationship with organic and low-input systems enhancing exchanges between research on integrated (i.e. low inputs) and organic farming systems. We intend to follow a global approach, which combines interdisciplinarity research (agronomy, genetics, technology, etc).

In France winter bread wheat is one of the most important cash crops in organic farming (more than 30 000 ha in 2007). Hardy bread wheat cultivars, originating from public and private breeding programmes combine, as never before, resistance to diseases with satisfactory yield potential in integrated farming (Loyce and al. 2007). The objective is, first, to evaluate genetic material originating from breeding programmes for low input systems (high disease and lodging resistance, N standard quality) under organic farming conditions and, then, to define important agronomic characteristics of cultivar types adapted to organic farming in collaboration with technical institute on organic farming (ITAB) (Rolland et al 2002). Thus, we suggest an index selection method for the selection of new lines.

Materials and methods

From 2004 to 2007, INRA conducted a multidisciplinary study in a multi-site experiment in four organic certified farms and INRA experimental stations close to

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organic farms: Rennes (Bretagne), Le Moulon (Ile de France), Toulouse (Midi toulousain) and Lusignan (Poitou). From 25 to 30 bread wheat pure lines were compared annually. Experiments were designed in randomised complete block with four replicates per environment in organic and two replications in low inputs (low sowing density, N-60 kg, only one herbicide). Plots were assessed for weeds, diseases, nitrogen nutrition, lodging, yield and grain quality traits (protein content, zeleny, alveograph, French bread-making test). The aim was to test varieties in various conditions to screen its ability to adapt to different agronomical and edaphic constraints. Varieties assessed were selected from (1) conventional French breeding programme with traits that are supposed to best answer organic demand, (2) varieties from Austria, Germany and Switzerland (with priority to those specifically bred for organic agriculture), and (3) advanced lines from INRA breeding programmes.

Results

Crop Yield : According to locations, crop yield varies from 6.9 t.ha^{-1} when soil fertility and climatic conditions were favourable for high crop yield in organic conditions (2004 in Rennes) to 2.7 t.ha^{-1} in non optimal conditions with poor soil and-or brown rust and weeds (Lusignan 2007). From Koreli to CF99102 genotypes, including mixture (association), good yields are registered in organic conditions (Figure 1).

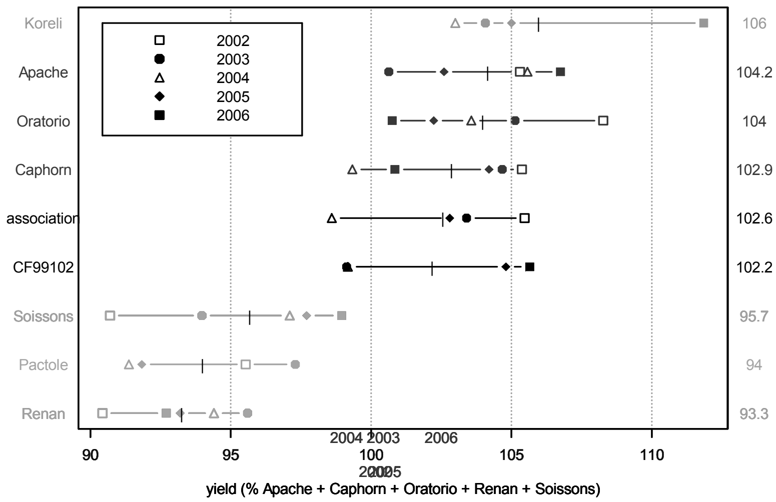

Figure 1: Yield for lines tested for more than three years in organic trials

Weed competitiveness: Important wheat traits influencing shading ability and thus weed growth are plant height and ground cover. Goyer (2004) proposed a method simplified from Hansen (2000) to approach weed competitiveness with two parameters (using standardized variables): crop canopy height and wheat ground cover at GS34. Pegassos is the cultivar with one of the best morphologies, due to a planophile leaf inclination and high plants (Drews, 2002). We also measured the genotype competitiveness for weeds suppression. Two controls were used, with and whitout weeds (manual weeds control) on two cultivar references: Caphorn (low competitiveness) and Renan (high competitiveness).

Quality for bread-making: French bread-baking, protein content, zeleny and alveograph baking strength (W), are relatively closely connected (Figure 2). A quality index taking into account protein content and W seemed relevant.

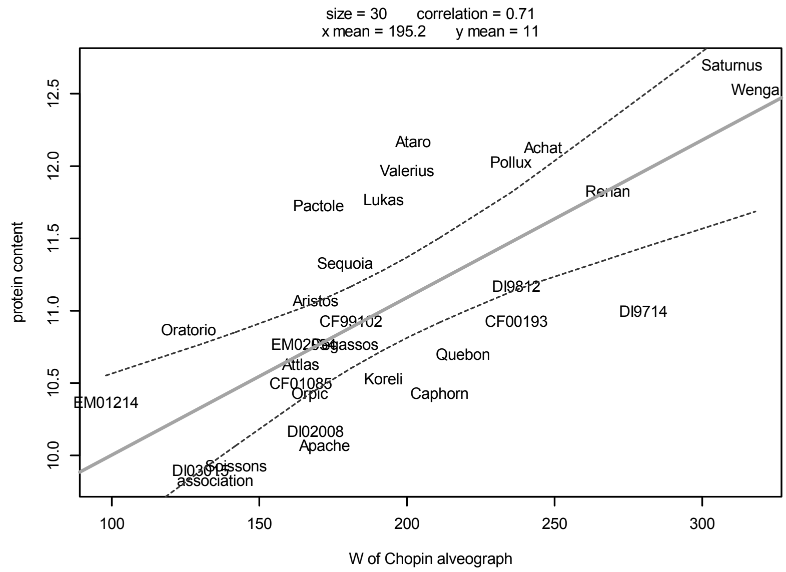

Figure 2: Correlation between W of alveograph and proteins content, year 2005

Discussion

INRA bread wheat ring test aims also at comparing the performance of a particular set of varieties over contrasting environments with an emphasis on low-input and organic conditions. Genotype and environment interaction, stability of yield (figure 3) and quality as well as research for particularly useful germplasm, traits and ideotypes for low-input and organic farming – for both direct use and breeding – are the main interest. The low inputs trial results are always higher than organic. According to occurrence of relevant limiting factors in each pedoclimatic situation (N, weeds, brown rust, etc), variety yield from fourteen low inputs trials are more or less correlated with results from organic trials ($0.256<r^2<0.967$). 2004 and 2005 are quite different years but low inputs are useful for low-input and also organic selection. Different degrees of yield stability and protein yield stability were found.

To improve selection criteria to select cultivars best adapted to organic farming (good response to low level of nutrients, good competitive ability against weeds, etc), we proposed a global selection index (IGS) which takes into account yield (Y), quality (W of alveograph and protein content (P)) and weed competition (crop canopy height (H) and wheat ground cover (WGC)) to optimise results. The higher weighting given to the quality data compared with the data for weed competition is due to commercial value.

$$IGS = Y + 2\times(W + P) + (H + WGC)$$

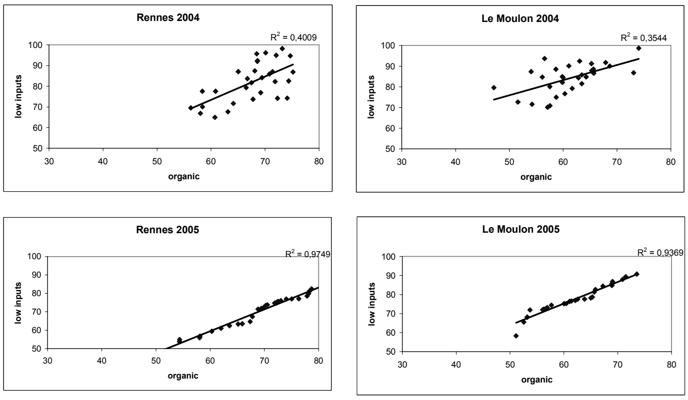

Figure 3: Correlation between yield (t-1.ha) in organic and low inputs, 2004 and 2005

Conclusion

Networking is useful to study specific traits required for organic farming, such as weed competition, in order to transfer them as selection criteria in breeding programs. A key issue will be the variety registration system, which is not adapted to lines for very low input and organic conditions.

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Differences between spring wheat cultivars in susceptibility to Fusarium caused seedling blight

Timmermans, B.G.H.[1] & Osman, A.M.[1]

Key words: Spring wheat, *Fusarium*, seedling blight, cultivar differences, growth rates

Abstract

Fusarium spp. present on spring wheat seeds can infect seedlings and cause reduced plant densities and higher wheat infestations. In the current project, variation between commercially available spring wheat cultivars in their tolerance to Fusarium seedling blight was investigated in a pot and a field trail. Additionally, initial growth rates of cultivars were measured to investigate possible relations with tolerance. Preliminary analysis shows presence of tolerance differences between the spring wheat cultivars in the pot and field experiment. This difference was relatively robust (experiment x cultivar interaction was not significant). Preliminary analysis also showed a relation between tolerance and initial growth rates of cultivars in the field experiment. The presence of robust differences in tolerance and relations with growth rates of commercially available cultivars form good possibilities for future breeding.

Introduction

Fusarium species are important pests for conventional and organic cereal production. Especially in wet years, they can infect wheat spikes during flowering and cause Fusarium head blight or scab (Birzele *et al*., 2002) Infection decreases the amount and quality of the yield and can result in high levels of mycotoxins (Parry *et al*., 1995). For organic agriculture a second problem exists: the use of non-chemically treated infected seeds can result in seedling blight and hence lower plant densities (Jones, 1999). These do not necessarily result in lower yields (Gooding *et al*., 2002) but can lead to a delay in canopy closure, and make crops less competitive against weeds. The aim of the current project is to investigate the presence of differences in susceptibility to seedling blight between spring wheat cultivars and if differences can potentially be linked to early development rates of the cultivars.

Materials and methods

Seeds of six spring wheat cultivars (Melon, Lavett, SW Kungsjet, Epos, Pasteur, Thasos) were used containing three Fusarium infection levels (averages 1, 11 and 25%, precise infection levels measured in a Blottertest, De Tempe, 1958). Seeds originated from an organic field that was inoculated with *F. culmorum* in 2004.

Field experiment: Seeds were sown in a field on an organic farm on clay soil (Colijnsplaat, The Netherlands) on 11 April 2007. Experimental set up as randomized block design with four repetitions and 20 m^2 plot size. Percentage of seedling emergence was measured on 29 May (after 1.5 month of hot and dry conditions) by counting six transects of 1 m in each plot. Measurements of above-ground dry matter

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were done in the lowest infection level (1% Fusarium infected seeds on average) on 7 and 18 June, by cutting 0.4 m^2 of all plots at ground level and measuring dry weight after drying at 105°C.

Pot experiment: Seeds were sown in a sandy soil (originating from a former organic grass field) in 5 litre pots at the experimental organic farm Droevendaal, Wageningen University and Research Centre, Wageningen, The Netherlands, on 26 March 2007. Experimental set up was a randomized block design with four repetitions, and each plot contained 20 pots of 5 litre, with 5 seeds sown in each pot (resulting in 100 sown seeds per plot). Pots were watered regularly to maintain optimal moisture conditions for plant growth.

For each cultivar the percentage of lost seedlings per percentage of Fusarium in the seed was determined by calculating the slope of the linear regression line of lost seedlings on the level of Fusarium infection in the seeds. Relative growth rates of dry matter were calculated in the lowest infection treatment (1% infected seed) by nonlinear regression (equation: $W_t=W_0$*exp(relative growth rate*time), in which W_t and W_0 represent weights on time t and 0, respectively). All statistics were performed using GenStat Seventh Edition version 9.1.0.147, VSN Internation LTD, Rothamsted, and R version 2.4.0 (R Development Core Team, 2006).

Results

In field and pot experiments a significant relation ($p<0.001$) between reduction in plant numbers shortly after emergence and Fusarium in seed measured in the Blotter test was found. The difference in plant tolerance to seedling blight was highly significant ($p<0.001$) between pot and field, revealing a general lower tolerance to Fusarium in the pot experiment (Fig. 1).

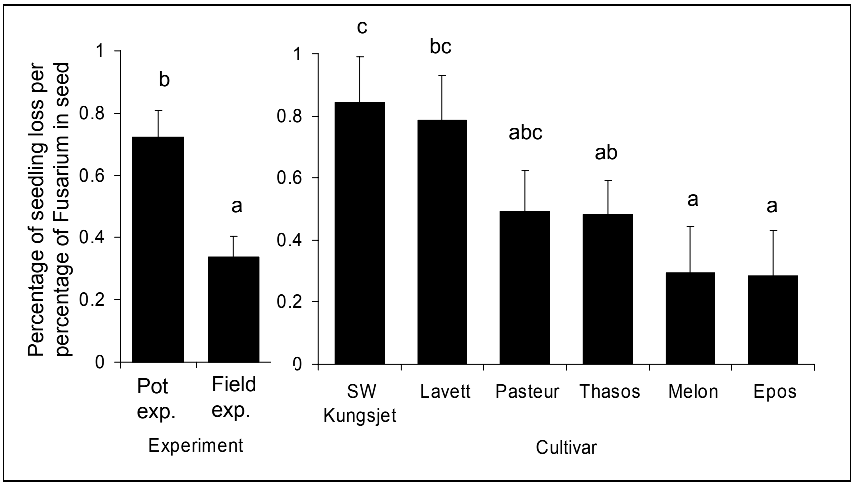

Figure 1: Percentage of lost seedlings per percentage of Fusarium in the seed for the pot and field experiment and for all six cultivars. Error bars indicate standard error of the means, significant letters indicate significant differences (p<0.05).

Differences in tolerance between the six spring wheat cultivars were significant (p<0.01, Fig. 1): in both field and pot experiments, tolerance for Fusarium seedling blight was highest for cultivars Epos and Melon, and lowest for SW Kungsjet and Lavett. The cultivar x experiment interaction was not significant, showing the relative robustness of these differences.

First preliminary analysis of the results indicated a correlation between tolerance and the relative growth rate without Fusarium of the cultivars in the field experiment (Fig. 2): the higher the relative growth rate of the cultivars was in the field, the higher the tolerance to seedling blight. In the pot experiment, no significant differences in relative growth rate between the cultivars were measured.

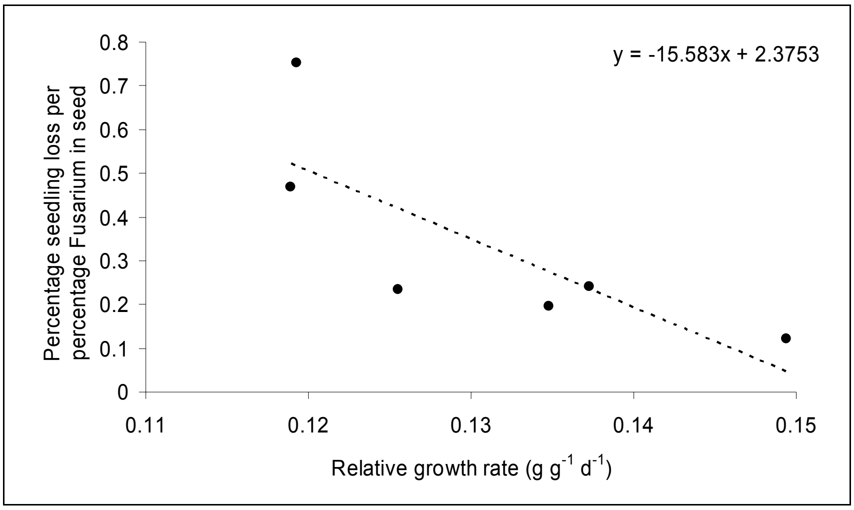

Figure 2: Percentage of seedling loss per percentage of Fusarium in seed plotted against the relative growth rates measured in the low infection treatment in the field, 2007. Broken line indicates a linear trend, equation shown in graph.

Discussion and conclusion

First preliminary analysis of these results indicate significant, and relatively robust differences between spring wheat cultivars in their tolerance to Fusarium caused seedling blight. Results are in accordance with results from previous year (Timmermans and Osman, 2007). Strikingly, Lavett, the cultivar that is most widely used in practice in The Netherlands (Osman *et al.* 2005), was one of the most susceptible cultivars in both experiments. Other authors have mentioned differences in cultivars sensitivity to Fusarium seedling blight for winter wheat, that seem at least partly related to susceptibility to seedling blight (Browne and Cooke, 2005). In the field, an indication was found for a relation between relative growth rates of cultivars and resistance to seedling blight. This relation can potentially be used as a criterion in future breeding; however, further analysis of current and former experiments has to ensure that it is robust in different environments. Plans for near future include combining these results with data measured in former experiments. Also, analysis of two years-measurements on light interception and crop closure (potentially delayed by seedling blight) and measurements on actual weed infestation are to be included.

Acknowledgments

The authors gratefully acknowledge funding from the European Community financial participation under the Sixth Framework Programme for Research, Technological Development and Demonstration Activities, for the Integrated Project QUALITYLOWINPUTFOOD,FP6-FOOD-CT-2003- 506358. Fusarium infected seeds for this research were produced in a collaborative research project on varietal resistance of spring wheat against Fusarium Head Blight of Plant Research International (PRI) and Louis Bolk Institute. This project is funded by the Dutch Ministry of Agriculture, Nature and Food Quality (DLO Programme 388-II, Breeding for Organic Farming). We thank Olga Scholten, Greet Steenhuis and Gerrit Huisman of PRI. We thank seed company. We acknowledge Theo Heijboer and staff of Experimental Farm “Rusthoeve” and Andries Siepel and staff of Experimental Farm “Droevendaal”.

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Does Wheat Cultivar Choice Affect Crop Quality and Soil Microbial Communities in Cropping Systems?

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Key words: wheat, soil microbial community, breadmaking quality, organic and conventional management

Abstract

Wheat (Triticum aestivum L.) *cultivars may have differential effects on soil microbial communities and the breadmaking quality of harvested grain. We compared six Canadian spring wheat cultivars under organic and conventional management systems for yield, breadmaking quality and soil phospholipid fatty acid analysis (PLFA) profile. Yields were lower, but protein levels were higher in the organic system. Cultivars differed for quality traits, but all cultivars had acceptable levels for processing. There were small differences in PLFA profiles for cultivars in the conventional system, but none in the organic system. More significant correlations between grain quality and PLFA measures were present in the organic system. Protein levels and breadmaking quality at least equal to conventional systems can be achieved in organic systems. Wheat cultivars differed for grain quality in both organic and conventional systems, and culivars altered the soil microbial profile in conventional systems. Microbes may play a greater role in determining crop quality in organic systems than in conventional systems.*

Introduction

Demand for organic foods has been increasing in Canada, in part because consumers perceive organic foods as having unique and/or superior quality than conventionally produced foods (Yiridoe et al. 2005). Research into the nutritional differences and sensory profiles of organic and conventional products has not yielded consistent results (Bourn and Prescott 2002).

Soil microbial communities play an important role in soil fertility and nutrient cycling, and are affected by production practices. Cropping systems management (organic and conventional) may (Bossio et al. 1998) or may not (Girvan et al. 2003) alter soil microbial communities. Crop cultivar selection can also affect soil microbial diversity (Germida and Siciliano 2001).

Understanding the effects of cultivar choice on soil microbial communities and crop quality may result in production systems with consistently high food quality. Our objectives were to determine the effect of spring wheat (*Triticum aestivum* L.) cultivar choice on soil microbial communities, crop productivity and breadmaking quality in both organic and conventional systems.

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Materials and methods

Six western Canadian spring wheat cultivars (Elsa, Glenlea, Go, Marquis, Park and Superb) were grown in four-replicate randomized complete blocks on two nearby sites (one organically managed and one conventionally managed) in 2005 and 2006 in Edmonton, AB, Canada (55°34´N, 113°31´W). The two sites had similar soil types.

Quality measures on grain included a number of processing measures which relate to final product quality. Protein levels over 12% are considered adequate in western Canada. Flour yield (FLY) is a measure of milling quality. Falling number (FN) indicates the sprouting resistance of the grain, affecting dough quality; grain over 400 has high sprouting resistance. Particle size index (PSI) indicates kernel hardness, with values generally 50-55 PSI. Mixing development time (MDT) is a measure of how long it takes to develop the dough; values between 2-3 minutes are desired. Soil biological biomass, % Gram- and Gram+ bacteria, % fungi, richness, evenness and diversity was determined using phospholipid fatty acid analysis (PLFA) on 5 soil samples randomly removed from each plot during crop growth (Clapperton et al. 1997).

Proc Mixed in SAS v.9.0 was used to analyze the combined experiment as a split plot, with management system as the main plot and cultivar as the subplot, replicated in time (year). The data were also analyzed separately by management system combined over years. For both analyses, years and blocks were considered random and management system and cultivar were considered fixed effects. Pearson correlations were conducted on site-year lsmeans.

Results

Tab. 1: Results of combined and separate statistical tests of breadmaking quality traits of wheat cultivars grown organically and conventionally

Cultivar	Yield ($t\ ha^{-1}$)	Grain protein (%)	FLY (%)	FN	PSI (%)	MDT (min.)
	Conventional					
Conventional mean	5.3	15.1	73	486	52	2.7
F test $_{cultivar}$ (df=5)	***	***	***	***	***	***
SE $_{cultivar}$	0.49	0.20	1	22	1	0.26
	Organic					
Organic mean	2.1	16.9	70	472	49	2.4
F test $_{cultivar}$ (df=5)	ns	***	***	***	***	***
SE $_{cultivar}$	0.77	0.46	1	78	2	0.16
	Combined ANOVA					
F test $_{mgmt}$ (df=1)	*	*	NS	NS	NS	NS
SE $_{mgmt}$	0.53	1.01	1	32	1	0.16
F test $_{cultivar}$ (df=5)	**	NS	NS	*	***	***
SE $_{cultivar}$	0.52	0.94	1	43	1	0.21
F test $_{mgmt*cultivar}$ (df=5)	*	NS	NS	NS	*	NS

NS=not significant (P≥0.10), * significant at P<0.10, *** significant at P<0.01, FLY=Flour yield , FN=Falling number, PSI=Particle size index, MDT=Mixing development time, SE=Standard error

When the management systems were analyzed separately, cultivars differed (P<0.01) for all breadmaking quality measures, except yield in the organic system (Table 1). Although cultivars differed for quality measures, most exhibited quality measures falling within accepted standards. However, Glenlea in the conventional system, and Go in the organic system had falling numbers below 400, suggesting these cultivars may have inferior dough under certain management systems.

In combined analyses, management had a significant effect on yield and grain protein. Yields under organic management were about half of those under conventional management. Grain protein levels were 12% higher in the organic system compared to the conventional system. Cultivar was a significant source of variation for all breadmaking quality traits except protein and FLY, with most values within standards.

The interaction of management × cultivar was significant (P<0.10) for yield and PSI. Superb yielded more grain than Marquis in the conventional system. Marquis yielded the lowest of the six varieties in both systems.

In the separate analysis for the PLFA measures, cultivar altered (P<0.05) % fungi, PLFA evenness and diversity in the conventional system (Table 2). Superb had higher % fungi, PLFA evenness and diversity than the other cultivars. Cultivar did not alter (P>0.10) any of the PLFA measures in the organic system.

Tab. 2: Lsmeans of cultivars under conventional management for % fungi, PLFA evenness and diversity from management-separated statistical tests

Cultivar	% Fungi	Evenness	Diversity
Elsa	0.93 b	0.82 ab	2.63 ab
Glenlea	0.90 b	0.80 b	2.61 b
Go	1.02 ab	0.82 ab	2.68 ab
Marquis	0.91 b	0.82 ab	2.68 ab
Park	1.05 ab	0.79 b	2.57 b
Superb	1.37 a	0.85 a	2.81 a

Lsmeans followed by the same letter within columns are not significantly different at the P<0.05 level, with Tukey's adjustment. Lsmeans separation was carried out using the pdiff option in SAS.

Correlation analysis suggested some relationships between grain quality and the soil microbial community in both systems, with more correlations in the organic system. Eighteen of 42 correlations were significant in the organic system, and only seven of 42 correlations were significant in the conventional system (data not shown). The % fungi was positively associated with yield under organic management (r=0.9***) and under conventional management (r=0.7**).

Discussion

Protein content of grain is an important factor in breadmaking quality, and was higher in the organic system. Other experiments have reported protein levels in organic systems to be lower (Poutala et al. 1993) or the same (Ryan et al. 2004) as conventional systems. Lower yields and heavy applications of compost for many years prior to the wheat crops in the organic system may explain the higher protein content in organic wheat. However, this experiment demonstrates that it is possible to have similar protein levels in organic and conventional systems.

Cultivars chosen for this experiment differed for some measures of quality as well as yield in both organic and conventional systems. The oldest cultivar, Marquis, yielded lowest in both the organic and conventional system, indicating that breeding has improved yields over the last century. Cultivar choice also affected some measures of the soil microbial community, but only in the conventional system. Management system did not affect microbes. It appears that factors other than cultivar are important in determining microbial community structure in organic systems.

More significant relationships between grain quality and soil microbes in the organic system may indicate that soil microbes play a greater role in determining crop quality in the organic system than the conventional system. The positive correlation between yield and % fungi may be due in part to mycorrhizal fungi (Olsson et al. 1999), as mycorrhizae can benefit plant nutrient uptake and crop productivity.

Conclusion

Yields were lower in the organic system, but protein levels and breadmaking quality at least equal to conventional systems can be achieved in organic systems. Cultivar choice altered grain quality and yield in both systems, but did not have an effect on soil microbial communities in the organic system. Soil microbes may play a greater role in determining crop quality in organic systems than in conventional systems.

Acknowledgments

We gratefully acknowledge the financial support of the Natural Sciences and Engineering Research Council, Alberta Ingenuity and a research grant from the Alberta Crop Industry Development Fund. Thanks to K. Strenzke and A. Navabi for technical and scientific support.

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Organic crop production in the tropics

Options for improving soil fertility in the southern part of the Republic of Bénin: Where does Mucuna find its niche?

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Key words: legume adoption, soil fertility, ethno-economics, local knowledge, Bénin

Abstract

Empirical evidence has shown that small-scale farmers can use a non-food, green manure legume as soil-fertilising technology only if it provides immediate benefits other than soil fertility improvement. In the southern part of the Republic of Bénin, however, subsistence-oriented farmers chose Mucuna pruriens *exclusively for soil fertility. In this they had the opportunity to select dual-purpose grain legumes for both soil fertility and food without season loss. The rationale behind this apparently irrational choice lies in the differentiated and economically sound land allocation to* Mucuna *and grain legumes.*

Introduction

The use of green manure (GM) legumes as nitrogen-fixing crops has been advocated as one of the most affordable soil-fertilising technologies for small-scale farmers. In practice, however, resource requirements of GM technology often conflict with the short-term objectives of this target group. Small-scale farmers cannot afford to grow GM legumes simply for the sake of soil fertility unless the seeds of the legumes are edible or in a few cases where GM legumes could be used primarily to combat noxious weeds (e.g. *Imperata cylindrica*) (Douthwaite et al. 2002).

In order to address the trade-off between soil fertility and food concerns, Schulz et al. (2003) have suggested the development of biomass-rich varieties of local grain legumes. However, the soil fertilising effect of these varieties is potentially lower than that of GM legumes because of their grain yields, which entail a substantial removal of nutrients from the system. On the whole, the search for niches susceptible to solving the "GM vs. grain legumes dilemma" remains the cornerstone of promoting soil-fertilising legume options that can be accepted by small-scale farmers.

Study area, materials and methods

The study was conducted from 2000 to 2002 in 4 villages, representative of the major landscapes and land use systems prevailing in southern Bénin. These villages were Agbassakpa (07°04' N, 02°26' E) located on a peneplain built on the Precambrian crystalline basement with ferruginous soils (Luvisols); Azozoundji (07°08' N, 02°03' E) and Zomondji (06°09' N, 01°09' E) located on the plateaux locally called *Terres de*

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Barre with ferralitic soils (Nitosols); and Djregbe (06°41' N, 02°61' E) on the costal plain with very poor quartz sand soils (Regosols).

The choice of the villages was based on the need to represent the existing land use intensification gradient: Land fallowing (3 to 5 years) was still practised in Agbassakpa and Azozoundji, but hardly in Zomondji and not at all in Djregbe. Access to mineral fertilisers was restricted in all 4 villages. The length of the growing period ranges from 211-270 days, rainfall is bi-modally distributed averaging 1,100 mm a^{-1}. The farming system is rain-fed and maize-based.

In each village, 8 legume options comprising 5 GM species and 3 food grain legume species were introduced to farmers. The introduced GM species were *Aeschynomene histrix* (accession I.12463), *Centrosema molle (syn. C. pubescens*) (I.152), *Mucuna pruriens* and *Pueraria phaseoloides* (commercial varieties), and *Stylosanthes guianensis* (I.15557) while the food grain legume comprised *Arachis hypogaea* (69-101), *Glycine max* (TGX 1448-2E), and *Vigna unguiculata* (IT84D-449, Mawuwena).

Researcher-managed demonstration plots were established in each village. These were in addition to individual trials that were freely designed and managed by volunteer farmers. Seeds were distributed free of charge and based on the participants' choices. To monitor farmers' experimentation process and legume diffusion pathways, both quantitative and qualitative methods were used. The number of adopters was counted seasonally, the areas planted with the introduced legume options were mapped, measured and reasons for adoption, re- or dis-adoption were assessed using periodic workshops, field days and focus group discussions. The rationale behind the utilisation of the species was assessed by eliciting the local soil taxonomy and the value, i.e., yield potentials, attributed to the fields planted with the introduced species. To get a more systematic picture of the comparative advantage of the technology options that were introduced, the ethno-economic values of the legume fields were included in the cost/benefit calculations involved. This was done using the Partial Budget Analysis (PBA) of legume utilisation (Bellon & Taylor 1993). Because of their food advantage, preference of grain legumes over GM legumes was taken as the baseline scenario. Therefore, in-depth analysis (PBA, soil taxonomy etc.) was made only in cases where GM legumes were preferred to grain legumes. The information used in this article is derived from the last data collection in 2002, 4 seasons after the first seed distribution.

Results and discussion

In Zomondji, farmers' preferences were clearly for the grain legumes. The soil-fertilising effect of Mucuna and *P. phaseoloides* was acknowledged, but the species were not chosen because of land constraints. Also Djregbe's farmers were more in favour of grain legumes, because of their food property. In contrast, Agbassakpa's and Azozoundji's farmers favoured the GM legume options in addition to the grain legumes (Table 1). The GM legumes were evaluated according to their "leaf size", "aggressiveness of growth habit" and "soil covering speed". As a result, Mucuna was preferred to every other species, which were qualified either as "second Mucuna" (*P. phaseoloides*) or simply as "small-leafed" species. The weed suppressing property of Mucuna was acknowledged, not as a primary advantage but just as a further confirmation of the "strength of Mucuna". The grain legumes varieties were judged according to their grain yield and not for their soil-fertilising effect, which became the exclusivity of Mucuna.

Tab. 1: Intensity of utilisation of the introduced legume options after 2 years of experimentation

Legume	Azozoundji (N[a]=125)		Agbassakpa (N[a]=90)	
	No. of users	Average area (m²) per user (% of afs [c1])	No. of users	Average area (m²) per user (% of afs[c2].)
Aeschynomene. histrix	8	169.2 (3.9)	1	225 (0.8)
Arachis. hypogaea	116	114.7 (2.7)	87	212.4 (0.7)
Centrosema molle	0	0 (0)	0	0 (0)
Glycine max	121	341.9 (8.1)	43	264.5 (0.9)
Mucuna pruriens	108	244.5 (5.8)	43	287.5 (1,0)
Pueraria. phaseoloides	0	0 (0)	0	0 (0)
Stylosanthes guianensis	1	138 (3.2)	16	261 (0.9%)
Vigna unguiculata	112	(n.a.[b])	17	635.3 (2.2%)

Notes: [a]: Total number of participants; [b]: n.a.=non available; [c]: afs: Average farm size comprising all types of fields including fallows. In Azozoundji, afs [c1]= 4229,5 m²; in Agbassakpa, afs [c2]=28970,3 m².

The maps of the legume fields show that the species were planted along the local soil fertility gradient, respectively on fields classified as *Fangle*, *Kunxo* and *Sisa* as defined in Table 2.

Tab. 2: Local soil taxonomy in Agbassakpa and Azozoundji

Soil category	Category subset	Suitability for crops	Fertility level	Need of fertiliser
Fangle	Fangle	Potentially for maize	Potentially fertile	2 seasons of grain legume to get smoother
Kunxo	Fertile	Maize	Fertile	No need
	Middle fertile	Maize/grain legume rotation	Middle fertile	Grain legume rotation
	Poor	Only grain legume	Poor	Mineral fertiliser
Sisa	Sisa	No crop	Exhausted	Not worth of fertilisation

The grain legumes were grown either on *Fangle* or *Kunxo* while Mucuna was planted on *Sisa* soil. How could farmers choose Mucuna while having the option to use cowpea (*Vigna unguiculata*) - the grain legume that traditionally has been most used for soil fertility in both villages? In the light of the negative rate of return (-42.7%) yielded by a shift from cowpea-maize to Mucuna-maize rotations (Table 3), farmers' choice of Mucuna appeared irrational. However, considering that the *Sisa* fields allocated to Mucuna cannot sustain cowpea, the opportunity costs of Mucuna is to be equated to zero, at least according to farmers' perceptions. Thus, the Mucuna technology becomes more profitable than that of cowpea: the marginal rate of return with a replacement of cowpea by Mucuna would then be 397.7% (data not shown).

Tab. 3: Partial budget analysis of a maize crop after Mucuna (MM) and cowpea (CM) in Azozoundji

Item	Mucuna/Maize (MM)	Cowpea/Maize (CM)
Gross farm benefits		
1 Average grain yield of subsequent maize on Sisa soils for CM and other soils for CM (kg/ha)	1,500	750
2 Price (FCFA[a])/kg)	112	112
3 Gross margin gate benefits (FCFA/ha) (1x2)	168,000	84,000
Variable input costs (FCFA/ha)		
4 Land preparation	25,500	8,625
5 Opportunity costs for lost season	129,716.54	0
6 Total variable input costs (4+5)	155,216.54[(d)]	8,625[(e)]
Net benefit		
7 Net benefit (kg/ha) (3-6)	12,783.46[(b)]	75,375[(c)]
8 Change in net benefits with a shift from cowpea to Mucuna soil fertilising technology [[(b)] – [(c)]]		-62,592
9 Change in total variable input costs with a shift from cowpea to Mucuna technology [[(d)] – [(e)]]		146,592
10 Marginal rate of return (%) (100 x 8 ÷ 9)		-42.7

Note: [a]: Franc de la Communauté Financière Africaine: 656 FCFA =1 Euro

Conclusions

Smallholder farmers can choose GM legumes to improve poor soils that are not suitable for the production of food crops. In the Republic of Bénin, these potential GM niches were found in non-sandy areas, where land is moderately available, i.e., scarce enough scarce to impose a shifting cultivation based on soil fertility taxonomy.

Acknowledgments

The funding from the German Federal Ministry for Economic Cooperation and Development and the Deutsche Gesellschaft für Technische Zusammenarbeit is gratefully acknowledged. Special thanks also go to scientists of the International Institute of Tropical Agriculture, the International Livestock Research Institute and the Institut National des Recherches Agricoles du Bénin, for their academic support.

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Effect of green manure rotation, biol and cultivar on the production of organic spinach (*Spinacea oleracea*)

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Key words: Biol, green manure rotation, spinach, *Spinacea oleracea*

Abstract

Two cultivars (Open Pollination OP and hybrid) were evaluated in a rotation with green manure (Crotalaria juncea) and four biol concentrations (0, 20, 40 and 100%) on organic spinach crop. A statistical complete randomized block under factorial design was used. The yield was highly statically significant for the rotation with green manure (24.3 t/ha), biol (25.8 t/ha) and the interaction of rotation x cultivar (25.2 t/ha), where the production of the OP was superior to hybrid, when green manure was used. High yields obtained when green manure in rotation and high biol concentrations were used, justifies its wide and common use, especially with small farmers, improving the spinach organic production efficiency even when an OP cultivar was used.

Introduction

Organic agriculture in Peru involves more than 100 000 small farmer families. Organic agriculture aims to obtain high nutritional quality food with environmental respect, preserving soil fertility and genetic diversity (Alvarado 2004).

Crop rotation is an antique practice used to increase yields, keep soil fertility in a natural way and as a strategy to prevent pest and diseases. Several authors define it as sequence of different crops, associated or not, in a tract of land for limited time and not necessarily repeated in the same order or a crop sequence system in a specific area (Altieri 1999), therefore the succession in the time it's the most important in the system to maintain soil fertility.

An adequate planning of crop rotation allows attending soil requirements efficiently and can be started using green manure or fodder crops with great contribution of biomass and nitrogen (*Fabaceae*), to generate crop fertility conditions (Kolmans & Vásquez 1996). Therefore rotations can not be carried out of a random, because it can also generate negative effects, such as sorghum root allelopathic exudates that affects yield (Altieri 1999).

Organic fertilizers are obtained directly or indirectly from plants or animals during the rotting process, and they are an important source of essential nutrients, organic matter, humus substances and plant growth regulators. ***Biol*** is a popular name of a liquid organic fertilizer, which is obtained from a biodigestor (anaerobic fermentation of manure, green plants in closed recipients). Different micro organism are in charge to transform these organic materials in humic substances and a sort of amino acid, vitamins, AIA, gibberellins and mineral complex from the non humic fraction of the organic matter. Biol has become very popular across Latin America, especially among

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small producers in order to easy to produce, low costs and better effects. Biol is used in many crops, with soil or foliage applications and variable concentrations.

This study was aimed to evaluate the organic production of spinach (*Spinacea oleracea*) in an organic plot depending on three factors: rotation with green manure (*Crotalaria juncea* L.); biol effect and the response of two cultivars of spinach, one open pollinated (OP) and a hybrid.

Materials and methods

The essay was conducted between at the *El Huerto* (Vegetable Research Program) of the Universidad Nacional Agraria La Molina (UNALM) in Lima, Perú. The average temperature varied between 13º C and 19ºC with an average of 16º C and a relative humidity of 87%, finding within the optimal temperature range (13-18ºC) for the crop (Ugás et al 2000).

The characteristics of soil presents low levels of CE (0.72 dSm^{-1}), moderately alkaline (pH 8), low organic matter content (1.8%), gritty and frank texture, average levels of CIC, but high content of phosphorus and potassium, characteristics suitable for the cultivation of spinach.

Materials

Seeds: Viroflay cultivar seeds (open pollinated OP) were used, and Quinto hybrid.

Biol: Obtained by a 10 m^3 capacity biodigestor, from Bioagricultura Casablanca in Pachacamac, with the following characteristics (Table Nº 1).

Tab. 1: Biol analysis from a biodigestor. Pachacamac, Perú

CE dS/m	pH	Solid g/l	Organic matter g/l	N mg/l	P mg/l	K mg/l	Ca mg/l	Mg mg/l	Na mg/l
15.3	8.2	23.6	5.4	980	121	6760	220.4	53.4	542

Source: Soil and Fertility laboratory UNALM

Pest control: It was used yellow traps, colored glue traps and oil to control white fly (*Liriomyza huidobrensis, Bemisia tabaci*), ash to control black worms (*Agrotis spp*), as well as water cultural control for root rotting (*Fusarium spp*).

Study Factors

Rotation. The spinach was planted in two adjacent plots: one where the last crop harvested was corn (*Zea mays*) and the second where the preceding crop was crotalaria (*Crotalaria juncea*) incorporated to the soil.

Cultivar. Two spinach cultivars (*Spinacea oleracea L.*) were used: Viroflay, open-pollinated (OP) and Quinto (hybrid).

Biol concentrations. Three biol concentrations were used in foliar application: 20, 40 and 100% plus a witness (without application).

Treatments and experimental design. The combination of three factors: rotation, cultivar and biol, lead to 16 treatments. It was used statistical complete randomized block design with factorial arrangements. The averages were confirmed by the Duncan test (Alpha = 0.05) using the test of least squares (Alpha = 0.05) when working with the interactions between different factors

Results

Growth. The OP cultivar obtained the largest size, over the hybrid cultivar when rotation with green manure was used. Both cultivars (hybrid and OP) obtained larger sizes when biol concentration increased (fig. 1).

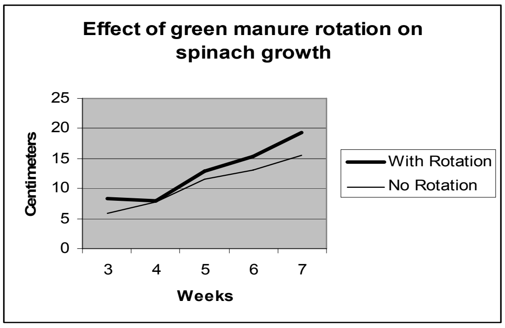

Figure 1: Effect of green manure rotation on spinach growth

Yield. According to single factors (TABLE Nº 2), highly statistically significant differences were found for green manure rotation and higher concentrations of biol factors; these factors were superior to the cultivar factor (hybrid and OP), being decisive in improving yields of organic spinach crop. Under this conditions, the effect of the type of cultivar (hybrid or OP) was less important that biol and rotation effects.

Tab. 2: Simple effects and interactions of rotation with green manure (*Crotalaria juncea),* biol and cultivar on spinach yields (*Spinacea oleracea*).

Treatments	Yields (t/ha)
Rotation	
Without Crotalaria (WC)	17.97 b
With Crotalaria (C)	24.29 a **
Cultivar	
Viroflay (OP)	19.44
Quinto (Hyb)	22.82 (ns)
Biol (%)	
0	15.47 b
20	20.26 ab
40	22.99 a
100	25.80 a**
Rotation X Cultivar	
WC x OP	13.65 b

Treatments	Yields (t/ha)
WC x Hyb C x OP C x Hyb	22.29 a 25.24 a 23.34 a**
Rotation x biol	n.s
Cultivar x biol	n.s
Rotation x Cv x biol	n.s

* Significant for P<0.05 ; *** significant for P<0.001

Interaction factor was highly significant only with the combination of rotation with cultivar, even when OP cultivar was used. Other double or triple interactions were not significant. These results confirm the superior effect of the rotation with green manure over foliar fertilizer (biol) and type of cultivar.

Discussion and Conclusions

Results demonstrated that in organic spinach crop the rotation with green manure is a major factor than cultivar (hybrid /OP) or organic foliar fertilizer (concentration of biol). The best response of the cultivar OP was obtained when used rotation with green manure, demonstrating it is a valuable factor to obtain better yields in organic spinach crop. Hybrid cultivar did not obtain higher yields, because the specific nutrition and environment requirements are achievable only with chemical inputs (Arroyo 2005). In Argelia, in desert conditions, the production of spinach under unfavorable conditions was greater with OP than the hybrids (Gutierrez & Tapia 2006). The rotation with green manure (*Crotalaria juncea*) showed that at the same environmental conditions OP can be more efficient reaching higher yields than hybrid. Biol concentration increased the yield, gaining maximum efficiency when 100% foliar concentration was used (23.37 t / ha). Biol effects are consistent with other essays like pickles (*Cucumis sativus*), where higher yields were obtained with biol 50% (25.7 t/ ha) in an out-of-season planting and green beans (*Phaseolus vulgaris*) where the highest yields (17.9 t/ ha) were obtained with 100% of the foliage biol (Barrios 2001). Therefore spinach yields can be explained by the effect of simple factors (Rotation or cultivate biol concentration) independently and by the interaction of double rotation with green manure x cultivar. When not using green manure in the rotation, the yield was increased only by the effect of cultivars.

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Organic matter addition in organic farming – Impact on root development and yields in maize and cowpea over dry seasons

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Key words: Organic matter, WHC, Roots, Maize, Cowpea, Yields

Abstract

Organic matter and its proper management are vital in tropical organic farming to maintain productivity. A field study thus placed rice straw or Gliricidia leaves on the soil surface or the material was incorporated into soil. The impact of these treatments on soil moisture, root development and yields of organically grown maize or cowpea were evaluated in an Asian dry season. Incorporation increased soil moisture retention in the soil and hence induced better root growth, culminating in higher yields. The impact was greater in maize, especially with Gliricidia leaves. The benefits of incorporating organic matter in dry seasons for tropical organic farming are presented.

Introduction

The availability of organic matter in tropical Asian farming systems is low and is generally of poor quality (Katyal et al., 2001). Management of the available organic matter is thus important to derive maximum benefits (Giller et al., 2006). Incorporating organic matter within conventional farming systems showed stimulation of root growth (Sangakkara et al., 2004). Similar studies within a tropical organic system have not been reported. However Ball et al. (2007) report this effect in temperate conditions. Hence a field study evaluated the impact of different methods of placing two common tropical organic materials on water holding capacity of the rooting zone of a tropical organic system. The impact on root growth and yields of two common tropical crops (maize – *Zea mays* and cowpea *Vigna unguiculata*) was also determined over a minor season when the crops are subjected to moisture stress.

Materials and methods

The experiment was conducted on an organic farm located in the intermediate zone of Sri Lanka, at Kurunegala (83°N, 79°E, and 116 m above sea level) in the minor season of 2005 lasting from May to August. The soil of the site was an Ultisol, with an organic C content of 1.89 $\pm$ 0.44% and N content of 38 ($\pm$ 1.99) $mg.kg^{-1}$ and a sandy loam texture. Rainfall received in this season was 214 mm and the mean temperature was 31°C $\pm$ 2.33 °C. With the onset of the rains in May, land was prepared, plots of 3 x 2 m demarcated. Soils were sampled at 12 locations to a depth of 30 cm at intervals of 0 - 10, 10 – 20 and 20 – 40 cm using a core sampler and Water Holding Capacity (WHC) was determined. Thereafter, leaves of *Gliricidia sepium* (C:N ratio 21.4) and rice straw (C:N ratio 39.8) were either applied to the surface or incorporated into the top 40 cm manually. The rate of addition was equivalent to 5 Mt dry matter per ha. The control treatment had no organic matter. Thus the experiment had 5 treatments replicated four times within a randomized block design.

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At 14 days after adding organic matter, soils of all plots were sampled again to the same depths and WHC was determined. Seeds of either maize or cowpea (Var Ruwan or Arlington respectively) were planted at the recommended spacing and maintained organically. At flower initiation of both crops, core samples were obtained from two locations per plot from the depths of 0 – 20 cm and 20 – 40 cm, roots washed and total lengths determined by the grid method to calculate root length densities (RLD). Seed yields were determined at crop maturity. The data was subjected to statistical analysis using a GLM model and significance of treatment differences were determined using LSD values.

Results and Discussion

The WHC of the soils prior to adding organic matter declined significantly with depth (i.e. 18.2, 16.5 and 15.1% (S.E. 2.11, n= 12) at depths of 0 – 10, 10 – 20 and 20 – 40 cm respectively. This clearly indicated the more compact soil structure within the root zone on this organic farm.

Organic matter increased WHC of soils when compared to the control (Table 1). Incorporation of the material increased the beneficial impact to a greater extent, especially when rice straw, was added. This is due to the slower decomposition of this material with its greater C:N ratio, when compared to the leguminous Gliricidia leaves. The lower increase in WHC on the surface is due to the faster breakdown of the material, especially Gliricidia leaves. However the importance of organic matter in enhancing WHC of tropical soils was clearly evident as shown by Olness and Archer (2005), who stated that a 1% increase in soil C enhances WHC by 2 to >5%, depending on the soil texture.

Tab. 1: Water holding capacity of soil as affected by organic matter and its method of application

Organic matter	Method of addition	WHC (%)	
		0 – 20 cm	20 – 40 cm
Rice straw	Surface	19.5	18.6
	Incorporated	20.2	19.8
Gliricidia	Surface	19.2	16.5
	Incorporated	19.9	19.1
Control		17.5	16.3
SE mean (n=40)		0.41	0.84

Organic matter stimulated root development (RLD) of both species (Table 2). The interaction between organic matter and the method of addition was also significant. The greater beneficial impact was observed with maize, which has a fibrous root system when compared to the tap root system of cowpea. This can also be attributed to the more drought tolerance of cowpea and its deep rooting ability. Surface application of rice straw enhanced RLD of maize, especially in the top layer of soil and more than in cowpea (Table 2). The beneficial impact was also greater than when Gliricidia was applied to the surface. This again is due to the slower breakdown of straw. In contrast, the differences in the RLD in cowpea in the two soil depths were not as greater as in maize when the organic matter was applied to the surface. Incorporation induced better root development in both soil layers, especially with rice straw. Although the RLD of both species in the top layer of soil was lower when the organic matter was incorporated, there was an overall stimulation of roots within the soil profile due to incorporation. This can clearly be related to the better WHC of the lower soil layer when the organic matter, especially straw was incorporated.

Tab. 2: RLD of maize and cowpea as affected by organic matter and method of addition

Organic matter	Addition	Root Length Density ($cm.cm^{-3}$)			
		Maize		Cowpea	
		0 – 20 cm	20 – 40 cm	0 – 20 cm	20 – 40 cm
Rice straw	Surface	25.6	12.8	14.5	12.7
	Incorporation	22.4	20.7	10.1	10.6
Gliricidia	Surface	23.1	10.4	11.4	9.3
	Incorporation	19.6	18.0	10.5	10.1
Control		15.6	12.8	9.4	8.5
LSD (p=0.05)	Material	0.031	0.027	0.018	0.037
	Incorporation	0.004	0.018	0.006	0.033

Organic matter increased seed yields of both species over the control, irrespective of the type and method of addition (Table 3). This clearly highlights the role of organic matter in organic farming, especially in the dry seasons when crops are subjected to soil moisture stress. The beneficial impact was greater in maize than in cowpea in this season, due to the greater susceptibility of the cereal to moisture stress.

Incorporation of the organic matter increased yields significantly, and again the impact was greater in maize. This is due to the better root distribution in the soil profile due to incorporation. A positive correlation could thus be established between RLD and yields for maize ($Y = 14.254Ln(X) - 83.396$ ($r^2 = 0.8845$) and cowpea ($Y = 9.521Ln(X) - 56.55$ ($r^2 = 0.7906$). The greater increase in yields with increasing RLD in maize also highlighted the greater beneficial effect of adding organic matter on the cereal, by the stimulation of root development, which could be related to enhanced water holding capacity.

Gliricidia increased yields to a greater extent than rice straw, especially when incorporated. The higher N content in the leaves and the more rapid breakdown would provide N, which is limiting in tropical cropping systems to the growing crops, especially maize. In contrast, cowpea could fix atmospheric N and hence is less benefited by this organic matter.

Tab. 3: Impact of method of addition of organic matter on yields of maize and cowpea

Organic matter	Addition	Seed yield kg ha^{-1}	
		Maize	Cowpea
Rice straw	Surface	1145	596
	Incorporation	1390	690
Gliricidia	Surface	1215	648
	Incorporation	1485	815
Control		885	480
LSD (p=0.05)		48.51	10.11

Conclusions

The field study highlights the importance of organic matter and its method of addition for crop growth and yields in tropical organic farming in the dry seasons. Organic matter stimulated root growth which in turn could enable the crop to enhance water use efficiencies. The use of material with a lower C:N ratio also accrues more benefits than straw, which is commonly used in tropical organic farming.

Acknowledgments

Gratitude is expressed to Mr. D S Jayasuria for providing the land on his organic farm.

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Harmonizing *Jhum* (Shifting Cultivation) with PGS Organic Standards in Northeast India: Key features and characteristics of *Jhum* for process harmonization

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Key words: Shifting cultivation, *jhum*, PGS, Northeast India

Abstract

Shifting cultivation, known as 'jhum' in Northeast India is widely distributed upland slash and burn agricultural system. Efforts to address jhum remained challenging tasks, more so due to its shortening cycle but continued livelihoods dependency for a large population of upland communities. With organic foods gaining popularity, harmonizing jhum with Participatory Guarantee System (PGS) organic standards may provide enhanced opportunities for improved livelihoods and environmental security in Northeast India. The paper explores these opportunities and focuses on the features and characteristics of jhum that would require in meeting the PGS organic standards.

Introduction

Shifting cultivation**,** locally known as ***jhum*** is a widely distributed form of agriculture in the upland areas of Northeast India. The practice involves site selection, slash and burn, followed by mixed cropping for a year or two and fallowing for certain years for recuperation of the land. In spite of various efforts of the government to address and contain *jhum*, over 443,000 families of upland rural communities of the region continue to partially or wholly depend on 'jhum' for their livelihoods, with total areas affected by the practice estimated between 1.73 to 13.81 million ha (NEC 2006). *Jhum* in Northeast India, including its variants such as *alder-based jhum* in Nagaland, *bun* cultivation in Meghalaya continue to attract diverse opinions. Its critiques call it as an inefficient and wasteful form of agriculture, while others see this as diversified livelihood system that ensures sustenance along with conservation of associated rich cultural heritage. The shortening jhum cycle (the intervening period between fallowing and returning to the same spot for cultivation) from traditional 10 years or more to 4-5 years on an average now is indeed a matter of concern. This is seriously impacting on the local livelihoods and environmental security in many pockets of the region.

However, given the farmers' knowledge and continuing adaptive innovations by responding to complex agro-ecological and socioeconomic dynamics, this system of farming with appropriate cycle provides the best options for sustainable use of land due to its inherent strengths and the institutions governing the practice. Harmonizing jhum with Participatory Guarantee System (PGS) would strengthen jhum as an agricultural and adaptive forest management practice based on scientific and sound ecological principles, particularly where the climate and land gradients are uniquely suitable primarily for jhum. PGS is a complementary system of organic guarantee that builds the organic movement, educates farmers and consumers and grows the domestic market for organic produce. In fact, such a parallel domestic certification system will end up facilitating the growth of Third Party Certified farms in India,

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thereby strengthening and increasing India's place as an Organic exporter (Khosla, 2006). The objective of the present study is to explore these possibilities and opportunities of harmonizing shifting cultivation practices (jhum) with the PGS organic standards for securing improved livelihoods and environmental stability in Northeast India. The PGS organic certification and assurance system could be particularly suitable for the marginal farmers and shifting cultivators of the region.

Materials and methods

Materials for this paper are drawn from the output of a two-day stakeholders' consultative workshop held in Shillong during July 14-15, 2007. The workshop was attended by academicians, scientists, government agencies, NGOs, rural development workers, farmers' representatives and international research and development agencies to consider why and how *jhum* in Northeast India could be harmonized with PGS organic standards. The key features and characteristics of *jhum* that would be considered for harmonizing the practice with PGS standards were identified and qualified, which form part of the results of this paper. The concepts and implementation modalities were discussed with farmers, which received wide acceptance if organically produced crops could ensure higher and assured income.

Results and Discussion

The National Programme for Organic Production (NPOP) in India includes fallow lands for promotion of organic farming (GoI, 2005). Jhum cultivation practices ensure such fallow lands where PGS organic standards can be applied. For this purpose the following minimum characteristics ought to be met, besides other standards such as taking of pledge by the farmers, maintenance of diaries, etc. as required under PGS.

- *Zoning of PGS jhum*: The area for PGS jhum to be clearly demarcated and protected from non-organic non-PGS area, involving community institutions.
- *Jhum cycle*: At least 9-10 years jhum cycle with 8 years of fallowing and 1-2 years of cropping; in alder-based *jhum* with well-spread periodically pollarded trees, a minimum cycle of 4 years with 2 years fallowing and 2 years cropping.
- *Site selection*: The PGS jhum sites to be as per local jhum regulations, at least 400 m from major water source; 50 m from main road; not community or government forest reserved area; not primary or pristine forest.
- *Jhum clearing*: Precaution exercised by rationalizing land clearing based on availability of seeds/planting materials, and availability of labour for weeding; trees not clear-felled but looped branches, retaining as many standing trees.
- *Burning & fire management / precaution against fire*: Well established fire line maintained before burning; no destruction of adjacent biodiversity-rich forest by fires from jhum; no crop residues burnt; strong community fire management.
- *Labour*: No child labour employed; men and women share equal work-burden.
- *Seeds / planting materials*: Only local / indigenous seeds used; seeds exchange with other farmers prior to sowing as per local customs; seeds of local species of trees / fruit trees also sowed/planted along with jhum crops; no GMOs or HYV hybrid seeds used; if required, seeds treated only as per PGS organic standards.

- *Agronomic practices*: Well balanced/mixed agro-biodiversity planted or maintained; no tillage; no over planting of nutrient-exhaustive crops; very good mix of nitrogen fixing plants/crops, occupying at least 50% of the crop area; no serious or alarming attacks of pests and diseases; no chemical pesticides used.
- *Soil & water conservation practices*: Good soil and water conservation practices using both agronomic (through indigenous crop mix) and mechanical measures (using locally available materials or traditional good practices) maintained; no visible gully formation or other evidences of soil erosion in the field.
- *Weeding & weed management*: Removed weeds used for mulching; no germinating local tree species destroyed during weeding.
- *Pest management*: Integrated pest management (IPM) practiced; if required, organic pesticides used along with promotion of traditional preventive measures.
- *Harvesting & packaging*: Bags and containers used to harvest and transport jhum organic produce are clean and uncontaminated; used locally available uncontaminated leaves and bamboo baskets for packaging while transporting.
- *Crop residues*: Crop residues left in the field; no burning of crop residue.
- *Fallow management*: A minimum of 8 years of fallow periods maintained in a typical system; and 2 years in a pollarded-alder-based system.
- *Soil chemistry*: Soil properties maintained by appropriate crop mix cultivation, soil and moisture conservation practices, maintenance of at least 8 years fallow.
- *Soil flora and fauna*: Soil faunal and floral population maintained, including soil microbial status ensured by recycling of crop residues and optimum fallowing.
- *Biodiversity in the fields*: Crop biodiversity and biodiversity of fallow areas maintained or enhanced; live hedges maintained as jhum boundaries; *jhumscapes* appear with jhum as islands in the midst of enhanced forest cover.
- *Productivity & food security*: The overall practice is conservation farming with improved land productivity and enhanced food security and income.
- *Land tenure & social equity*: Equitable land access to all members of a given village; effectively prevents unequal or skewed privatization of common property resources, harmonizing with traditional system of social equity.
- *Conversion period*: Suggested period is 12-36 months for general fallow land; a fallow land with a period of 8 years or more may have shorter conversion period.
- *Packaging materials*: Local materials made of leaves, bamboo baskets, etc.; no plastic or non-biodegradable materials used.
- *Markets*: Need for establishing a network of markets and well-established supply chain for organically or naturally produced food crops from Jhum PGS.
- *Pricing and advertising support*: Initially market support for pricing and transport; also support for advertisement of 'niche' crops and consumer education.

However, successful initiation of jhum PGS would require partnership endeavour of the farmers, indigenous community institutions, government agencies and participating NGOs preferably through demonstrative pilot projects. Policy adoption on jhum PGS along with building of market network for organically produced 'niche crops' from jhum and consumer education and awareness would go a long way in grounding and popularizing jhum PGS in Northeast India. Meanwhile, the proponents of *jhum* PGS would have to prove that the organic and ecological standards meet those of NPOP (GoI, 2005) or as described by Khosla (2006) and ECOVIDA (2004).

Conclusions

The people of Northeast India represent a fascinating variety of cultures. Jhum plays an important cultural role in local customs, besides ensuring agro-biodiversity conservation and offering livelihood security to rural upland poor. It would be unfortunate if developmental programmes based on misjudged opinions about jhum suppress this unique form of agriculture. A balanced approach to development which also recognizes the merits of jhum is needed so that this remarkable form of organic farming persists into the 21st century. With appropriate PGS policy adoption and harmonizing jhum with PGS organic standards would enable jhum to be sustainable conservation and ecological farming practice.

Recent studies from the Eastern Himalayas showed that the practice represents enormous diversity of cultivation systems with farmers' ingenuity to local resource management (Kerkhoff and Sharma, 2006). It is widely recognized that several highly productive and sustainable agroforestry systems have their origins in local shifting cultivators' responses to the need to reduce or improve fallow cycles of shifting cultivation (Cairns, 2007). These collectively represent new hopes for shifting cultivation and harmonizing jhum with PGS organic standards could be a rewarding option of translating these hopes and dreams into realities.

Acknowledgments

I would like to thank Mr. K. Moses Chalai, PCDS, NERCOMP-IFAD and Mr. Mattia Prayer Galetti, CPM for India, IFAD for the encouragements and supports.

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What can organic agriculture contribute to sustainable development? – Long-term comparisons of farming systems in the tropics

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Key words: long-term experiments, system comparison, production systems, tropics, sustainability

Abstract

Despite the high demand for sound data on the agronomic, ecological and economic performance of organic agriculture in developing countries, systematic comparison of organic and conventional farming systems has not so far been carried out. The Research Institute of Organic Farming (FiBL), together with its partners, is presently establishing long-term comparisons of farming systems in various agro-ecological and agro-economic contexts to study the different parameters that are essential for sustainable development. To date, three study areas have been selected: (a) a sub-humid area in Kenya where farming is subsistence-oriented; (b) a semi-arid area in India where cotton is produced for the export market; and (c) a humid area in Bolivia where perennial fruits and cacao are produced for the domestic and export markets. The key elements in these comparisons are replicated long-term field trials. These are complemented by farm surveys and short-term trials under on-farm conditions. This network of comparison of farming systems in the tropics is expected to (1) put the discussion on the benefits and drawbacks of organic agriculture on a rational footing; (2) help to identify challenges for organic agriculture that can then be addressed systematically; (3) provide physical reference points for stakeholders in agricultural research and development and thus support agricultural policy dialogue at different levels.

Introduction

In Europe and North America, considerable research has been carried out on organic farming and its impact. The advantages of the organic system in terms of both ecosystem conservation and economic performance have been demonstrated by numerous studies (Pimentel et al. 2005, Offermann and Nieberg 2000, Stolze et al. 2000). An important contribution in this regard has been made by the DOK trial (DOK = (bio)dynamic, organic, conventional), conducted in Therwil, Switzerland, and now in its 28th year (Mäder et al. 2002). Organic farming is now also being promoted by non-governmental organizations (NGOs) in tropical countries, and farmers' groups are adopting organic methods of cultivation to improve their food security and their income (Kilcher 2007). So far, however, there have been no systematic studies examining the efficiency of organic farming methods in the tropics compared to conventional approaches with regard to achieving economic, social and environmental objectives (Parrott and Kalibwani 2006). Whether and how organic farming can contribute to

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development in low-income tropical countries is of interest not only to producers' organizations, but also to research institutes, development organizations, national authorities and international donors.

The Research Institute of Organic Agriculture (Forschungsinstitut für biologischen Landbau – FiBL), together with its partners, has set itself the task of establishing a network of long-term comparisons of farming systems to investigate the contribution of organic farming to enhancing food security, combating poverty and conserving tropical ecosystems.

Research questions

In the long-term comparisons of farming systems run by FiBL, organic farming is compared to conventional production with a view to addressing the following questions:

- How does organic farming influence yield and yield security, especially in years with extreme climatic conditions such as droughts or floods? What impact does it have on product quality and shelf-life?
- How does organic farming influence agro-ecosystem stability and availability and quality of natural resources, especially soil fertility, energy resources, biodiversity and beneficial organisms?
- Do organic products create value-added that generates higher incomes?
- How does organic farming affect the living standard of the farmers?
- How efficient is the organic farming system with regard to nutrient and energy use, and in terms of capital and labour requirement?

Methodology

Central to FiBL's comparison of farming systems in Africa, Asia and Latin America are replicated field trials reflecting the crop rotations and cultivation methods currently practised in the given locality (see also below). These trials are geared towards addressing agro-economic and environmental research questions over a longer period and investigating processes of change. Straightforward analysis of economic feasibility (gross margin) can also be carried out. In a second step, the same parameters are also compared in on-farm trials in conditions that reflect actual practice, but in a shorter time-frame. As part of this, the experiment is repeated for all farming techniques on every holding involved. To complete the picture, farm-level comparison of socio-economic aspects such as income structure and living standard is also carried out (Eyhorn et al. 2007). In regions where there are numerous organic holdings, farms are selected for study on the basis of random sampling. In locations where organic farming is not widespread, pairs of organic and conventional holdings operating under comparable conditions are selected for study. Case studies are also carried out to illustrate the process of conversion and its impact on the environmental, economic and social situation over a longer period (Lee and Fowler 2002). The data base obtained from the field and on-farm trials and surveys is subsequently made available for organic sector development in the region in question, and especially for agricultural training and extension, for market development and policy consultation.

Locations

FiBL and its partners are developing sites for long-term comparison of farming systems in three countries:

In Kenya, investigation centres on largely subsistence-oriented cultivation of maize and vegetables in sub-humid conditions. The farming methods – conventional and organic, at two levels of intensity in each case – were applied for the first time in March 2007. Local partners are the Institute of Insect Physiology and Ecology (ICIPE), the Tropical Soil Biology and Fertility Institute (TSBF-CIAT), the Kenyan Agricultural Research Institute (KARI) and the School of Environmental Studies and Human Sciences of Kenyatta University (KU).

In India, a comparison of farming systems based on cultivation of an export product – cotton – is being set up in a semi-arid region. Soya and wheat, another two important agricultural products in this region, are also included in the investigations. The trial consists of one organic, one biodynamic, one conventional and one GMO system, and operations commenced in the 2007 cotton season. The main local partner is a cotton trading company (bioRe India). Appraisal of research partners is currently under way.

A third site is currently under development in a humid region of Bolivia. In this case, the crop that the trial will focus on is a long-standing export product, cacao, cultivated in agroforestry systems. Planting of the trial site will be carried out in April 2008. The following institutions have joined forces to form a network of partners: Promoción e investigación de productos andinos (PROINPA), Instituto de Ecología de la Universidad La Paz, Asociación de organizaciones de productores ecológicos de Bolivia (AOPEB), El Ceibo.

Strategic objectives

FiBL is developing this network for long-term comparison of farming systems because:

- the debate on organic farming in southern countries needs to be put on an rational basis;
- it will provide governments and donors in southern countries with support for making strategic decisions and developing action plans;
- it will help to identify challenges for organic farming in southern countries and address them systematically;
- it will provide decisive results-based support for developing organic farming in the region in question, as demonstrated by the experience of the DOK trials in Switzerland in the 1970s and 80s.

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Green manuring for tropical organic cropping – A comparative analysis

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Key words: green manures, application, soils, yields, seasons

Abstract

Green manuring is an essential component of tropical organic farming. Field studies evaluated the use of three legumes as in situ or ex situ green manures, along with a nonlegume green manure and a control to ascertain their impacts on soil properties and yields of maize and mung bean grown in major (wet) and minor (dry) seasons. In situ green manuring, especially with legumes, had the most beneficial impact on soil properties, while with ex situ methods, the use of leaves alone improved soil properties. Yields were increased to a greater extent by green manuring in the minor season, and the in situ system proved to be more beneficial. In ex situ green manuring, greater benefits were obtained by the application of leaves alone. The impact of different green manures and their application methods is presented.

Introduction

Green manures are an ideal method of sustaining soil fertility in the tropics (Joergensen, 2002, Fageria, 2007), and in organic farming, for both soil fertility and microbial activity (Palm et al., 2001). Many studies in Asia (e.g. Katyal et al., 2001) highlight the value of green manures, although no studies report the benefits of *ex situ* or *in situ* application of the same material in comparison to that of only *ex situ* green manures on tropical upland crops. Field studies were carried out to compare how green manures grown *in situ* and *ex situ* affected selected soil properties and yields of maize (*Zea mays*) and mungbean (*Vigna radiata*) cultivated in the major and minor seasons of tropical Asia, in contrast to application of only *ex situ* manures.

Materials and methods

The study was carried out at the Experimental Station (418 m above sea level, 8°N, 81°E) of the University of Peradeniya, Sri Lanka, located in the mid-country intermediate zone, over the period October 2004 to August 2005, to encompass the major (WET) and minor (DRY) season corresponding to the Northeast and Southwest monsoons. The soil was an Ultisol (Rhodoult) with a sandy clay loam texture. The site received 722 mm and 236 mm of rainfall in the major and minor seasons and the me an temperature and humidity were 29°C + 2.3°C and 69.5 + 2.33%

The experiment had 9 treatments per species (maize and mungbean), namely ex situ application of gliricidia (Gliricidia sepium) or tithonia (Tithonia diversifolia) leaves, or twigs and leaves, *in situ* or *ex situ* application of crotolaria (*Crotalaria juncea*) or sesbania (*Sesbania rostrata*), and a control with no green manures, replicated three times in a randomized block design.

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The land was well prepared manually in August 2004 and March 2005 on adjacent blocks, with 18 plots of 2x2 m demarcated per replicate. Seeds of crotalaria or sesbania were broadcast on the selected plots for the two crops, and populations of these two species were maintained in an adjacent block for *ex situ* green manuring. In early October 2004 or May 2005, with the rains of the major and minor seasons, the biomass of the two planted green manures were estimated and the selected green manures were applied *in situ* or *ex situ* to the plots at a rate equivalent to 4 t/ ha of dry matter. The *ex situ* green manures – gliricidia and tithonia leaves or leaves and twigs, and sesbania or crotalaria *ex situ* were obtained nearby. C:N ratios of samples were determined. At 15 days after incorporation, soils of the plots were sampled to a depth of 30 cm using cores and analyzed for pH, bulk density, water holding capacity, and soil N by standard techniques as described by Anderson and Ingram (1993). Thereafter, seeds of maize (Var Ruwan OPV) or mungbean (Var MI5) were planted and maintained as per local recommendations without any chemical inputs. Seed yields were determined at crop maturity. The data was subjected to analysis of variance using a general linear model.

Results and Discussion

Sesbania and crotalaria had the highest N contents (Table 1) and the lowest C:N ratios, which are important in green manures. The inclusion of twigs, which is done by most tropical farmers in *ex situ* mulching, reduced N content and increased the C:N ratios of gliricidia and tithonia. Furthermore, tithonia had the lowest N contents and hence the highest C: N ratios thus indicating its inability to provide N to plants in organic systems, although it is known to provide P to crops (Cong and Merkcx, 2005).

Tab. 1. Nitrogen and C: N ratios of the selected green manures

Green manure	N %	C:N ratio
Gliricidia leaves	3.25	18.4
Gliricidia leaves and twigs	2.91	20.9
Crotalaria juncea plants	4.08	14.8
Sesbania rostrata plants	4.56	14.1
Tithonia leaves	0.58	25.7
Tithonia leaves and twigs	0.45	29.4
Probability (n=24)	0.018	0.009

Green manures had no significant impact on soil pH, although bulk density declined significantly when compared to the control (Table 2). *In situ* green manures reduced bulk density to the greatest extent. In *ex situ* mulching, leaves and twigs reduced bulk density more than when leaves alone were added, because of the higher lignin content of the former. The WHC followed the same trend as bulk density, and there was a significant positive correlation (r= 0.76*) between these two variables. Soil N was increased significantly by the legume green manures when compared to the control and tithonia. Again, *in situ* green manuring had a greater significant impact and also the use of leaves alone of gliricidia. This illustrated the benefits of *in situ* green manuring for enhancing soil properties and N. If *ex situ* manuring is adopted, the use of leaves alone would develop a better soil for organic farming

Tab. 2 Selected soil properties at planting as affected by green manures in wet (S1) and dry (S2) seasons, Es = addition *ex situ*, IS = addition *in situ*

Green manure	Ad.	pH (1:2.5 H_2O)		Bulk density $Mg.m^{-3}$		WHC %		Soil N (% Dry wt)	
		S1	S2	S1	S2	S1	S2	S1	S2
Gliricidia L*	Es	6.14	6.23	1.24	1.25	18.4	18.7	2.15	2.02
Gliricidia L & T	Es	6.25	6.39	1.22	1.21	19.9	19.2	2.04	1.98
Crotalaria	Is	6.46	6.52	1.18	1.21	20.2	19.6	2.24	2.15
	Es	6.38	6.27	1.21	1.24	18.5	19.3	2.14	2.05
Sesbania	Is	6.34	6.18	1.19	1.23	19.8	18.7	2.21	2.11
	Es	6.15	6.22	1.23	1.25	18.6	19.1	2.11	1.99
Tithonia L	Es	6.50	6.58	1.29	1.31	19.5	19.4	1.76	1.77
Tithonia L & T	Es	6.24	6.43	1.24	1.25	18.2	19.8	1.62	1.65
Control		6.15	6.13	1.35	1.36	15.6	14.8	1.58	1.54
Probability (p=0.05)		0.049	0.057	0.038	0.024	0.046	0.018	0.021	0.017

*L & T refer to leaves and twigs respectively

Green manures enhanced yields of both crops, especially the lower yields in the minor dry season, which could be attributed to the enhancement of soil water holding capacity. The legume material when grown *in situ* had a greater beneficial impact. In *ex situ* green manuring, the use of leaves alone had the greatest beneficial impact. Tithonia, although it provides P to plants, could not have the same impact on yields as N is the most limiting nutrient in most tropical soils (de Costa and Sangakkara (2006).

Tab. 3. Yields of maize and mungbean (kg ha^{-1}) in major and minor seasons as affected by green manures and method of application

Green manure	Addition	Maize		Mungbean	
		Major	Minor	Major	Minor
Gliricidia L	Ex situ	3251	2471	956	674
Gliricidia L & T		2433	1958	825	615
Crotalaria	In situ	3998	2941	999	701
	Ex situ	3704	2665	921	756
Sesbania	In situ	3790	2781	1001	795
	Ex situ	3410	2485	954	741
Tithonia L	Ex situ	3041	2104	825	642
Tithonia L & T	Ex situ	2534	1917	758	542
Control		1844	1452	458	329
Probability (p=0.05)		0.038	0.027	0.005	0.019

Thus, the study highlighted the importance of green manuring for tropical organic cropping. Legumes, especially as *in situ* green manures, had a greater beneficial impact, especially in the minor dry seasons. If *ex situ* green manuring is adopted, the use of leaves is the best option rather than the common practice of adding the entire shoot.

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Population Density and Distance to Market Does not Influence the Farmers' Use of Organic Manure

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Key words: Organic manure, socio-economic-ecological-modeling, integrated soil fertility management, Savannas, Nigeria.

Abstract

This study developed and employed a socio-economic-ecological-modeling (SEEM) framework in its analyses. The SEEM is made up of four resource use domains of high/low population density and high/low access to market and two agro-ecologies in the savanna of Nigeria. Data used comprises a sample of 320 farm households in northern Nigeria. The pattern of organic manure use varied slightly and insignificantly across agro-ecological and resource use domains. The major finding of the study is that the resource use domains made use of same amount of organic manure. The level of organic manure use is, however, below the recommended levels for the cereal-based production systems in the study area. Policy that encourages the intensity of manure use and crop-livestock integration is recommended to support integrated soil fertility management practices in the study area.

Introduction

Population pressure increases, shortened fallow cycles, cropping intensification, inaccessibility and low output pries and concerns about agricultural sustainability and self-sufficiency have combined to contribute to increased demand for integrated soil fertility management of the agricultural resource base. Following this situation, organic manure in the form of animal manure becomes one of the principal sources of nutrients for soil fertility maintenance and crop production. Also, there is need to investigate the present level of use of organic manure in order to knowledge gap by agro-ecologies using the methodologies of resource use domains which are importance drivers of agricultural intensification and commercialization (Manyong et al. 2003). Hence, this study assessed the socioeconomic and ecological interactions in organic manure use in northern Nigeria.

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Materials and methods

This study was conducted in the savannas of northern Nigeria - the northern Guinea savanna (NGS) and the Sudan savanna (SS) agro-ecological zones (AEZ) represented by the Kaduna and Kano States as benchmark areas, respectively (Manyong et al., 2003). The *length of growing period* (LGP) was adopted in stratifying sample by global agro-ecological zoning (FAO/IIASA, 2000). The LGP is 150-180 days for the NGS and 90-150 days for the SS. Kaduna State lies between latitudes 9^{0} $04^{/}$ to $11^{0}50^{/}$ N and longitude $6^{0}09^{/}$ to $10^{0}41^{/}$ E. Kano State lies between latitudes $10^{0}33^{/}$ to $12^{0}37^{/}$ N and longitude $7^{0}34^{/}$ to $9^{0}25^{/}$ E. The NGS and the SS were chosen because these two zones support the highest concentration and density of livestock in Nigeria (Thornton et al., 2002; Manyong et al., 2003).

Four socio-economic resource use domains of the clusters of similar resource and farming conditions, resulting from a combination of high and low population density areas and high and low market access areas were generated through a geo-spatial mapping estimated using the Arcview© software - a GIS software. In deriving the population factors, a rural population density of less than 100 people per square kilometer was estimated and identified as low population density (LP) while a population density of 100–500 people per square kilometer was estimated and identified as high population density (HP). Anything otherwise was defined as an urban population. Also a proximity of 20 km radius to a town or city was defined as high market access (HM); anything otherwise was defined as low market access (LM). These domains reflect differences in opportunities and correspond to agricultural intensification, which is in turn strongly influenced by population density and access to markets (Devendra and Pezo, 2002). A total of 20 farm households were randomly selected from the pool of villages generated by the GIS by using the random number table that resulted to 320 farm households from 16 in the study area. The coordinates of the geo-referenced 16 villages were verified using a hand-held Magellan© 330 geo-positioning system (GPS) instrument during the ground verification/truthing exercise. Data analysis involved the use of descriptive and inferential statistics.

Results and Discussion

The use of manure is a well established practice in the agricultural system in the study area. Ninety percent of the farmers used manure, though at low intensity of use. The mean manure use in the study area is 1850 kg ha^{-1}. This represents 382 percent increase over the 485 kg ha^{-1} reported by Manyong et al. (2003). The results thus show higher level of intensification in organic fertilizer use in the study area. Also, there was higher level of organic fertilizer use (or intensification) of 1870 ± 1170 kg ha^{-1} in the SS compared to the of 1830 ± 1570 kg ha^{-1} in the NGS. However, the averages are still insufficient to meet the animal manure of 3–5 tons ha^{-1} required to maintain cereal grain yields in the region (Bationo and Mokwunye, 1991, Chianu and Tsujii, 2004). Analysis of means difference show that there was no significant difference in use of manure in the two agroecological zones, and by socioeconomic/resource use domains. It should be emphasized; therefore, that increased use of organic fertilizer is required to meet the challenges of increasing human population, low agricultural productivity, high land use intensity and expansion of agriculture to marginal lands.

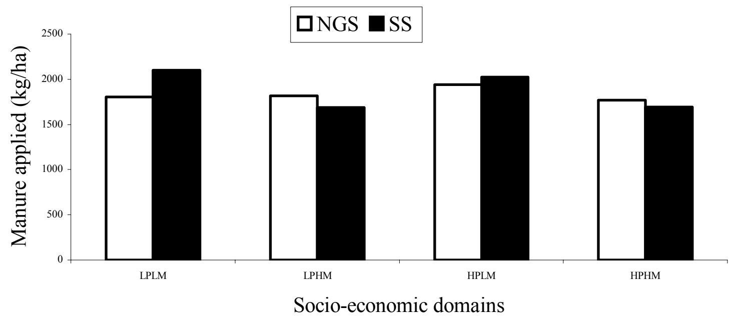

Figure 1: Manure use by socio-economic domains

Conclusions

The extent of manure use varied widely across socio-economic resource use domains. The low population density and low market access (LPLM) socio-economic domains had higher intensification (2100 kg ha^{-1}) in manure used in the SS compared to the 1803 kg ha^{-1} of the NGS (Figure 1). Given the socio - economic domains of low population, the difference observed in the intensification levels (reduction) of manure use per hectare (1685 kg ha^{-1}), when we moved to the LPHM in the SS, could be explained for the difference in the access to the market. While there are differences in the manure used per hectare across the socio-economic domains, the low market access areas intensified more in manure use as hypothesized, than the high market access area, perhaps because of the greater grassland and availability of fodder for animal to generate manure as well as high livestock density in the area.

Acknowledgments

The authors thank the International Institute of Tropical Agriculture (IITA) and Directorate General for Development Cooperation (DGDC), Belgium, for funding this project.

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Organization of a Sustainable Agroforestry Model for Small Farmers in the Montes de Oro Region, Puntarenas, Costa Rica

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Key words: organic coffee, Costa Rica, small farmers, bird diversity, farming systems

Abstract

The Montes de Oro Region, in the Puntarenas Province, Costa Rica, is a marginal agricultural area with coffee production as the main activity. The region faces a number of social and economic problems, worsened by the reduction in forest areas, increase in soil erosion, absence of sustainable land production alternatives and heavy dependence to imported pesticides.

This project looked to protect the region's biodiversity and to contribute to mitigate the negative environmental effects through the implementation of organic coffee production systems, integrating ecological, social and economic factors to offer sustainable and profitable production alternatives. Six components were looked at: associated crops, establishment of shade trees and windbreaks, fertilization, studies of bird diversity and improved coffee processing systems. We present the results of a three year study case.

Introduction

In spite of the low international coffee prices, coffee production in Costa Rica is still an important commercial activity. Its contribution to the national Gross Internal Product during the last years has been around 15%, and it represents approximately 4% of the total exports. About 91% of the coffee production is concentrated in small or medium size farms and the activity offers employment to more than 300.000 people during harvesting time (ICAFE, 2004).

The Montes de Oro region, in the Puntarenas Province, Costa Rica, is a marginal agricultural area with coffee production as the main activity, although during the last years there has been a strong migration of farmers to cities, in search of better job opportunities. The region faces a number of social and economic problems, worsened by the reduction in forest areas, increase in soil erosion, absence of sustainable land production alternatives and a heavy dependence to imported pesticides.

The objectives of the present project were: to protect the region's biodiversity and to contribute to mitigate the negative environmental effects through maintenance or implementation of organic coffee production systems, integrating ecological, social and economic factors to offer sustainable and profitable production alternatives.

The project worked on 6 components: 1) associated crops, 2) establishment of shade trees using fruit and native forest trees 3) establishment of windbreaks 4) fertilization 5) studies of bird diversity and 6) improved coffee processing systems.

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Sustainable Production Model Components

1) Associated crops

A survey was carried out among 149 farmers belonging to ten localities to identify the crops more frequently intercropped with coffee. According to the survey, the main crops associated to coffee plantations are tomato, sweet pepper, dry and green beans and corn. Farmers said to prefer these crops as they are well known, have a safe market and are easy and fast to produce. However, it also has to do with tradition and the lack of knowledge about other promising crops and improved varieties. Due to these results, farmers were trained on new technologies used in organic vegetable production (greenhouse, seedling production, pest control, improved varieties and soil conservation practices).

The project also participated in an interinstitutional effort to organize a vegetable gathering center for the region. The main market problems identified in the survey were: high cost of transport (43%), intermediaries (15%), lack of markets (13%), low and unstable prices (8%), bad roads (6%), poor farmers' organization (5%) and other factors (10%). Farmers were asked to suggest how to improve the crop market. They are well aware that a change in attitude is necessary and that they should organize themselves to access safer markets, obtain better prices and reduce production costs; however, they pointed out the need of more efforts from the local authorities.

2) Establishment of shade plants.

The use of shade trees benefit coffee plantations in various ways: they enhance fauna diversity, improvement of ecological conditions of the production unit and produce goods of immediate usage (Benzing 2001).

Shade plants were produced in the Cedral Farmers' Association nursery. A total of 8,400 shade trees were distributed during two years among farmers of Montes de Oro for 77.6 ha of coffee with shade. The tree species planted were *Leucaena*, *Gliricidia sepium*, *Albizia adinocephala*, *Erytrina poeppigiana*, *Casia* and *Alnus jorullensis*; of this 1,934 were fruit trees (avocado, various citrus species, macadamia and soursoup). The introduction of shade and fruit trees had various purposes: diet improvement within the population, an alternative income for the farmers, and the protection of water springs.

3) Establishment of windbreaks.

Windbreaks are formed by one or more lines of plants of the same or of different plant species which cover different height structure, planted parallel and perpendicular to predominant wind. The use of windbreaks reduces eolic erosion, protects crops, animals and water springs, and helps prevent pasture from drying out during summer.

A total of 42.500 trees were established for 37.000 m of windbreaks, with 367 ha protected at 5 years after planted, when maximum growth of the trees was expected. Different arrangements of the following tree species were used: *Cassuarina equisetifolia*, *Eucalyptus* spp., *Eugenia jambos*, *Coutorea latiflora* and *Cupressus lucitanica*.

4) Fertilization

With the aim of reducing the high costs of fertilization without affecting grain quality and production, four fertilization alternatives were evaluated, together with a generalized application of Bocashi (5 ton ha-1): two annual applications of a physical mixture of N, K and B at a cost of US $60 ha-1 yr-1; 2) two annual applications of a physical mixture of N, K, Mg and B at a cost f US $66 ha-1 yr-1; 3) two annual applications of a physical mixture of N, K, at a cost of US $47 ha-1 yr-1; 4) two annual applications of a physical mixture of the formula 18-5-15-6-2 (600 kg ha-1 yr-1) at a cost of $100 ha-1 yr-1.

All of the fertilizer alternatives had higher productions than the conventional fertilizer scheme accounting for an increase of 8 – 10% for alternatives 1 and 3, and of 18% for alternative 2. In conclusion, it is possible to reduce production costs without affecting yield.

5) Bird diversity

A study was carried out to evaluate bird diversity and abundance in two areas of Montes de Oro. The first area (1300 masl) was located in the very humid premontane life zone, dominated by coffee plantations, cattle farms, secondary forest and border of harvested forests. The second area (1000-1450 masl) corresponded to the montane life zone.

A total of 151 bird species was found in the study area. Ten species were exclusive to the limit between the premontane and montane forest, i.e. they were not present in coffee farms. From the 141 species found in the zone where coffee is grown (premontane forest), 28 species were never registered in coffee plantations, while the rest (80%) were observed in coffee and surrounding farms. The 28 species not registered in coffee plantations were insectivorous and frugivorous birds, dependent of the forest for feeding, or that occasionally come out the forest but need native fruits for their nourishment (Stiles y Skutch 1989).

The number of birds found in coffee farms was similar to that of the surrounding zone; however, bird diversity was higher in the surrounding areas than in the coffee farms. It is recommended to plant native fruit trees within the coffee plantations to attract bird populations. The recommended tree species are: *Citharexylum caudatum* (Verbenaceae), *Ficus pertusa* (Moraceae), *Trichilia havanensis* (Meliaceae), *Ocotea* and *Nectandra* spp. (Lauraceae), *Conostegia xalapensis* (Melastomataceae), *Dendropanax arbore* (Araliaceae) and *Sorocea trophoides* (Moraceae). It was also suggested to increase the number of shade trees within the coffee plantations to increase insect population for insectivorous birds.

6) Coffee processing

A Compact Ecological Processing Unit (UCBE) was purchased to process the organic coffee. This unit reduces the water required for processing from 800 l to only 11 l (for 258 Kg of coffee), also reducing contaminations and costs of treatment of residual waters. In addition, there is a significant reduction in energy consumption, since there is no need to use the main plant to process the small amounts of coffee produced at the beginning and end of the harvesting season.

The use of the new unit also reduced the time from depulping to storage from 10 days in conventional processing to 3 days, which increases the grain yield and quality. The size of coffee yard was increased in order to use solar energy for drying the coffee beans thus reducing signifficantly the use of wood during coffee processing. All these improvements resulted in the CoopeMontes de Oro processing plant being granted with the ISO14000 certification, which implies an improvement in environmental protection and quality.

Conclusions

Farmers were receptive to the improvements suggested. Vegetable production increased in diversity, quantity and quality. However, the establishment of a vegetable gathering centre was never achieved.

New agroforestry practices were introduced: a) windbreaks, which resulted in the protection of 367 ha of crop land, b) water spring protection, which will assure water availability for farmers living downstream, c) shade trees, which improve nutrient cycle, represent a long term cash crop, benefit fauna diversity, and farmers' nutrition.

From a total of 250 farmers from Montes de Oro, Puntarenas, 10 % went into organic coffee and are certified by ECOLOGICA; their production was sold at $200/100 kg of roasted coffee in 2006; 80% sell their coffee as fair trade with a price of $131/100 kg; the rest of the producers are conventional, and their production is paid at $80/100 kg.

With this project, the Montes de Oro farmers' lifestyle was improved.

Acknowledgments

This work could not been done without the aid of Allan González, Javier Flores, Johel Chávez, Luis Alpízar, Farmers Association of Cedral, Víctor Julio Arce and the financial support from the Dutch Government and Fundecooperación, Costa Rica.

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Study the effects of conventional and low input production system on quantitative and qualitative yield of *Silybum marianum* L.

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Keywords: *Silybum marianum*, production system, planting time, seed yield, quality.

Abstract

This investigation was carried out in the spring of 2005 – 2007 in the Research Station of Rangelands in Hamand - Damavand region of IRAN to study the effects of conventional and low input production systems on seed yield and sylimarin percentage of Silybum marianum L. This experiment was done in split-split plot based on randomized complete block design with 3 replications. Treatments were 2 production systems (Conventional and Low input system) in the main plots, 3 planting time (25 of March, 4 and 14 of April) in the sub plots and 2 seed types (Improved and Native of Khoozestan) in the sub-sub plots. Results showed that there was a significant difference between production systems. The highest height (125.8cm) and number of capitols per plant (10.4) were obtained in conventional system. While other traits including capitol diameter (7.028cm), number of seed per capitol (125), 1000 seed weight (25.006g), seed yield (1888.072kg/ha), silymarin percentage (%7.711) and silymarin yield (150.443lit/ha) were recorded in the low input system. Results showed that because of using vermicopmpost and its effects on plant growth in low input system, highest seed yield and silymarin yield were obtained in this treatment. Seed planting in the first time of planting (25 of March) had the same effect on growth and yield. Highest values were recorded in the first time of planting (25 of March). Also, improved seed caused more seed and silymarin yield. Results showed that for getting highest seed and silymarin yield, using improved seed and low input production system is necessary. Also, according to the climatic condition, seed must be planted as early as possible. In this investigation, the best time of planting is 5 March).

Introduction

Siybum marianum is native of the East Mediterranean and Asia Minor, and is one of the most frequent medicinal herbs grown in Iran (Anonymous, 2003). The pharmaceutical industry uses the content of flavonolignans (silybin, silymarin, silydianin and silicristin) in the seeds, which have a hepato-protective effect. The most important its constituent is Silymarin that is used widely in pharmaceutical industry (Omer *et al*., 1995). Medicinal plants production is mainly dependant on ecological condition. In this respect, using correct production system is crucial. In Iran, there are more than 7500 plant species which most of them have valuable active substances. One of the most important of them is *silybum marianum*. Recently its cultivation has started and several drugs have produced from its silymarin (anonymous, 2003). This is very important to reduce chemical drugs and increase individual health. The

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question of the right planting time of Milk thistle in relation to its yield and silymarin content has been subject of discussion. Although it is stated that Milk thistle should be sown in autumn, but it is dependant on ecological condition and objective of production. There are no studies on spring cultivation of Milk thistle in these regions. One of the problems in Hamand region is finding out the adaptability and correct production system. In low input production system, less energy and chemicals is used. So, such systems are accordance with principles of sustainability and ecosystem health (Sharma, 2002). Milk thistle is a long day plant and planting time has major effects on seed yield and silymarine percentage (Omer *et al.*, 1990). So, by choosing correct time of planting, plant density and production system, growth and development will accordance with optimum temperature and solar radiation in the local region and subsequently seed yield and silymarin percentage will increase. Objective of this investigation is to find out the suitable production system, seed type and planting time of Milk thistle to exploit its yield potential for its recommendation to the farmers of Hamand region.

Materials and methods

Field study was carried out in the spring of 2005-2007 at the Rangeland Research Station of HAMAND - DAMAVAND region at east part of Tehran province in IRAN. The soil of the experimental plots was loamy in texture, rich in nitrogen, available phosphorus and medium in potassium with slightly alkaline in reaction (table 1).

Tab. 1: Physical and chemical characteristics of soil in experiment site

Texture	OC%	Total N%	Available P (ppm)	Available K (ppm)	pH
Silty Loam	0.5	0.05	20	349	7.6

Treatments were two levels of production system (Conventional and Low input system), 3 times of planting (25 of March, 4 and 14 of April) and two seed type (Improved seed and Native seed of KHOOZESTAN). In conventional production system, chemical fertilizers (according to the soil test and fertilizers recommended by Research Institute of Soil and Water for the region) and chemical herbicides were used. While, in low input system, 50% of the fertilizers amount in the conventional system were applied and weeds hoed only by hand. Also, 15 ton/ha vermicompose were used in low input production system. The experiment design was split - split plot with three replications. There were 6 rows with 5m long and 3m width in each plot. Plots were irrigated at 7 days intervals. Final harvest was taken from two central rows ($2m^2$) by hand. Harvesting was started when seeds in capitols matured and silks were appeared in the capitols. Then, seeds were dried in the oven at 75^{o}C for 48 hours. Silymarine of seed was extracted at the laboratory of IA university of Roodehen.

Statistical analysis

Data ware subjected to statistical analysis using ANOVA, a statistical package available from SAS. Means comparisons were done by Duncan multiple range test at 5% level.

Results

There were significant differences in all measured traits in response to production systems. Results show that the highest number of capitol per plant (10.4 capitol/plant) and height (125.8cm) were obtained from the conventional production systems. (Table1). These results are supported by previous studies (Omer et al., 1990). The highest capitol diameter (7/1cm), seed number per capitol (125 seed), 1000 seed weight (25.1 g), seed yield (1888/1 kg/ha), silymarin percentage (%7.7) and silymarin yield (150.4 lit/ha) were obtained from low input system. Integration of chemical fertilizers and vermicompost improved soil composition and caused better condition for plant growth and development. This is related to the higher soil biology activities, better soil composition and nutrient availability in the soil (Sharma, 2002). Among the various levels of planting time, the highest yield and silymarin percentage were obtained from the first level of planting time (25 of March). In regards to seed type, the highest seed numbers per capitol and silymarin percentage were obtained from native seed of KHOOZESTAN. But, in other traits, improved seed had better results and significantly was better. The results of this investigation showed that using low input system and improved seed are essential for obtaining the highest seed yield and silymarin percentage. As it is clear in the table 1, farmers in the Hamand region, must start to plant milk thistle at the time which ecological condition allow them. So, 25 of March is the best time. In the low production system, quantitative and qualitative yield is more than conventional system and, of course, expenses will decrease and incomes will be more. This is the thing that farmers and ecologists are looking for it.

Tab. 2: Mean comparison for quantitative and qualitative characters in milk thistle

Treatment	Height (cm)	No. of seed per flower	1000 seed weight (g)	Seed yield (kg/ha)	Silymarin %
Conventional system	125.8 a	10.4 b	17.5 b	1099.5 b	5.9 b
Low input system	94.5 b	125 a	25 a	1888.1 a	7.7 a
25 March	127.2 a	132.4 a	26.6 a	1868.7 a	8.6 a
4 April	111.8 b	112.8 b	20.1 b	1462.2 b	6.7 b
14 April	91.7 c	98.8 b	17 b	1150.5 c	5.1 c
Improved seed	130.3 a	126.7 a	25.1 a	1832.3 a	6 b
Native seed	90.2 b	102.6 b	17.4 b	1155.4 b	7.6 a

*Means with similar letters are not significant at the 5% probability level (Duncan test).

Discussion

The results of this investigation showed that using low input system and improved seed are essential for obtaining the highest seed yield and silymarin percentage. As it is clear in the table 1, farmers in the Hamand region, must start to plant milk thistle at the time which ecological condition allow them. So, 25 of March is the best time. In the low production system, quantitative and qualitative yield is more than conventional system and, of course, expenses will decrease and incomes will be more. This is the thing that farmers and ecologists are looking for it.

Acknowledgments

The authors thanks Department of Research of IA University, Roodehen branch for financial support.

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Integrating pigeonpea in maize based farming systems may increase food production and alleviate poverty

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Key words: multifunctional crops, intercrops, cash crops, gender, food security

Abstract

Pressure on natural resources implies that millions of farmers in semi-arid eastern and southern Africa face very low and declining crop yields. Major natural constraints are the nitrogen and phosphorus supply together with insufficient and highly variable rainfall. This article addresses the possibilities for improved soil fertility, increased productivity and income opportunities among smallholders in semi-arid eastern and southern Africa through the integration of improved pigeonpea in maize-based cropping systems. Specifically farmers' experiences with cultivation and integration of pigeonpea in maize-based cropping systems are discussed. This includes how the integration of pigeonpea affects the livelihood situation of rural smallholders – male as well as female in terms of increased food security, increased income, improved gender equity in access to resources etc. While many 'blessings' of integrating the multi-purpose crop pigeonpea in maize-based cropping systems are confirmed, it is also shown that socio-economic and biophysical diversity must be taken into account when evaluating impact of pigeonpea on livelihoods of different groups of farmers.

Introduction

Growing population, unequal distribution of and increasing pressure on natural resources in Africa implies that cultivation takes place on more and more marginal land, causing millions of farmers in semi-arid Eastern and Southern Africa to face low and declining crop yields. Coupled with removal of fertilizer subsidies in the early 1990is, the constraints of limited nitrogen and phosphorus supply together with insufficient and variable rainfall are being felt by an increasing number of farmers. Hence, farmers are especially looking for biological alternatives to establish cropping systems characterized by high production capacity and stability in order to obtain cash income opportunities and food security but too little emphasis has been put on developing such alternatives.

Intercropping of maize and grain legumes is a common practice in many areas in Africa although the rationale behind is not always clear. Pigeonpea is a multipurpose leguminous shrub, which thrives on poor soils. It is grown with the aim of increasing household cash income and for food, fodder, firewood, and soil fertility improvement. There is an increasing international market for pigeonpea grain. Thus, maize

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intercropped with long-duration pigeonpea has emerged as a highly productive system with multiple beneficial effects on the farming systems. Consequently, these cropping systems are widespread in some areas of eastern and southern Africa. Intriguingly, however, few kilometres away pigeonpea may not be found without apparent socio-economic, cultural, or biophysical causes to explain the change.

The objective of this article is to present results from a multidisciplinary and participatory on-farm study in Malawi and Tanzania. The overall theme of the study is to investigate the possibilities to improve soil fertility, increase productivity and income opportunities among smallholders in semi-arid eastern and southern Africa through the integration of pigeonpea in maize-based cropping systems.

Throughout the research, it was assumed that the agronomic results could be interpreted through a socio-economic prism and that yields of each component of the intercropped crops of maize and pigeonpea may be affected by the composition, size and gender of the farming households, as well as these households access to farmland.

Materials and methods

In Tanzania, maize is a major food crop, grown and consumed as stable food by the majority of the population in Tanzania. Half of all Tanzanians are considered to be basically poor and the poorest sections of the rural population are mainly found in semi-arid and remote areas. Between 12-15% of all rural households in Tanzania are female headed (World Bank, 2000). In Malawi over 90% of the total cultivated land area is planted to maize, mostly by resource poor smallholders. Eighty percent of the rural population is farming less than one hectare (Anon, 2003) which causes many families to live on the edge of hunger. Forty percent of the families with less than 0.5 hectare are female headed (Anderson, 2002).

In Tanzania, clusters of villages were selected in Babati district and Gairo Division, Kilosa District, Morogoro Region. In Malawi, two extension planning areas (EPA) were selected, each containing several villages. Nyambi EPA is located within Kawinga Rural Development Projects and Machinga Agricultural Development Division. Ntonda EPA is located within Blantyre Rural Development Projects and Blantyre Agricultural Development Division.

A total of more than 80 farmers were selected, equally distributed at the four research locations, based on their willingness to be involved in research. The selection was done at group meetings with farmers and based on (i) size of landholding, (ii) type of land tenure, and (iii) gender.

The agronomic performance of local and improved pigeonpea genotypes was studied at trial plots fully managed by farmers under farmers' conditions. Data are included from the two cropping seasons of 2001-2002 and 2002-2003, which means that the crop yields from total of 640 plots are included in the data analysis. These data are presented as means over the two years.

The data were analyzed by multiple regression analysis using a general linear model via the SAS GLM procedure. Open-ended questions were evaluated by calculating the mean response using the LSMEANS procedure after having identified the major categories represented by the answers. Comparison of the means for the individual treatments was done using a Waller-Duncan *t*-test.

Results and Discussion

Productivity measured as grain yield showed tremendous differences both in sole maize and in maize grown together with three pigeonpea genotypes. Maize yield decreased ($P<0.05$) in the order Babati>Ntonda>Gairo>Nyambi. However, pigeonpea grain yield followed an order of Ntonda>Babati>Nyambi>Gairo.

The importance of pigeonpea in producing protein is illustrated as the highest nitrogen yield is obtained in some of the areas with the lowest maize yield. Inclusion of the other crop parts only enlarges these differences as the differences in nitrogen content accounts to the residues also. This is important, as large proportions of the residues are re-circulated.

Across all environments, maize yields tended to decrease (P=12) in female-headed households compared to male (data not shown). Maize yields even further decreased at households headed by single parents or females. In contrast, the pigeonpea grain yields were unaffected (P=0.69; data not shown) by gender of household head, although the pigeonpea grain yields of single parent/female headed households tended to be higher than for the other types of households.

In the literature it is often argued that female farmers are less productive than male farmers in relation to maize yields because women have less access to chemical inputs and technical know-how than men. The current study shows that women's productivity in relation to other crops than maize, such as pigeonpea, in some cases can be even higher than that of men without access to special inputs.

Across all environments, the access of households to land influenced maize yields (P=0.12) and pigeonpea yields in particular (P=0.006) (data partly shown in Fig. 1). Clearly those households with most land obtained the highest maize yields. However, pigeonpea showed exactly the opposite effect; favoured by the households with small land access.

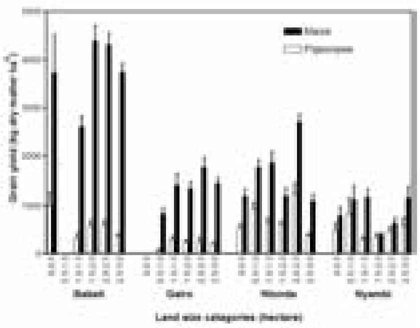

Figure 1: Relation between land size and mean grain yields from four sites of maize and pigeonpea over two consecutive cropping seasons. Bars represent ±SE; n varies depending on category.

The data yields no clear indication of why grain yield of pigeonpea should be higher at the smaller holdings. However, as there is no relation (R^2 = 0.08) between land size and household size, it is hypothesized that the lower pigeonpea grain yields at those households with the largest land holdings can possibly be sought in constraints in seed availability at planting; a common feature for many of the trial farmers and also reported elsewhere (Snapp et al., 2002).

Labour constraint during weeding of the crop is well known to reduce maize yield but pigeonpea yield is not affected by a few weeks delay in weeding which gives farmers more flexibility in coping with the agricultural tasks during peak seasons. The present data confirm that household size has no effect (P=0.55) on grain yield of pigeonpea but significantly affected (P=0.01) maize grain yield (Fig. 2).

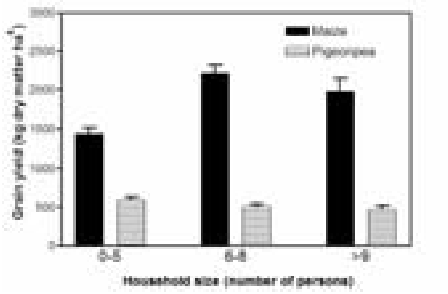

Figure 2: Relation between household size and mean grain yields of maize and pigeonpea over two consecutive cropping seasons. Bars represent ±SE; n=480 for pigeonpea and 640 for maize.

Conclusions and perspectives

Integration of pigeonpea into the maize based farming systems in all cases significant increased total productivity of food and fuelwood and it generated a potential high-value cash crop. In perspective, there is effective market demand for both whole grain as well as processed pigeonpea products from Eastern and Southern Africa in several global markets. Further a local market for green pods is rapidly developing in the larger cities. A significant backup must however be created to make a market-approach a realistic strategy for resource-poor farmers despite the multifunctional advantages of pigeonpea.

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Plant Products as Biopesticides: Building On Traditional Knowledge Of Vrkshayurveda: Traditional Indian Plant Science

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Key words: Biopesticides, traditional knowledge, sustainable agriculture, vrkshayurveda

Abstract

Today there is a global search for alternatives to chemical pesticides and as part of this process there are various efforts to test the use and efficacy of natural products for pest control and crop protection. Our Centre has been involved in exploring the traditional knowledge regarding the use of natural products for pest control and crop protection. As part of this effort, we have looked at the traditional folk practices prevalent among farmers as well as information from classical literature on the subject drawn from Vrkshayurveda (traditional Indian plant science). Following this, we have carried out experiments for standardizing and field testing promising natural products by determining the precise range and kind of pests controlled by them, determining the optimum concentration where they can be effective against pests without being harmful to useful organisms and predators as well as studying their mode of action. Subsequently, we have also developed storage forms of various of these products by using methods based on Ayurveda. Studies on the stability and shelf life of these products are also being carried out through an insect rearing laboratory. Finally, we have also set up village based biopesticides units where a range of these products are being prepared thus providing valuable inputs to sustainable agriculture and a means of livelihood to rural women and farmers.

Introduction

Vrkshayurveda literally means – "The Science of Life of Plants". There is a vast body of literature on Vrkshayurveda both in Sanskrit and our regional languages. It encompasses areas such as collection, selection and storage of seeds; germination, sowing, various techniques of plant propagation, grafting, nursing and irrigation; testing and classification of soil and selection of soils suitable for various plants/types of plants; manuring; pest and disease management/preventive and promotive care to build up disease resistance and to cultivate healthy plants; nomenclature, taxonomy, description and classification of plants to suit varied purposes; favourable and unfavourable meteorological conditions for various operations related to cultivation (such as sowing, harvesting) and use of plants as indicators of weather, water, minerals, etc. A series of publications brought out in recent years provides an overview of varied aspects of Vrkshayurveda, covering – a general introduction to this area, plant propagation techniques, nomenclature and taxonomy and pest control and disease management in Vrkshayurveda (1-2).

The Centre for Indian Knowledge has been involved in doing a lot of work relating to Vrkshayurveda for the past several years (3-6). This has included survey and

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collection of literature on Vrkshayurveda, shortlisting techniques and recipes for specific problems and testing out prescriptions of Vrkshayurveda in practice. Our Centre has been working with several plant products and also experimenting to test the efficacy of these plant products against different pests in farmers' fields.

Standardisation of Use

Over the last ten years our Centre has carried out a large number of experiments and tests to standardize the use of plant products for pest control. Even though a large number of anecdotal accounts and field reports are available a lot of rigorous work needs to be carried out before we can state that the efficacy of use of a plant product has been convincingly demonstrated. Based on these experiments, we have tested out practically the utility of a large number of plants and their extracts for different pests, crops and diseases. Some of the plants for which we have carried out such tests are neem, garlic, onion, persian lilac, turmeric, ginger, tobacco, papaya, leucas, pongam, tulasi, aloe, custard apple, vitex, sweetflag, poison nut, calotropis etc. Farmers are used to pesticides which are packaged and available from the shelf. Even though farmers realise the importance of using plant products as alternatives to chemical pesticides, the widespread use of these plant products will take a while to become very popular. One of the ways by which they can be popularised is to process it and make it available to the farmers in a readily usable form.

Materials and Methods

Ayurvedic approach to produce Storage Forms : Subsequently, we commenced a project for the preparation of storage forms of biopesticides based on ayurvedic principles. This work was taken up with an objective to prepare storage forms of biopesticides with increased shelf life. The Centre has a good expertise in the area of vrkshayurveda and ayurveda and hence we thought it would be best to take up processing of these plants along ayurvedic principles. The shelf life (i.e. the period for which they can be stored without loss of biological activity) of some ayurvedic preparations are as follows Swarasa or juice (3 – 4 hours), Kashayam or water extract (24 hours), the storage forms are - Churna or dry powder (6 – 12 months), Thailam or oil extract (1 – 3 years), Arkam or distillate (1 – 5 years), Asava / Arshta or fermented extracts (3 – 5 years)

Results and Discussion

Experimentation with the Storage Forms : After initial trials with 60 preparations the number of preparations taken for detailed experimentation were narrowed down to 25 preparations. The biopesticides that were prepared were tested out in experimental plots laid out in the CIKS experimental farms as well as in farmers' field. However, we have not carried out comparisons of these preparations with commercially available storage forms of biopesticides. A list of thirteen of these products that have been tried out and found to be effective are given below.

Table 1: Selected promising biopesticides, d = days, m = month, w = week

Name of the Preparation	Croptested	Effective Against	Shelf Life
Adathoda kashayam	Paddy Vegetables	Leaf folder, bacterial leaf blight, *Helminthosporium* leaf spot	3 m
Pudhina kashayam			
Thriphala kashayam	Paddy, Ladies finger	Bacterial leaf blight and *Helmintho sporium* leaf spot,	3 m
Andrographis kashayam	Vegetables	Aphids and borers in brinjal, ladies finger	3 m
Sida kashayam			
Prosophis kashayam	Paddy	Bacterial leaf blight, *Helminthosporium* leaf spot, Blast	3 m
Barley *Sesamum* Horsegram kashayam	Vegetables	Acts as fruit yield enhancer	3 m
Cow's urine arkam & Sweet flag arkam	Paddy, Ladies finger, Chilli	Bacterial leaf blight, *Helminthosporium* leaf spot, vein clearing disease, fusarium wilt,	6 m
Garlic arkam	Paddy	Leaf folder, bacterial leaf blight, *Helminthosporium* leaf spot	6 m
Neem seed extract	All crops	Leaf folder, aphids, Jassids, fruit borer and stem borer	1 m
Five leaf extract	All crops	Jassids and borers	1 w
Garlic, Ginger, Chilli extract	All crop	Hoppers and borers	3 d

Conclusion

Summing up we present below some of the special features and highlights of our efforts

1. A large amount of literature has been collected and processed to identify traditional practices relating to plant protection from folk practices of farmers, reported field practices and the classical textual literature of vrkshayurveda.

2. We have tested and standardized the use of several practices looking into detail at some identified plants, which were listed earlier.

3. We have experimented with and standardized storage forms of thirteen these natural products, which can be prepared based on the ayurvedic approach.
4. Using the technologies that have been developed we have set up village based biopesticide units in nine different locations in Tamil Nadu. It serves multiple purposes of providing safe and tested plant products as biopesticides for organic farming using technologies that can be practiced and transferred to women farmers who maintain these units.
5. Simultaneously, we have set up an insect rearing laboratory where we test out the mode of action of these products as well as the shelf life of these biopesticides.

Acknowledgements

We would like to thank the Department of Science and Technology of the Government of India and the Compas project of the ETC Foundation, Netherlands for the financial support provided for this study.

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Use of Tharu Ethnobotanical Knowledge for Organic Insect Pests Management of *Cucurbita pepo* L. cv. 'zucchini'

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Key words: Ethnic community, plant resources, pesticidal plants, farmers' field experiment.

Abstract

Tharu ethnic communities are rich in ethno-botanical knowledge on the utilization of plants for various proposes to fulfil their daily needs. They have precise knowledge about distribution, abundance, cultural practices, pest management, harvesting, and proper use of these plant resources. Gurau of Tharu communities and elderly people have sound knowledge on medicinal and pesticidal plants. Information on twenty-four locally available plants having pesticidal value, have been collected from the Tharu communities of Dibya Nagar and Meghauli VDCs, Chitwan. Out of them four of the most promising plants were selected to test their efficacy in farmers' field conditions. In order to assess the effectiveness of plant materials on insect pests of vegetables, a farmers' field experiment was conducted in Dibya Nagar during the summer of 2006. The plants selected to test efficacy against insect pests of Zucchini are Azadiracta indica, Justicia adhatoda, Persicaria barbata, and Artemisia indica. Plant extracts made from fresh green leaves of the selected plants at a concentration of 1:5 were applied at seven days intervals. It was found that A. indica had most promising effect on the pests, followed by P. barbata. However, all other treatments had positive effect. Similarly, the research result indicated possibility of using plant materials towards development of organic pest management methods.

Introduction

Ethno-botany deals with study of the relationship between people and plants and refers to the study of how people of a particular culture and region make use of plants. The term 'Ethno-botany' was first used by Harshberger (1896) who defined it as "the study of relationship that exits between people of primitive societies and their plant environment". A modern definition given by Nancy Turner (1988) is that "ethnobotany is the science of peoples' interactions with plants".

Tharu are a culturally and linguistically diverse ethnic group that lives along the Indo-Nepal border in the region known as Tarai. There are almost 1.2 million Tharu in Nepal, and smaller numbers live in the adjacent areas of India. In the last census, Tharus appear as one of the ethnic minorities of Nepal (Krauskopff, 1999). Tharu population is mostly found in rural plain areas near by the riverbanks. Their livelihood depends on agriculture livestock and fishing in natural water bodies like rivers, streams, lakes etc.

Organic pest management consists of a range of activities that support each other. Most of management practices are long-term activities that aim at preventing pests and diseases from affecting a crop. It includes several activities to minimize the pests' population, including use of botanical plant products.

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Zucchini (*Cucurbita pepo* L. cv. zucchini) is becoming popular in Nepal. It is rich in Vitamin B and C and minerals. It can be grown from terai to the mid hills in Nepal. Red pumpkin beetle (*Aulacophora foveicollis*) is the most important pest. Zucchini is also susceptible to powdery and downy mildew and fruit fly.

The majority of Tharu farmers cannot afford to purchase pesticides. Nepal is rich in ethno-botanical knowledge and botanical pesticides. However, a detailed study of the use and effectiveness of botanical pesticides is required.

Materials and methods

There were mainly two parts of this study. The first part of this study included collection of information on Tharu ethnobotanical knowledge on pest management and second part of the study included a farmer's field experiment.

Questionnaires for the semi-structured interviews were prepared to collect the information on Tharu ethnobotanical knowledge, especially on pest management.

Dibya Nagar and Megauli Village Development Committees (VDCs) of Chitwan district were purposively selected for this study to have better Tharu ethnobotanical knowledge as most Tharus live there. For the selection of key informants, one preliminary survey was carried out in these sites through field visit and using semi-structured questionnaire. Twenty informants from different villages of the Dibyanagar and twenty informants from Meghauli VDCs were selected based on information of preliminary survey. Designed questionnaires were pre-tested with five informants.

A total of forty household surveys were made from both VDCs. Family members were encouraged to participate during the process of information collection. Due care was given to collect reliable information from the informants using cross-questioning and triangulation. Two verification meetings were organized to validate collected information.

A list of twenty-four locally available pesticidal plants was prepared based on the information collected from the household survey and verification meetings. From this, the four most promising plants, based on pair-wise ranking, were selected to test their efficacy in the farmers' field experiment.

The farmer's field experiment was conducted in a Randomized Complete Block Design (RCBD) with five treatments and five replications in the farmers' field.

A primary solution was prepared with one kg of plant leaves by pulverizing them over the stone grinder. One litre of water was added to the resulting slurry, and then this mixture was screened through the thin muslin clothes. The solution was then mixed in the ratio of 1:5 of the primary solution and water. The resulting solutions were sprayed over zucchini plants in seven day intervals. Biological information such as scale of pest damage and total marketable yield were recorded. The effectiveness of plant solutions was categorised as the severity of leaf damage in the scale of 1-5 in the descending order.

Results from farmers' field experiment were analyzed using MSTAT-C software package. Duncan's Multiple Range Test (DMRT) was used to measure the significant differences among the treatment means.

Results

Tharus have rich knowledge on distribution, abundance, cultural practices, pest management, harvesting, and proper use of the plant resources. Based on the information collected from the household survey and information verification meetings, information on 24 locally available pesticidal plants has been collected. Four most promising plant species have been selected from these 24 plants for the farmers' field experiments to test the efficacy of selected plant species over insect pests of zucchini. Pair-wise preference ranking, one of the Participatory Rural Appraisal tools, was used to select these four plant species.

The plants selected to test their efficacy against insect pest of Zucchini were Neem (*A. indica),* Asuro (*Justicia adhatoda*), Bisundari (*P. barbata*), and Artemisia (*Artemisia indica*).

Tab. 1: Mean of plant height (cm), number of leaves per plant, number of insects per plants, scale of damage and production (ton/ha.) of zucchini in farmers fields in 2006.

Treatments	Plant height	No. of leaves	No. of insects	Scale of damage	Production
Asuro	9.332^{a}	7.302^{ab}	3.050^{a}	2.872^{ab}	8.40^{bc}
Bishunhari	9.292^{a}	7.732^{ab}	2.900^{a}	2.702^{b}	11.40^{ab}
Titepati	9.430^{a}	7.500^{ab}	3.550^{a}	2.884^{ab}	9.30^{b}
Neem	9.318^{a}	8.052^{a}	1.650^{a}	2.584^{b}	15.90^{a}
Control	8.818^{a}	6.662^{b}	3.650^{a}	3.306^{a}	4.20^{c}
CV	8.92%	12.38%	62.03%	12.94%	36.52%
SEm	0.3685	0.4123	0.8211	0.1661	1.607
$LSD_{0.05}$	1.105	1.236	2.462	0.4981	4.818

Means followed by the same letter for each treatment are not significantly different at 5% (P = 0.05) level according to Duncan's multiple range tests.

Discussion

Based on the analysis of variance and Duncan's multiple range tests, Neem (*A. indica)* has been found most effective followed by Bishunhari (*P. barbata*) in terms of controlling damage by insect pest and increasing total marketable yield.

Some of the parameters such as the height of plant and number of insects were found to be insignificant among the treatments (P= >0.05). Similarly, the observation for parameters such as numbers of leaves, scale of damage and production were found significantly different (P=<0.05) among the treatments. Effect of differnet treatments on height of plants and number of insects were found to be non significant.

From this experiment, it is found that Neem (*A. indica)* possessed the most promising effect on insect pests of zucchini plants. However, all other treatments resulted some sorts of positive effect for the management of insect pests of zucchini.

The results are in accordance with Neupane (1999) reported that Neem has insecticidal, repelling, antifeeding, growth inhibiting, fungicidal, and nematicidal properties, and can control larvae and adult of chewing and sucking insects, including insect pests of cucurbits.

Conclusions

Tharu ethnic communities of Nepal are rich in ethnobotanical knowledge on the utilization of plants of pesticidal value and their use for pest management. Neem (*A. indica*) has been found most effective followed by Bishunhari (*P. barbata*) in term of damaged by insect pest and total marketable yield among four selected and 24 locally available pesticidal plants.

Acknowledgments

I would like to express my gratitude and appreciation to Dr. Dharma Raj Dangol, Associate Professor, Department of Environment Science, Institute of Agriculture and Animal Science, Rampur, for his valuable guidance, continuous encouragement, advice, support during experiment and preparation of manuscript.

I would like to express thanks to Ecological Services Centre for providing me financial support for this study. I am also thankful to farmers involved in study for their valuable information and active participation in experiment.

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Knowledge transfer and dissemination

Organic Pilot Farms in North Rhine-Westphalia (Germany)

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Key words: on-farm research, participation, inter- and transdisciplinarity

Abstract

Since 1993, research, advisory service and practice work together in the German Federal State of North Rhine-Westphalia (NRW) on solutions for selected issues of plant cultivation and animal husbandry with practical relevance for organic farmers. The project that is funded by NRW and the European Union entails demonstration and optimisation of selected organically operating farms and their methods of production as well as professional advice. The project is coordinated by the Institute of Organic Agriculture and executed in cooperation with the Chamber of Agriculture and contributes effectively to the expansion of Organic Agriculture (OA) in NRW.

In this successful participatory and interdisciplinary cooperation between practice, extension service and research, 30 farms that are distributed all over NRW and integrate a wide range of different types of production in their typical local region are involved in developing the research questions, executing experiments and discussing results. Solutions are assessed and optimised on farm level and demonstrated in the practice of major farms in order to secure the knowledge transfer in extended agricultural practice. The feasibility of the methods is immediately assessed by practitioners and transmitted to colleagues.

On-farm research - a transdisciplinary approach

Aims

The project 'Organic Pilot Farms in North Rhine-Westphalia' was initiated in 1993 by the Ministry of the Environment and Conservation, Agriculture and Consumer Protection in NRW to strengthen and establish OA in NRW. Decentral on-farm research, demonstration, extension and transfer of knowledge are the basis of this project. Agricultural science (University of Bonn), extension service (Chamber of Agriculture) and private organic farms cooperate aiming to increase scientific knowledge and to improve quality of advisory services by creating places for demonstration and discussion on practical farms in the region to transmit scientific results directly into agricultural practice. The technical, ecological and economic feasibility of Organic Farming (OF) systems is demonstrated to enhance the willingness of conventional farmers to convert to OF, an approach that meanwhile is pursued in the Netherlands as well (Brinks 2003).

Concept

'An increase of inter- and transdisciplinary approaches in agricultural sciences' was already requested in the memorandum 'Research for a Sustainable Agriculture' of the Federal Agency for Nature Conservation (BfN 2001). The memorandum 'Future Perspectives of Agricultural Science and Research' of the German Research

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Foundation (DFG 2005) is consciously oriented on practicability. An improved exchange between theory and implementation into practical use is recommended. This concept, which has been pursued in the project 'Organic Pilot Farms in North Rhine-Westphalia' for more than one decade, has proved to be serviceable and successful in an evaluation through the German Federal Agricultural Research Centre (FAL) and is international basis in all CGIAR Centres.

The concept is based on private organic farms, so-called 'Pilot Farms', which are distributed all over NRW integrating a wide range of different farm types, from vegetable growers to livestock breeders, in their typical local region. Additionally, they had been selected for innovation and competence in communication, the main issues for daily collaboration. Pilot Farms provide sites for factorial field experiments, supported by demonstration fields in which scientific results are proved and displayed under different regional and climatic conditions and, if necessary, modified for the integration into the individual farm. All decentral scientific trials and demonstration fields are available for regional advisory services of the chambers of agriculture and the organic growing associations. Thus, the Pilot Farms are essential places of exchange for scientists, advisors and practitioners.

The schedule of the project is:

- ***Research***
  On Pilot Farms factorial field experiments on questions of interest for the practice are conducted by scientists of the University of Bonn and the Chamber of Agriculture NRW, in close cooperation.
- ***Knowledge Transfer***
  entails conversion and use of scientific results under practical and site specific conditions as well as enhancement to practicable procedures.
- ***Demonstration***
  The technical, ecological and economic producibility is demonstrated decentral as an advice both for conventional farmers with interest in converting to OF and for farmers already working organically.

Research needs are detected in direct dialogue with the agricultural practice, problems of current interest can be continuously incorporated in scientific work. Pilot Farmers are intensively involved in raising the research questions implementing the experiments as well as discussing the results. This inter- and transdisciplinary approach, which had also been successful and essential in cooperations between science and practical farmers in the United States (Wuest et al. 1999) and in the Netherlands (Langeveld et al. 2005), opens a panel of relevance control for scientists. Research separated from practical interest can be avoided.

Through intensive and long-lasting cooperation between practice, extension and research an efficient work on relevant scopes and a direct knowledge transfer of scientific results into practice are provided immediately. The farmers themselves contribute to spreading knowledge directly from farmer to farmer in their own diction.

Communication

Researchers, advisers and Pilot Farmers meet several times a year (cp. Thompson & Thompson 1990). During the growing season field trials and demonstration plots can be used for advisory services. New strategies are presented and discussed on field inspections that are open for all interested farmers irrespective of their mode of farming. In wintertime results get reviewed with all participants together in project meetings. Details get well thought-out and new demand is mutually ascertained in thematic working groups (arable crops, potatoes, vegetables, dairy cows, poultry, pigs). Research deliverables are published in annual reports of all experiments, on the website www.leitbetriebe.oekolandbau.nrw.de and in practitioner-oriented journals, too.

Participatory research and knowledge transfer

Developing new cultivation strategies is an open, participatory process of all project partners. The following examples give an insight in the chances of transdisciplinary cooperation:

Indirect weed control

The use of morphological variation of winter wheat (*Triticum aestivum* L.) cultivars as a tool for indirect weed control was applied as a disciplinary project of agronomy. The results substantiated that weed suppression and shading ability through crop cover, crop height and leaf inclination (planophile vs. erectophile leaf inclination) were inversely correlated (Eisele & Köpke 1997). Out of these results an interdisciplinary research group, founded by the German Research Foundation (DFG), was arranged at the University of Bonn. Later on transdisciplinarity became subsequently workable in the EU-Project 'Strategies of Weed Control in Organic Farming, WECOF' and finally the results were presented to farmers in demonstration fields on Pilot Farms (Neuhoff et al. 2005).

Underseeds in potatoes

To minimise erosion and nitrate leaching the suitability of different underseeds in potatoes (*Solanum tuberosum*) were tested in the late 1990's. These promising approaches had been reviewed very critically by practice until two Pilot Farmers in cooperation with an adviser of the Chamber of Agriculture in NRW started to use this strategy in practice. They reported less weed infestation and better harvest conditions by a reduced amount of clods. With increasing interest these positive statements were followed by their colleagues. An examination of different underseeds under practical site conditions was requested. From 2005 to 2007 in fifteen factorial field trials and in seven demonstration plots distributed all over NRW amongst others *Raphanus sativus*, *Sinapis alba* and *Fagopyrum esculentum* were undersown in potato stands in order to control weed infestation after senescence of potato shoots. Different sowing dates were tested. Weed dry matter as well as the density of *Chenopodium album* were reduced mainly by oil radish and early sowing combined with the last mechanical treatment (ridging). Buckwheat able to suppress weed growth efficiently is suggested to be used in vegetable production (Stumm & Köpke 2007). By presenting the prosperous results in several articles and on conferences, mostly by a researcher together with a convinced Pilot Farmer, underseeds in potatoes became an accepted strategy to reduce weed infestation after senescence of potato shoots in practice.

Conclusions

The transdisciplinary cooperation in the project 'Organic Pilot Farms in North Rhine-Westphalia' was distinguished on an international conference for its applied operation method and the efficient knowledge transfer (Lange & Lehmann 2005, while scientists can only present conclusive results. As shown in the example *Underseeds in potatoes*, the presentation of results in articles and on conferences by researchers together with a convinced practitioner who demonstrates that he is ready to bear the financial risk of the new method has become a central issue to develop confidence of practical farmers into the feasibility of new strategies.

Acknowledgments

We thank all Pilot Farmers and the Chamber of Agriculture in NRW for promoting the project by steady interest and engagement no less than the Federal State of NRW and the European Union for their funding.

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The development of an international *curriculum* on organic farming in China

Pugliese, M.[1] & Gullino, M. L.[1]

Key words: China, education, standards, academic institutions, teaching, learning

Abstract

The project "Organic farming: social, ethical, economical, scientific and technical aspects in a global perspective" was founded by European Commission within the framework of Asia Link programme. The specific objective was the development of a curriculum on organic farming suitable to the Chinese educational framework, and the development of relevant learning and teaching tools supporting the implementation of the developed curriculum within the Chinese partners' institutions. It consisted of four major components: seminars, visits abroad, PhD student mobility and summer schools. The developed curriculum *consist of six major components for a total of 30 credits: a core course on organic farming (8 credits); four specific courses in biological system management of pests, diseases and weeds, soil quality management, organic animal production, and food quality and food safety (20 credits); and approximately 2 credits for experimental learning on farms. Direct target groups of the project activities were professors and associate professors, postgraduate and graduate students. The project indirectly addressed also private and public industries, non-governmental and governmental organisations. The project lasted 24 months, starting from December 2005.*

Introduction

Decades of intensive and extensive agriculture aimed at guarantee food security for a growing population, have lead in China to extremely negative impact on the environment (e.g. water eutrophication, soil salinisation, loss of soil fertility, aquifers' depletion, water pollution, overproduction of wastes), due to the overexploitation of natural resources (e.g. soil and water) and the excessive use of chemical fertilisers and pesticides. As an example, in the areas of intensive agriculture where up to 5 cropping cycles can occur in the same year on the same soil, the total annual quantity of nitrogen released into the soil goes beyond 1,500 Kg per hectare (Gullino *et al.,* 2006). Agriculture based on obsolete production patterns has also direct impact on the commercialisation of agricultural products, both nationally and internationally. Chinese agriculture is still characterised by low quality of food products. While the production and demand of organic food is rapidly increasing in China (Willer and Yussefi, 2007) due to the raising awareness of consumers about health and environmental issues, the national agriculture production is not yet ready to give a full positive response to this demand. The lack of capacity to produce added value products and the consequent limited access to foreign markets is perceived as a lost opportunity to increase Chinese farmers' income and ameliorate living standards in rural areas. At a production level, the lack of updated technical and scientific know-how among local

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technicians and extension agents is perceived as one of the major barriers towards the adoption of organic agricultural practices. There is an urgent need to create new profiles of professionals, with updated skills, able to locally support the structural and capacity changes sought by the Chinese government. To properly tackle the whole situation, the Chinese Government is, *inter alia*, planning measures aimed at strengthening scientific research and education in agriculture and giving national research a greater international profile. China gives great attention to the development of high-quality universities and to the introduction of new innovative curricula, while acknowledging the "historical" role of national academic institutions in providing essential technical and scientific information which base reliable and effective policy measures upon (Clini *et al.,* 2008). In this framework, there is a perceived need for Chinese academic institutions – in their recognised role of support to policy makers - to develop and disseminate a better understanding of organic farming as an essential mean to promote sustainable agriculture, in terms of environmental protection, food safety, and higher market opportunities.

Activities

The project "Organic farming: social, ethical, economical, scientific and technical aspects in a global perspective" was founded by European Commission within the framework of Asia Link programme. The specific objective was the development of a curriculum on organic farming suitable to the Chinese educational framework, and the development of relevant learning and teaching tools supporting the implementation of the developed curriculum within the Chinese partners' institutions.

The project was coordinated by Agroinnova of the University of Torino in Italy, in collaboration with Tuscia University in Italy, University of Bonn in Germany, Wageningen University in The Netherlands, and four Chinese Universities, i.e. China Agricultural University in Beijing, Zhejiang University in Hangzhou, North East Agricultural University in Harbin and Qinghai College of Animal Husbandry. The proposed partnership built upon existing collaboration on organic farming between European and Chinese Universities.

Among the activities implemented there are: the stabilishment of a Scientific Committee, with experts from each project partners institution and the applicant; the development of electronic tools, i.e. seven newsletters and a website (www.bioasialink.net) for project outcomes dissemination; the design of a curriculum in organic farming suitable to the particular educational needs of the Chinese partner institutions and of China in general; the development of proper teaching materials and manual supporting the future implementation of the curriculum on organic farming; the organization of three seminars and one academic conference in Beijing and Hangzhou aimed to facilitate the dialogue between universities and stakeholders (i.e. governmental authorities, private companies, NGOs, etc.). Many students and professors were involved in the activities. Among them, 12 Chinese professors spent three-months in European Universities for research and academic activities, 12 Chinese PhD students spent one-year in European Universities whithin a three years PhD programme and 8 European PhD students spent up to 4 months in Chinese Universities for research. Two two-weeks summer schools in Europe for 32 Chinese and 16 European students were organized.

Curriculum development

After two years of discussion the partners involved in the project defined the main topics and contents of the *curriculum*, according to Chinese partners requirements. The *curriculum* address scientific, technical, social and economical aspects of organic farming, on a “from field to table” basis. A total of 30 credits will include a 4 weeks on-farm internship. The *curriculum* has six major components: a core course on organic farming with twelve courses for a total of 8 credits; four specific courses in biological system management of pests, diseases and weeds, soil quality management, organic animal production, and food quality and food safety for a total of 20 credits; and approximately 2 credits for experimental learning on farms. The topics treated in the core course include principles, standards and philosophical and historical development of organic farming, environmental assessment of organic farming, strategies and technologies for organic food production, certification and labelling, marketing, case studies in organic farming and excursions to organic farms. The core course would be further on integrated in the first semester of a MSc course, while the specific courses would be integrated in a second semester according to the different needs of different academic institutions.

Conclusions

The synergic role provided by different Universities involved in the project represents a strong effective effort toward the development of organic agriculture. In Europe a strong effort is given to Universities involved in organic farming and many courses started since 2001 in several EU members like Italy, Norway, Germany, Denmark and United Kingdom (Francis, 2004; ENOAT, 2004). This project represents the first step towards the development of a sino-european *curriculum* on organic farming, and it would provide the basis for the development of well-trained and skilled technicians on organic agriculture in China.

Acknowledgments

We would like to acknowledge the European commission by supporting this work in the framework of the Asia-Link programme and all partners involved in the Asia–Link Project “Organic Farming: ethical, economic, technical and scientific aspects in a global perspective” CN/ASIA-LINK/028 (108-962).

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Dissemination of Organic Agricultural Information: The Role of Key Communicator Networks in Rural Bangladesh

Sarker, M.A[1], & Itohara, Y.[2]

Key words: Dissemination, organic agricultural information, key communicators, communication networks and rural Bangladesh

Abstract

The study was attempted to measure the role of the key communicators in the dissemination of organic agricultural information in the Tangail district of Bangladesh. The findings of the study revealed that there are six key communicators who are actively working in disseminating organic agricultural information among the ordinary farmers. Among these six key communicators, one is high communicator who usually provide advice and information to ordinary farmers as well as other key communicators. Thus identifying these key communicators from a community, the development organization can train up them and use them successfully in the promotion of organic farming in rural Bangladesh.

Introduction

Need of agricultural information is the basic necessity for the farmers as it plays a pivotal role in enlightening them, raising their level of knowledge and eventually help in their decision making process regarding farming activities. Effective communication between scientific information sources and the farmers is the key to economic progress of an agro-based nation. In Bangladesh, the Department of Agricultural Extension (DAE) is bridging the gap between research organizations (scientific information sources) and the farmers in order to promote sustainable agriculture and socio-economic development of the people in the farming community (DAE, 1999). However, unfortunately DAE and other government organizations have no active initiative to disseminate organic agricultural information among the farming community (Rahman and Yamao, 2007). According to IFOAM (1996), NGOs are the initiator of the organic agricultural movement in Bangladesh and 138 NGOs jointly have formed the Forum for Regenerative Agriculture Movement (FORAM). Among these NGOs a few leading NGOs are continuing their efforts in expansion of organic agriculture among the ordinary farmers, which started in the early 1980s. Thus adopter organic farmers mostly need to depend on NGOs and local progressive farmers for receiving organic information. A study of Sarker and Itohara (2007) showed that organic farmers in Bangladesh usually receive organic farming related information from friends and relatives, model farmers and opinion leaders who are treated as the key communicators. **The key communicators** are progressive farmers, input dealers, friends and community members who care about organic agriculture and have a desire to help the organic farmers to provide them with the most useful information. They gather information from the NGO and other information sources regarding their perceptions, questions and/or opinions about the organic agriculture, at the same time they spread information back to the organic farming community creating a partnership

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with the NGOs and other organizations. The research of Kashem and Halim (1991) showed that farmers pay more credibility to advice and information received from the model farmers, opinion leaders and other fellow farmers rather than any other sources. Thus it is essential to identify those key communicators and their needs for training to best optimize their role as the helping hands of the extension workers in promoting organic farming in Bangladesh. Keeping in mind this reality the present study was carried out by the researchers.

Materials and methods

The Tangail district of Bangladesh was purposively selected, and the study was conducted at Pirojepur village under Madhupur *upazila* (sub-district). The necessary data for the study was collected from 60 organic farmers out of 320 organic farm families of the study area. The key communicators regarding the dissemination of organic agricultural information were identified by using the sociometric method as suggested by Giles (1974), Young (1996) and used by Manohari (2002). At first six communicators were identified through a focus group discussion (FGD) where the organic farmers and the field staff of PROSHIKA (a leading NGO in Bangladesh) were the participants. In the next step the respondents were asked to give his/her first, second and third preferences in the order of his or her inclination to any of those three persons by whom he or she was influenced in the regards to organic farming. For one's preferenence of first, second and third choices the weightages were 3, 2 and 1 respectively. Thus the sociometric scores for one key communicator were calculated by using the formula: $SS= (3X N_1) + (2XN_2) + (1XN_3)$; [where, N_1= Nr. of respondents gives the 1st choice; N_2= Nr. of respondents gives the 2nd choice and N_3= Nr. of respondents gives the 3rd choice].Further the key communicators were categorized into 3 distinct categories based on the ascending order of cumulative percentage of sociometric scores. Key communicators having the cumulative percentage upto 25 were considered as low communicators, where they were treated as medium communicators within the range of 26-75 cumulative percentage. At the other end, key communicator with cumulative percentages of more than 75 were treated as the high communicator. In additon a sociogram was made, to show the communication networks that exist among the organic farmers of the study area while the basis was the first preferences of the respondents.

Results

Tab. 1: Communicators' profile based on sociometric scores

Key communicato rs	Preference by nr. of respondents			Sociometric scores	%	Cumulativ e %	Category
	1st	2nd	3rd				
1	1	-	1	4.0	1.1	1.1	Low
2	2	1	2	10.0	2.77	3.87	Low
3	3	8	3	28.0	7.73	11.60	Low
4	6	12	17	59.0	16.29	27.90	Medium
5	10	16	19	81.0	22.38	50.27	Medium
6	38	24	18	180.0	49.73	100	High

Total	60	60	60	362.0	100	

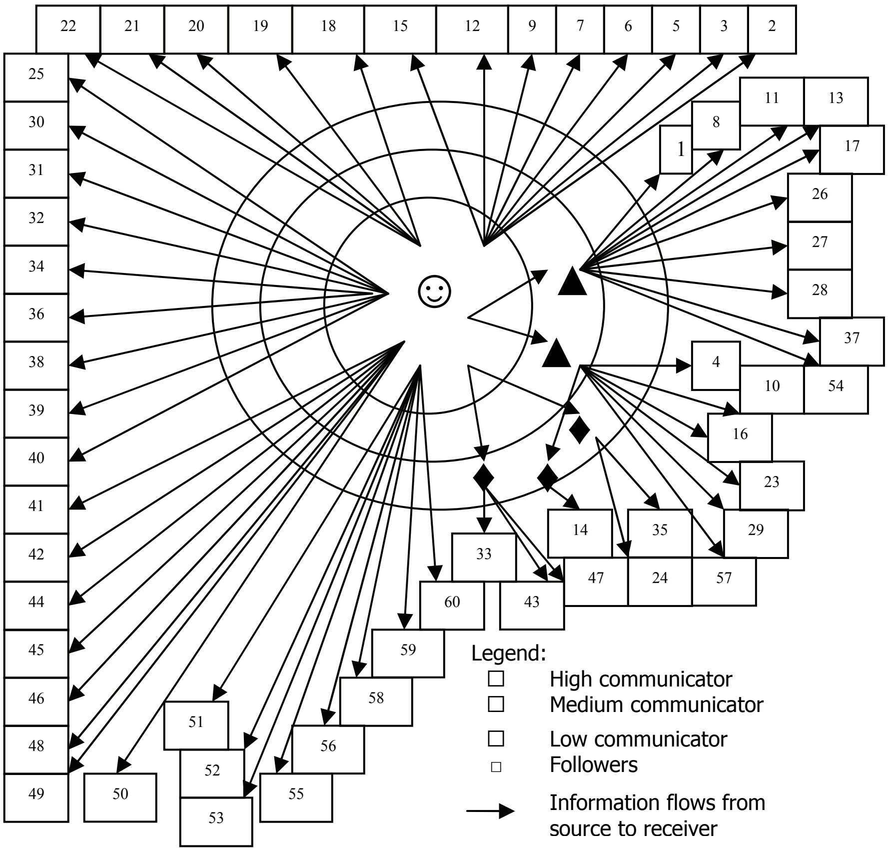

Figure 1: Communication networks exist among the organic farmers of the study area

Discussion

It was evident from table 1 that out of six identified key communicators, three of them belong to the category of low communicator while two of them belong to medium and only one person belongs to high communicator categories respectively. Findings showed that these 3 low communicators' cumulative percentage of sociometric scores ranged between 1.1–11.60. While two of them were identified as medium communicators and their cumulative percentage ranged between 27.90 – 50.28. This is because the majority of the respondents consult them either as 2nd or 3rd liking and a very few of them consult as their 1st liking for receiving organic advice and information. On the other side only one communicator was identified as high communicator with the 100 cumulative percentages of sociometric scores. This is because the majority of the respondent farmers consult him as their 1st preference for organic agricultural information followed by 2nd and 3rd preferences. The researchers further came to know that this identified high communicator is a highly educated person and doing organic agriculture with the guidance of PROSHIKA since the beginning of organic farming in this area. Thus he has expertise and all other ordinary organic farmers consult him regarding organic farming when needing information.

It is clearly understood from figure 1 that not only the ordinary organic farmers consult with the high communicator, moreover all the medium communicators and two of the low communicators also consult him regarding various aspects of organic agriculture. Thus the role of the high communicator is proved as the highest contributing factor in the dissemination of organic agricultural information. The role of the medium communicator is also recognized as important from the study as ordinary farmers as well as one low communicator also consult one of the medium communicator for organic advice and information. The researchers also came to know that PROSHIKA employed only one Technical Worker (TW) who has a four year diploma in agriculture (not a bachelor degree from a university) is assigned to promote organic farming in the 3 villages of Madhupur sub-district *(*PROSHIKA, 2006)*.* It is barely possible for him to meet the information needs of all the organic farmers of the 3 villages. Thus PROSHIKA focused on identifying the key communicators and used them for disseminating organic agricultural information among the ordinary organic farmers which eventually saved expenses for the extra manpower.

Conclusions

From the above study it can be concluded that the concerned Government and Non-Government agencies should concentrate their highest efforts in identifying the key communicators and developing their capacity which ultimately affords the greatest benefit to the organic farming community with proper flow of information at all times as well as to shrink the expenses of the organization.

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Socio-psychological characteristics of farmers in the adoption of organic farming practices in coconut based homesteads of humid tropics

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Key words: homestead, socio-psychological characteristics, adoption, organic farming

Abstract

A study was conducted to find out the socio-psychological characteristics of farmers in the adoption of organic farming practices in coconut-based homesteads of the humid tropics. Multistage random sampling technique was followed to select 105 'coconut based homestead farmers' in Thiruvananthapuram district of Kerala state, India. A pre-tested structured interview schedule was administered to elicit data. The study revealed that the farmers' socio-psychological characteristics such as education, innovativeness, risk orientation, market perception, self-confidence, information seeking behavior, awareness, knowledge and attitude towards organic farming practices have significant correlation with their adoption behaviour.

Introduction

Kerala, a southern state of Indian subcontinent of humid tropics is characterized by predominance of small holdings called homesteads. A homestead is an operational unit in which a number of crops, major one being coconut, are grown with or without livestock, poultry and fish, mainly for the purpose of satisfying the farmers and his families basic needs. These homesteads constitute more than 30 per cent of the total cultivable area and about 85 per cent of these holdings have a size of less than 0.5 ha. Coconut, the major crop of small and marginal homestead farmers, enjoys a distinct place in the economy of Kerala. About 2.5 million farmers are earning their livelihood directly or indirectly from coconut cultivation.(Nampoothiri. (2001).

A major share of coconut production comes from small and marginal farmers in the State. There is a potential for promotion of organic farming among these farmers who are now unable to convert to commercial agriculture.(Pradeepkumar, et.al (2004). However in certain areas especially in the plantation horticulture adjacent to homesteads, continuous use of chemical fertilizers and its impact results in increased soil acidity, imbalance of major and micronutrients and degradation in soil biological properties.(Parthasarathi, (2002) The situation demands application of cost-effective organic nutrient sources, which helps in improving the soil fertility and productivity.

Adoption of any agricultural practice depends on the socio-psychological characteristics of the farmers.(Sherief, A.K.2002). Organic agricultural practices are no exception to this. The present study was conducted to find out the socio-psychological characteristics, which influence the adoption of organic farming practices in homesteads of humid tropics by the coconut based homestead farmers.

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Materials and methods

The study was conducted in the Kalliyoor, Venganoor and Kuzhuvilam panchayats of Nemom, Adhiyannoor and Chirayinkeezhu blocks respectively in the Thiruvananthapuram district of Kerala state. Multistage random sampling technique was administered to identify 105 coconut based homestead farmers. Based on judges rating, fourteen socio- psychological characteristics of farmers were selected. These include age, experience in coconut cultivation, education, livestock possession, trainings attended, innovativeness, risk orientation, market perception, self confidence, environmental orientation, information seeking behaviour, awareness on organic farming practices, knowledge on organic farming practices, and attitude towards organic farming practices. The data were collected with a pre-tested, structured interview schedule. In order to examine the relationship and rate of dependence of the selected fourteen independent variables on adoption of organic farming practices, correlation coefficient was tested and analysed.

Results

The socio-psychological characteristics of coconut based homestead farmers and their relationship with adoption of organic farming practices are depicted in Table1.

Tab. 1: Correlation between socio-psychological characteristics with adoption of organic farming practices

SI No	Independent variables	Correlation coefficient (r)
1	Age	0.0995
2	Experience in coconut cultivation	0.1167
3	Education	0.4834**
4	Livestock possession	0.1179
5	Training attended	0.0711
6	Innovativeness	0.3717**
7	Risk orientation	0.2730**
8	Market perception	0.8952**
9	Self confidence	0.5256**
10	Environmental orientation	0.0747
11	information seeking behaviour	0.4383**
12	Awareness on organic farming practices	0.3589**
13	Knowledge on organic farming practices	0.9468**
14	Attitude towards organic farming practices	0.5867**

** significant for $P<0.001$

A close observation of Table 1 reveals that education, innovativeness, risk orientation, market perception, self-confidence, information seeking behavior, awareness, knowledge and attitude towards organic farming practices have positive and significant correlation with adoption of organic farming practices. Among these factors, knowledge about organic farming practices, market perception, attitude towards organic farming practices, and self-confidence have more influence on the adoption.

Discussion

Education helps an individual to acquire more knowledge, understand the techniques better and strive to get accurate information for use in farming. This may be the reason why farmers' education level has positive and significant influence on the adoption of organic farming practices. The farmer innovativeness showed positive and significant influence on the adoption. Innovative farmers are progressive in outlook and are always keen in updating their farming practices. Hence they tend to seek changes in their farming practices. Further, the farmers who are willing to take risk in farming always have a propensity to attempt new technologies without hesitation. This may be the reason for the positive significant relation of adoption with risk orientation. Furthermore, having realized the upward market trend of organic produce, farmers are motivated to adopt organic farming practices to reap an early reward. Hence the positive relationship of market perception to adoption of organic farming practices.

It is observed from the study that the self confidence had positive and significant relationship with adoption. Self confidence makes farmers to develop ability to face risks and seek new information. Self confidence level of farmers, determines the decisions for adopting organic farming practices. This might be the reason for a significant and positive relationship between self confidence and adoption. The information seeking behaviour also had positive and significant relationship with adoption. In this era of digital and communication technology, farmers can gather information through various information sources. Authentic information from reliable sources might have facilitated higher level of adoption.

The correlation coefficient between awareness and knowledge on adoption of organic farming practices were found to be positive and significant. With the increase in awareness and knowledge on the degradation of environment and higher level of pesticidal toxicity in food, farmers develop favorable attitude towards organic farming through their own experience which led to the higher level of adoption. Similarly, attitude exhibits positive and significant correlation with adoption. High level of awareness and knowledge might have contributed to the farmers to change their attitude. This implies that farmers with positive attitude tend to adopt organic farming practices more quickly than the farmers with negative attitude.

The socio-psychological characteristics of the farmers such as age, experience in coconut cultivation, livestock possession, trainings attended and environmental orientation had no significant correlation with adoption of organic farming practices, showing no significant influence on the adoption of organic farming practices.

Conclusions

In humid tropics like Kerala in India, homestead farming has been one of the survival strategies of the farmers in coconut based homesteads. Adoption of organic agricultural practice in these homesteads greatly depend on the socio-psychological characteristics of these farmers It is evident from this study that the socio-psychological characteristics of farmers like the education level, innovativeness, risk orientation, market perception, self-confidence, information seeking behavior, awareness, knowledge and attitude towards organic farming have high influence on the adoption of organic agriculture in coconut based homesteads in Kerala. Among these factors, knowledge about organic farming practices, market perception, attitude towards organic farming practices, and self-confidence have more influence on the adoption. Hence efforts should be made to create more knowledge and understanding among the farmers about the organic farming practices, its advantages and marketing possibilities, which inturn will develop more positive attitude, and improve the self-confidence of the farmers, leading to increased adoption of organic farming practices in coconut based homesteads of humid tropics.

Acknowledgements

The authors acknowledge the support rendered by Kerala Agricultural University for the conduct of the research study.

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Cross-disciplinary and participatory research methods: What can we learn?

Cross-Disciplinary Analysis of the On-Farm Transition from Conventional to Organic Vegetable Production

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Key words: Soil, cropping systems, organic transition, regression trees, canonical correspondence analysis

Abstract

This farm-scale analysis of the three-year transition to organic from conventional vegetable production tracked the changes in crop, soil, pest and management on two ranches (40 and 47 ha) in the Salinas Valley, California. Many small plantings of a diverse set of cash crop and cover crop species were used, as compared to only a few species in large monocultures in conventional production. The general trends with time were: increase in soil biological indicators, low soil nitrate pools, adequate crop nutrients, minor disease and weed problems, and sporadic mild insect damage. Some crops and cultivars consistently produced higher yields than others, relative to the maximum yield for a given crop. Differences in insect and disease damage were also observed. These results support the value of initially using a biodiverse set of taxa to reduce risk, then later choosing the best-suited varieties for optimal production. The grower used some principles of organic farming (e.g., crop diversity, crop rotation, and organic matter management), but also relied on substitution-based management, such as fertigation with soluble nutrients, initially heavy applications of organic pesticides, and use of inputs derived from off-farm sources. The organic transition was conducive to both production goals and environmental quality.

Introduction

In California, large scale vegetable producers are starting to adopt organic practices to meet the growing market demand (Giles, 2004; Klonsky, 2004), and are now distributing produce to national and international marketplaces. Research on the transition to organic production by conventional, large scale growers requires methodology that represents decision making options at the whole-farm scale. Agricultural transition periods require adaptive management to meet production goals in an environmentally-sound fashion. Frequent and repeated sampling is needed to capture changes in management, yields, and other biophysical responses, and as a result, organic transition periods have rarely been studied under the conditions of dynamic decision-making on the scale of actual farms. Using indicator variables in

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large-scale studies, e.g., yield, nutrient content, pest damage indices, and soil properties, along with multivariate statistics, can show the linkages between management factors, environmental conditions, and crop performance. The outcomes of multi-year, multidisciplinary studies can generate hypotheses regarding factors that optimize the success of the transition to organic production.

An instructive organic transition occurred in the Salinas Valley, California, where one of the USA's largest cool-season vegetable production companies converted two ranches according to the California Certified Organic Farmer guidelines (Smukler et al., ms. submitted). Our cooperative research partnership jointly designed a project to monitor the temporal and spatial progress of the organic transition across the ranches. Each ranch was surrounded by conventional vegetable production that typically uses more than 150 kg of synthetic nitrogen (N) fertilizer per crop, frequent application of pesticides, and intensive hand labor for weeding, thinning, and harvesting.

On the two ranches, a network of 81 points was sampled at nearly every crop and cover crop harvest for a set of indicators for crop productivity, pest pressure, and soil status for 2.75 years. The design provided a large data set and a variety of different conditions that were conducive to analysis by multivariate methods, i.e., Classification and Regression Trees (CART) and Canonical Correspondence Analysis (CCA) to describe ecological relationships but also suggest pathways for management improvement (McCune and Grace, 2002).

Materials and methods

The project began in June, 2000, at the onset of the three-year period required for organic transition by the California Organic Food Act and National Organics Program on two ranches owned by Tanimura and Antle, Inc. Sampling ended in March, 2003, at a common end point prior to planting the crops for the spring season. The ranches had been divided into management blocks many years before. Three transects were established across 9 of these blocks (6 at Storm Ranch and three at Daugherty Ranch), for 27 permanent transects. The soil type is mainly Salinas clay loam.

The grower recorded all management operations, e.g., Intensive tillage, direct seeding of vegetables, and drip irrigation. Cover crops were usually planted once every year. Compost (C:N=18) was applied at least once per year. Pelleted chicken manure fertilizer (2.5-2-2.5) was applied prior to plantings (1100 kg ha^{-1} supplying 28 kg N ha^{-1}). Then a soluble fertilizer (6.0–0.4– 0.2) was applied multiple times through the drip tape during each crop growth cycle. Total application rates ranged from 25 kg N ha^{-1} for baby greens to 244 kg N ha^{-1} for celery. Several organically certified pesticides were used during the transition. Weather data were from a nearby station.

Along each transect, three sampling plots were evenly placed at least 35 m apart, for 81 plots in total on the 27 transects (54 at Storm Ranch and 27 at Daugherty Ranch). Soil samples were taken in June, 2000, and again in March, 2003, before organic certification. This composes the soil properties data set. In addition, throughout the transition, crops and soils were sampled within one week of harvest of each transect. This composes the crop and soil monitoring data set. At each sampling, soil cores, aboveground biomass and harvestable yield, and weeds were sampled, and presence/absence of damage by insects or disease was noted. For analytical procedures, see Cavagnaro et al. (2005) and Smukler et al. (ms submitted).

Analysis of variance (ANOVA) tested for year to year changes in relative yield, and soil biological activity, as well as by growing season during the transition period. Log linear models tested for differences in the categorical data for presence/absence of shoot damage by insects or disease, or for root disease. Recursive regression trees (CART) explored the relationship between management and relative yield, and damage to crops from insects, and disease for all crop taxa excluding cover crops. CCA examined how soil properties changed in the different transects.

Results

Crop performance increased over the three-year period based on relative yields, (observed yield of each crop divided by the observed maximum yield ever measured for that crop during the three year period, expressed as a percentage). During the most intensively cropped season, which was the summer, there was a significant increase in relative yields from 45% in the first year to 62% in year three. CART regression trees showed that: 1) Most of the variation in relative yield was explained by crop selection. The red leaf and green leaf lettuces had higher relative yields than romaine. 2) Different cultivars also showed different levels of performance, e.g., for baby greens, cilantro, frisee, and parsley. 3) Some management blocks were prone to lower relative yields, suggesting specialized needs for improving inputs.

Insect damage, measured by presence/absence, increased from an average of 3% during the summer of the first year, to 66% in the second summer, but then decreased in the summer of the third year to 28%, reflecting general trends in outbreaks in the region. Similarly, fall and spring damage increased from year one to year two, decreasing in year three. The crops that were most damaged were broccoli, endive, frisee, green leaf, radicchio, and romaine, while the least damaged crops were cilantro, escarole, baby greens and parsley. The lettuce aphid was the most important pest, especially in year two on romaine, and high applications of Bt and other organic pesticides were relatively ineffective. CART regression trees showed that: 1) Higher dew point (>13°C) and thus higher relative humidity, was a factor that contributed to insect damage. 2) Under these moister conditions, the most enclosed blocks were more likely to experience severe insect damage, compared to edge blocks near conventional production or paved roads. 3) High solar radiation and higher drip irrigation were also associated with higher pest damage especially for certain taxa.

There was an increase in leaf disease symptoms from the summer of year one, where 3% of the samples were infected, to the summer of year two, where 27% of the samples, followed in the summer of year three by a decrease to 7%. Red leaf and romaine lettuces had more incidences of leaf diseases than any of the other crops. The most important foliar disease was downy mildew of lettuce, forcing in year two, three romaine plantings to be disced before harvesting.

An indicator of weed pressure was the percentage of sampled plots containing weeds. For the Storm Ranch, in 2000, 2001, and 2002, respectively, 27, 39 and 16% of the plots contained weeds. For Daugherty Ranch, this was 4, 11, and 18%, respectively.

Over the three year transition period there was a trend towards greater soil biological activity. Soil microbial biomass carbon (C) at 0-15 cm depth increased ~25% during the most biologically active times of the year, which is the mild wet fall and spring, over the three-year period. Arbuscular mycorrhizal colonization was only 2.8% of the root length, but more than doubled to 6.8% by year three. By the second year, soil nitrate pools were very low, yet when N contents of each crop were compared with reported stringent critical deficiency values most were well above the critical value.

While mean values of soil C or N for the ranches did not change between the onset and the end of the transition period, there were significant changes in other soil parameters particularly between individual management blocks. Mean Olsen P, soluble K, and EC decreased, while pH increased. CCA analysis showed that changes in pH and EC were driven largely by higher silt, and amounts of Biolizer fertilizer and drip irrigation. Higher soil K was associated with higher amounts of chicken manure pellets. Thus, management blocks responded differently to the organic transition due to both soil characteristics and inputs.

Discussion

The transition from conventional to organic production was successful at a large scale even in a region dominated by conventional agriculture. Tanimura and Antle Inc. showed a distinct learning curve in relation to both nutrients, i.e., increased soluble fertilizer additions, and pest management, i.e., decreased use of organic pesticides. Overall, their management resulted in improved soil biological indicators, generally adequate plant available N with reduced soil nitrate, and a gradual increase in relative yields with time. The continued organic production at this site, and the expansion to other sites, suggests that it is economically viable.

Many organic growers manipulate plant species richness and evenness within the constraints of managing supply for market demand, as one of the main sets of allowable tools for farm management (Zehnder et al., 2007). This study shows that this may have benefits for mitigating risks associated with low yields and insect damage, and is best addressed through adaptive management.

Conclusions

These results demonstrate that some of the strategies that were developed by small-scale organic producers can be applied to larger-scale production to achieve a more sustainable agricultural intensification, which has far reaching implications as the demand for organic production increases.

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How to promote innovation and interdisciplinarity in organic food and farming research evaluation

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Key words: Research evaluation, Criteria and procedures, Innovation, Interdisciplinarity, CORE Organic.

Abstract

The development of organic food and farming research calls for system-oriented, innovative, interdisciplinary approaches. The process of evaluating research proposals is a crucial step towards this objective. Based on the EU CORE Organic pilot call for joint transnational research projects, we analysed to what extent the evaluation criteria and procedures implemented address this issue. Feedback on the experience of the target groups involved in this call was gathered and discussed in relation to findings from the literature. Our results show that interdisciplinary and innovative aspects could be better addressed, and evaluation criteria more clearly defined and delimited. This entails reshaping the main criteria and developing more suitable evaluation categories and sub-criteria. We also suggest creating mechanisms to enable funding of a few "risky" research projects, to facilitate entry of newcomers to the arena, to promote exploratory research projects and to support longitudinal interaction among applicants and assessors.

Introduction

As a cornerstone of knowledge production, research evaluation is the subject of considerable debate in the scientific arena. Based on our experience with the CORE Organic project and its associated pilot call for joint transnational research projects, we aim to bring this debate to the forefront of the organic food and farming (OFF) research arena. CORE Organic, an acronym for "Coordination of European Transnational Research in Organic Food and Farming" was initiated as a part of the European ERA-net Scheme, which is intended to step up cooperation among national research activities. One of the objectives of CORE Organic is to enhance the quality, relevance and utilisation of resources in European research in OFF. Research in organic farming, advocating a holistic approach, is still a relatively new research domain. This calls for strong integration of disciplinary perspectives and for development of specific methodologies to assess new research targets (Rasmussen *et al.*, 2006). Our objective is to assess to what extent the evaluation criteria and procedures used for the CORE Organic pilot call address these issues, particularly their suitability for promoting interdisciplinary and innovative research projects. Drawing on feedback of experience from the target groups involved in this call and analysis of the literature, we suggest some pathways to improve research evaluation

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procedures, arguing that improvement of evaluation procedures would also improve the quality of research in this field.

Materials and methods

In September 2006, eleven EU partners from CORE Organic launched a pilot call for transnational research projects in OFF. The following three thematic areas were chosen: animal health management, quality of organic food and innovative marketing strategies. 38 research proposals involving research consortia of at least three partner countries were submitted for selection. A panel of nine experts was selected for a consensus-building process. Evaluation was implemented with a set of 19 sub-criteria, aggregated into six main criteria. The scientific expert panel recommended the 17 projects that scored best in the evaluation to the Governing Board of CORE Organic, which then selected 8 projects[1] with the aim of matching the national priorities given by the 11 participating countries, covering the three thematic areas, and involving as many relevant partners as possible. The survey and assessment of the evaluation procedure consisted of a feedback evaluation exercise involving the different target groups that took part in the pilot call, including the expert panel, the Governing Board members, the national call contact persons and the applicants.

Results and discussion

The pilot call used a combination of classic criteria such as “scientific quality”, “choice of methods”, “relevance to the call”, and more specific ones such as “trans-national linkage”, “interdisciplinarity of the consortium” and “innovative research” (Table 1, left column). The experts’ survey showed that the proposed set of evaluation criteria fulfilled the expectations of most target groups involved in the CORE Organic pilot call, and that the participants were, on the whole, satisfied with the procedure. However, it emerged from the survey that the criteria used for evaluation should be better defined, and that developing more specific sub-criteria could allow a better balance between “scientific quality and robustness” and “interdisciplinary and innovation” (see Table 1, right column). Furthermore, the current list of sub-criteria already contains three criteria dealing with different aspects of interdisciplinarity. The fact that they are assigned to different main categories may weaken their significance. Meanwhile, some applicants and experts still suggest that major improvements should be undertaken in the evaluation procedure concerning the issues of interdisciplinarity and innovation. The fact that it is difficult to promote innovative research, and especially interdisciplinary research, is not new in science. The intention to advance knowledge by calling into question the current understanding, with its attendant paradigms and assumptions about quality criteria, usually suffers in a conventional peer review process known for its conservative and risk-minimising characteristics (Hacket and Chubin, 2003). Large pluri-disciplinary panels are acknowledged to be more efficient in evaluating interdisciplinary research.[2] When the peer panel comprises a healthy balance of the disciplines involved in the proposal, the panel system allows broad representation of divergent judgements and conflicting validation norms (Porter and Rossini, 1985). Furthermore, this system allows open debate about criteria assessments; this, when combined with a rough rating-scales model, is acknowledged to bring support to controversial innovative and interdisciplinary projects. From this

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[1] For a description of the projects see http://www.coreorganic.org/research/index.html

[2] A panel of 8 to 12 experts has been shown to be a good number.

perspective, a low level of agreement among reviewers on a peer panel is not an indication that the assessment lacks validity or legitimacy (Langfeld, 2001). Rather, it may indicate that the panel is highly competent because it represents a wide sample of the various views on what constitutes good and valuable research. The challenge, then, is to find a diverse set of experts that encompasses the various facets of a set of proposals, and to avoid duplicative perspectives. It can be assumed that the following prerequisites were met in the CORE Organic pilot call: each expert had basic knowledge of OFF, had been involved in OFF research projects that mobilised interactions with other disciplines (systemic and interdisciplinary approaches), and possessed expertise in at least one of the three identified topics. Both a rough rating scale and open decision-making process were used and low inter-reviewer agreement was achieved. Nevertheless, it seems that innovation in OFF needs to be strengthened. We suggest that a specific mechanism should be implemented in the evaluation process in order to allow a few “risky” research projects to be funded, *i.e*. to give temporary credibility to innovative work. At the same time this could facilitate the entry of newcomers into the arena and promote exploratory research projects. This procedure could be extended to projects which show a strong interdisciplinary dimension but a certain methodological weakness. As a gate-keeping mechanism, a later assessment step could also be implemented, consisting for example of a tutorial on the ongoing research.

At the same time, considering research evaluation as a negotiation and knowledge creation process, we advocate stronger longitudinal interaction among the applicants and assessors. This would not only generate competence, but also create a communication base that increases the number of people capable of conducting interdisciplinary evaluation with rigour (Klein, 2006).

Conclusions

Criteria and procedures used in the CORE Organic pilot call were judged as relevant by most of the stakeholders involved. However, the assessment process could be improved. Further work should focus particularly on refining criteria, devising mechanisms to allow funding of a few “risky” research projects, and allowing longitudinal interaction among the applicants and assessors.

Acknowledgement

This paper is based on the FP6 ERA-net project, "CORE Organic", which was carried out with financial support from the Commission of the European Communities. However, the views expressed herein are those of the authors and may not be regarded as reflecting the views of the Commission of the European Communities.

Tab. 1: Evaluation criteria for the selection of organic food and farming projects used in the CORE Organic pilot call and suggestions for improvements.

Evaluation criteria	Comments and suggestions for improvements
1 Scientific Innovation	This is the place to assess aims, hypotheses, novelty, new ideas, cross-disciplinary approaches, and knowledge of the literature. The experts have to apply their own ratios and weightings between all these aspects and summarize them into two simplifying criteria. More sub-criteria should be
1.1 Innovative research	
1.2 Scientific quality	
2 Methodology	Contains diverse criteria, *methodology* corresponding more to scientific quality, and others linked to dissemination. They should be considered apart, and criterion 2.3 may include
2.1 Choice of methods	
2.2 Plan for publication	
2.3 Plan for knowledge	
3 Consortium	Heterogeneity and overlapping definitions of the sub-criteria: "skills" of the individuals and groups to handle the research and "practical capacity" of the consortium to handle the project. *Interdisciplinarity of consortium* is not explicitly defined. The fact that different aspects of interdisciplinarity are assigned to different main categories weakens their significance
3.1 Qualification of consortium	
3.2 Complementary expertise	
3.3 Interdisciplinarity of	
3.4 True cooperation	
3.5 Trans-national linkage	
3.6 Scientific networks	
4 Project Management	These sub-criteria are considered difficult to judge by the experts. Additional types of skills and experts (management and organizational experts) should be included.
4.1 Project management	
4.2 Research plan	
4.3 Financial requirement	
5 Relevance	This criterion should include assessments of knowledge users. This is supported by the literature and by the experts, who state that assessing *Societal Relevance* is difficult for them.
5.1 Relevance for OFF	
5.2 Relevance to the call	
5.3 Societal relevance	
6 Added Value	Difficult to address this criterion that tries to assess the "emergent" components of the partnership.
6.1 Added value for EC	
6.2 Trans-national aspects	

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Learning in context – improved nutrient management in arable cropping systems through participatory research

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Keywords: Participatory research, sustainability, organic farming, nutrient management, organic fertilisers

Abstract

Participatory research (PR) provides opportunities to build knowledge relevant to site-specific farms conditions. This study used a PR approach to develop nutrient management strategies in stockless organic farming. A thorough problem identification process was carried out and the problem prioritised was how to combine preceding crop effects with fertilisation strategy in crop rotations. On-farm fertiliser (biogas digestion residues, chicken manure and meat-bone meal) experiments were conducted in spring wheat and winter rapeseed. Significant yield responses were achieved in spring wheat, up to 1200 kg ha^{-1}, and they were higher than in rapeseed. The implications of the results for nutrient management at crop rotation level are discussed.

Introduction

Learning in context is a process of gathering information and developing knowledge relevant to specific situations, such as site-specific conditions on farms (Eshuis & Stuiver, 2005). Participatory research (PR) is a tool to address relevant problems and facilitate technology transfer (Poudel *et al*., 2000). Sustainable practices need to be implemented on farms by farmers and can be improved by involving farmers in the research process. The background to the present project was the lack of knowledge on sustainable nutrient management strategies in stockless organic farming, since low nutrient use efficiencies (NUE) have been reported (Olesen *et al.,* 2007). Studies on optimal combinations of crop rotations and fertilisation strategies that include preceding crop effects and manuring are scarce. Participatory research was considered to be a suitable approach to address the complexity of nutrient management at the cropping system level. A PR project was started in 2006 and will end in 2008. Some of the results are reported in this paper.

Materials and methods

A group of six farmers with similar organic production systems in southern Sweden were selected to form a PR group together with an advisor and a researcher. In PR, identification and prioritisation of a common problem is central (Fujisaka, 1989). In this project, although we had specific funding for nutrient management studies we initiated a broad process of problem identification and used communication facility tools such as drawing problem-trees and solution-trees of high complexity to highlight biological

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and socio-economic issues. Each of the six farms was thoroughly described by the farmer, and problems and future possibilities of the individual farms were discussed and documented.

The cropping systems on the farms consisted mainly of spring cereals, one-year clover-grass green manure (GM) leys, winter rapeseed and green peas. The nutrient management strategies differed among the farms, from a strategy of no inputs of nutrients from outside the farm except N_2 fixation to inputs of nutrients replacing outputs and further on to 'inputs to get high yields'. Different kinds of manure and organic fertilisers based on food industry waste products were used.

Field experiments were conducted on the farms in 2006 and 2007. The experiments were managed in cooperation between the farmers and the local Agricultural Society. Here we briefly describe two fertilisation experiments in 2007 on two sites: spring wheat (*Triticum aestivum* L.) trial on a loam and winter rapeseed (*Brassica napus* L.) trial on a medium clay soil. The experimental plots were arranged in a randomised block design with three replicates. The following fertiliser treatments were included: Biogas digestion residues (0,8% total-N), chicken manure (2,1% total-N), and meat-bone-meal (9,5% total-N). In the spring wheat trial two intended rates, 50 and 100 kg total N ha^{-1}, of the organic fertilisers were applied in spring. In the winter rapeseed trial the organic fertilisers were spread in early spring 2007 in the standing crop with the intended N rate of 120 kg total-N ha^{-1}. Winter rapeseed was sown with 48 cm row distance in early September 2006.

Results

The relative importance of external inputs of organic fertilisers compared with N_2-fixing crops in the rotation was identified in the PR process to be a key issue for the farmers. The PR group was aware of the difficulty of devising long-term nutrient strategies during a project of three years, but concluded that short-term on-farm fertilisation experiments would be most valuable.

Significant fertiliser effects on yield and N uptake in grain were achieved in a spring wheat trial (Table 1). The intended fertiliser rates were not achieved for chicken manure due to discrepancy between preliminary and final fertiliser analyses. On average the lower fertiliser rate gave the highest NUE. The yield increase in rapeseed due to fertilisation was not significant due to large variation between plots, but was on average 600 kg ha^{-1}. The economic evaluation showed higher economic benefits from fertilisation in spring wheat compared with winter rapeseed. However, the wheat and rapeseed experiments were conducted on two different sites, making direct comparisons difficult.

The PR group discussed implementation of results for the cropping systems on the farms. Optimal fertiliser strategies in the crop rotation were the main focus for discussions. The conclusions can be summarised as follows: 1) Early spring application of organic fertilisers or a high nutrient-delivering preceding crop is crucial for good crop development and high NUE in winter rapeseed. 2) Low and variable NUE of organic fertilisation in rapeseed entail that a combination of a moderate nutrient-delivering preceding crop and a low early fertiliser application may be an advantageous option. 3) Large yield benefits could be achieved by applying organic fertilisers to spring cereals. 4) Low rates of organic fertiliser supply together with N_2-fixing crops in the rotation could be an economically and environmentally benign solution. 5) To get high NUE of organic fertilisers farmer's experiences show great importance of immediate fertiliser soil incorporation. 6) Successful weed management is a requirement for high NUE in the cropping system.

Tab. 1: Yield and protein concentration of spring wheat fertilised with different types of organic fertilisers in one on-farm field trial. NUE = (N in grain of fertilised wheat - N in grain of unfertilised wheat)/total N in applied fertiliser

Fertiliser	Total N in fertiliser ha^{-1}	Yield kg ha^{-1} 15%wc	Protein conc. %	N in grain kg ha^{-1}	NUE %
Unfertilised	-	3630a	11.4	62a	-
Biogas residues	52	4240b	11.9	75b	26
	104	4840c	12.5	90c	27
Chicken manure	33	4060ab	12.2	74b	37
	65	4260b	11.9	75b	20
Meat-bone meal	46	4330b	12.0	77bd	34
	92	4630bc	12.5	86cd	26
p-value		*0.006*	*n.s.*	*0.004*	*n.s.*

Discussion

Farmer PR offers possibilities to learn in context and to build knowledge that could lead to improvements of on-farm nutrient management. However there are drawbacks with the PR approach. It is time-consuming, at least in the short-term perspective, and it could be difficult to obtain funding for PR projects with very open aims. The flexibility and simplicity that are important traits of successful PR could lead to poor scientific validity of research results (Poudel *et al.,* 2000).

Agricultural knowledge stems from different sources and PR combines researcher-advisor-farmer inputs with possibilities to develop and implement cropping system solutions. Field experiments carried out by researchers tend to focus on evaluation of single factors excluding a cropping system context. With the PR approach the experimental design of field trials were formed by the group, with the outcome that locally available fertilisers were used and also that farmer's techniques concerning spreading and incorporation of the fertilisers were followed. The choice to conduct fertiliser trials in both spring wheat and rapeseed reflected the farmer's interests of comparing NUE for different crops in the rotation.

The difficulty with application of organic fertilisers to winter rapeseed observed in this project is consistent with other studies, mainly caused by the large nutrient requirements very early in the season (Rathke *et al.,* 2006). At the same time, it is crucial to avoid spreading manure on wet clayey soils, causing compaction injuries. A favourable preceding crop leaving residual N in the soil profile could consequently be an alternative to fertilisation. The farmers in the group grew GM leys, which could be a suitable preceding crop to rapeseed. Farmer's experience showed however difficulties to establish rapeseed after GM due to dried up soil and attacks of slugs. An alternative could be a pulse crop leaving at least moderate nutrient rich residues. The rapeseed probably needs supplementary fertilisation, depending on inherent soil nutrient-delivery. But then the farmer does not have to completely rely on fertilisation to get an acceptable yield. Furthermore an important lesson learned by the farmers was that it is of the utmost importance to have reliable manure analysis to enable high NUE of organic fertilisers. Ecological sustainability concerning fertiliser inputs was the focus of many discussions in the PR group. Earlier studies have sometimes shown negative nutrient balances in stockless organic farming caused by low or no inputs of fertilisers to the farm (Wivstad *et al.,* 2005). Olesen *et al.* (2007) stressed the importance of applying organic fertilisers to such cropping systems in order to maintain good crop yields and to ensure that crops are sufficiently competitive against perennial weeds. There was general agreement that the nutrient inputs and outputs need to be balanced for long-term on-farm sustainability. In a wider perspective, however, it is not sustainable to deplete non-renewable resources, e.g. phosphorus, to sustain nutrient needs on the farm. More advanced nutrient cycling in the food chain would decrease the need for using nutrient stocks.

Conclusions

* More sustainable solutions for nutrient management could be implemented by PR compared with researcher-managed studies. Different kinds of knowledge are combined in PR, providing a broader multidisciplinary base for decisions.

* Higher NUE of organic fertilisers could be achieved in spring cereals compared with in winter rapeseed.

* A combination of a moderate nutrient-delivering preceding crop and a supplementary fertilisation could be a solution for high NUE in winter rapeseed.

Acknowledgments

We acknowledge SLU Ekoforsk for funding the project and we very much appreciate the cooperation with the farmers Krister Andersson, Nils-Gösta Bengtsson, Lars Jönsson, Anders Persson, Sven-Bertil Swensson and Sone Trulsson and would like to thank them for their dedicated work and great enthusiasm.

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Research - Teaching Integration in Agroecology and Organic Farming

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Key words: farming systems, agroecology, organic farming, action research, learning landscapes

Abstract

Integration of research and teaching enhances the success of students in both areas, and contributes to preparation of graduates who are capable of handling the complexity of location-specific challenges in farming and food systems. A European Network of Organic Agriculture Teachers (ENOAT) convened a workshop in Italy in 2007 to explore the current state of integration and potentials for further developing this learning strategy in universities. We concluded that integration brings motivation to students and greater relevance to their learning environment, both key issues in providing success in the learning landscape

Introduction

Research results and practical experiences in agriculture and food systems provide the information we use in teaching courses, through journal articles, textbooks, farmer bulletins, and other types of learning materials. Research informs teaching. In addition, our teaching of research-derived knowledge and skills in principles of biological systems, ecosystem structure and function, experimental design and other technical areas influence future research, as these ideas are incorporated by our students. Teaching informs research. There is growing concern among our professionals that these two activities are too often disconnected. Teaching and research are often seen as distinct activities, with different goals, time frames, budgets, and specialists in the university. A workshop of the ENOAT in August, 2007 explored the importance of integrating research and teaching with the goal of improving both functions of the university. In this paper we relate the results of the workshop to future education in organic farming, and draw primarily from the proceedings edited by Caporali et al. (2007).

Methods

Linkages between research and teaching have been studied extensively, especially in education. Barnett (2005) describes the challenges of new linkages between research and teaching in established universities, while Brew (2006) explores how to bridge the research-teaching gap. Integration is more than making faculty assignments to these two activities. Success requires examination of how the university is organized, and

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even goes beyond our concerns about learning to address wider issues such as how economic and political pressures impact design of education (Brew, 2006). She expands on a future vision of institutions where academics and students work in collaboration to better understand the world, and to “develop the strategies, techniques, tools, knowledge and experience needed to solve complex, important, and yet unforeseen problems.” In contrast to Brew’s enthusiasm, Jenkins et al. (2003) conclude that most research evidence does not find a positive correlation between success in research and teaching, but there is potential value if integration is carefully built into courses and curricula. Integration of teaching and research depends on how we define them. Current university organization favors two different, unlinked activities, with separate budgets, faculty assignments, and facilities that do not foster integration (Barnett, 2005). Current consensus is that agroecology describes an academic field of systems study, while organic farming is the application and integration of science with practical farmer experience to design productive systems in the field and meet certification criteria. We have published three models of organization of the agricultural university, contrasting current rigid departments and disciplines with two futuristic plans that lead to a near-total integration of research and teaching under the umbrella of education (Lieblein et al., 2000). These could serve as models for teaching organic farming and agroecology, with the latter defined as the ecology of food systems. The ENOAT workshop focused on finding relevant connections between research and teaching, and on how a well-designed university program could enhance both objectives.

Results

Integration of research and teaching is especially important for the education in organic farming and agroecology because of the complexity of questions and many interactions integral to farming and food system. Understanding systems requires a transdisciplinary strategy for education that involves experiential learning. We have found it essential to tie learning to real world challenges and clients. This links research in the field with learning activities in the classroom. The ENOAT workshop revealed a wide range of opinions on what constitutes research, what characterizes teaching, and what could be gained by better integration.

Tab. 1: Essence of Research as Defined by ENOAT Workshop Participants, 2007.

What is research?	○ Activity performed in research centers to find new knowledge ○ Recombining old knowledge, constructing new connections ○ Solving practical problems, especially unsolved questions ○ Organizing experience and knowledge in new contexts ○ Paid or contract activity with obligations and requirements
What process is used in research?	○ Includes individual and group learning ○ Discovery, experimentation, observation, analysis, synthesis ○ Working closely with clients is essential to success in systems
What characterizes research?	○ Interest, curiosity, creativity ○ Objectivity and honesty in process and reporting results ○ Transdisciplinarity and systems focus

Research was viewed as a process of discovery, including combining prior knowledge and experience with new information often found in a new context (Table 1). Some viewed research as defining program priorities and setting in motion a process to solve practical problems. Steps include defining questions clearly, setting up accepted procedures to answer the questions, collecting data, analysis and interpretations, and reporting results. The job is not finished without publication or other dissemination of results. The term multidisciplinary was replaced in discussions and the proceedings by transdisciplinary, preferred because the latter refers to a "transcending" of disciplines rather than a collection of people with multiple talents. Teaching is a prime activity of the ENOAT workshop participants, and we asked what each person considered the essence of teaching. Groups of four discussed their responses and found three key characteristics to report. Responses gathered in a group plenary session are shown in Table 2. As conceptualized and practiced by this group of teachers of organic agriculture, teaching includes transmission of knowledge and interpretation in current and new contexts. The process of learning is complex, and we strive to promote both individual and group learning. One challenge is to stimulate curiosity, guide people through an examination of their own attitudes and preconceived ideas, and build motivation for action. Although there is great importance in building skills and knowledge, teaching should reach beyond these lower order issues to seek applications of what is learned and how this experience will interface with the real world and prepare graduates for the uncertainty and complexity they will face in the workplace and society.

Tab. 2: Essence of Teaching as Defined by ENOAT Workshop Participants, 2007.

What is teaching?	o Sharing, moving, and interpreting knowledge clearly to others o Catalyzing, promoting, and facilitating learning o Disseminating knowledge that can be applied in new contexts
What process is used in teaching?	o Promote individual and group learning o Stimulate curiosity, challenging attitudes, building motivation o Creating new capabilities and stimulating critical thinking skills
What characterizes teaching?	o Focus on skills, facts, theories and principles, and how to apply o Build communication skills, experiences and teamwork o More than merely a cognitive activity, but leads to application

Integration of research and teaching was explored in another workshop session. Participants were asked to envision a future learning landscape with close integration of research and teaching, and to describe what they would see in this landscape. Their ideas are summarized in Table 3. Some of the motivations for learning and aspects of application should be integral to any teaching situation. We found that greater motivation will result from students being a part of generating new information through research. Application of information to practical challenges is valuable.

Tab. 3: Vision of learning environment with integration of research and teaching, defined by ENOAT Workshop Participants, 2007.

Motivation of students and instructors?	o Teachers better prepared, and students more involved o Students are part of knowledge process, serve the community o Students feel teacher's conviction and passions for the topics
Relevance of materials in courses?	o High level of relevance to current topics and applications o Direct participation in research, higher awareness of needed results o Current context compared with past experiences, future situations
Focus of learning in the learning landscape?	o Literature and experience are connected in real world situations o Focus on practical issues, students more curious when involved o Learning process focused on interactions, large systems, context

Lastly, we focused on putting theory into action, and asked workshop participants what students would be better able to do as a result of research-teaching integration. As shown in Table 4, the instructors predicted that students would acquire new knowledge about the research process, better understand themselves and their capabilities, and be ready to deal with complexity. They will also be more in tune with the research process, and will be prepared to deal with whole systems with tools and methods that sort out complexity. We see students as more prepared for action and applications with clients and real problems, as compared to dealing with lower order questions where most of the answers are already known.

Tab. 4: What are students better able to do after graduation as a result of research-teaching integration, defined by ENOAT Workshop Participants, 2007.

What knowledge will be acquired?	o Know how to do research, and how to communicate results o Know and understand one's own limitations and strengths o Understand reality, learn to be flexible, deal with complexity
What will they understand about learning process?	o Know where to look, how to analyze, interpret, conclude from data o Use transdisciplinary and whole-systems thinking o Know how to ask relevant questions, process the answers
What will they learn about action and applications?	o Become open and ready to explore opportunities for practice o Gain ability to moderate among people with diverse views o Gain a broader perspective about potential career choices

Conclusions

We conclude from this workshop that integrating research and teaching at the university level in courses on organic farming and agroecology can bring greater motivation to both students and teachers, and that there is a higher probability of finding answers to society's questions. As compared to a more static and known learning environment, students will be encouraged to explore the unknown, applying their new knowledge and experience to real world situations where the answers may not be known. Dealing with complexity, uncertainty, and change will be important for our graduates, and how we design the learning landscape to best help them cope with that exciting future is the largest challenge facing us as educators. We think that integrating research with teaching will help in the process of both education and research. What they share is the process of learning.

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How do farmers research and learn? The example of organic farmers' experiments and innovations: A research concept

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Key words: Farmers' experiments, Organic farming, Local knowledge.

Abstract

Experimenting, adapting and innovating are central features of farmers' activities all over the world. Farmers hold valuable knowledge about their environment, they actively do experiments, and have their own research traditions. The development of organic farming systems is continually evolving through the experiments and innovations of organic farmers. So far, there has been little attempt to study the nature, characteristics, and factors associated with the experimental processes of farmers in a systematic, comprehensive way. A current research project investigates learning processes of organic farmers in Austria, Cuba and Israel through researching the multifaceted experiments they conduct and the innovations they obtain as possible results. This paper presents the research concept of the project.

Introduction

The history of farming shows how farmers have constantly developed and adapted their farming systems to changing agro-ecological and socioeconomic conditions. Farmers have an intimate knowledge of their local environment, conditions, problems, priorities, and criteria for evaluation, and they are actively engaged in experimentation as a part of their farming routine (Chambers et al. 1989, Rhoades and Bebbington, 1995, Sumberg and Okali, 1997). Organic farming research developed through pioneer farmers and scientists in the 1920s. Formal scientific research activities began in the 1970s through a few private research institutes. Organic farming chairs at universities and organic farming projects at state research institutes were only established later (Niggli and Willer, 2000). Therefore, organic farmers themselves have been responsible for most of the advances and innovations in organic farming, and have always researched topics pertinent to their production systems. Not surprisingly then, organic farmers have become the leaders and experts in this field (Bull 2000; Scialabba and Hattam, 2002). Through investigating farmers' experimental processes, formal researchers can broaden their epistemological base by understanding the importance of observation and experience, as well as tacit knowledge, and by learning from farmers' strategies how to deal with complexity (Hoffmann et al., 2007).

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Objectives

A research project about organic farmers' experiments and learning processes is carried out between January 2007 and December 2008. The objectives of the project are:

• to generate empirical knowledge on the processes by which organic farmers' local knowledge is created (Figure 1);
• to identify and define motives, topics, methods and outcomes of farmers' experiments;
• to understand the factors associated with variation in organic farmers' experiments within and among sites;
• to define the links between organic farmers' experiments and the local agricultural communication systems; and
• to understand the role that experimentation plays as a mode of learning and a strategy to deal with changes.

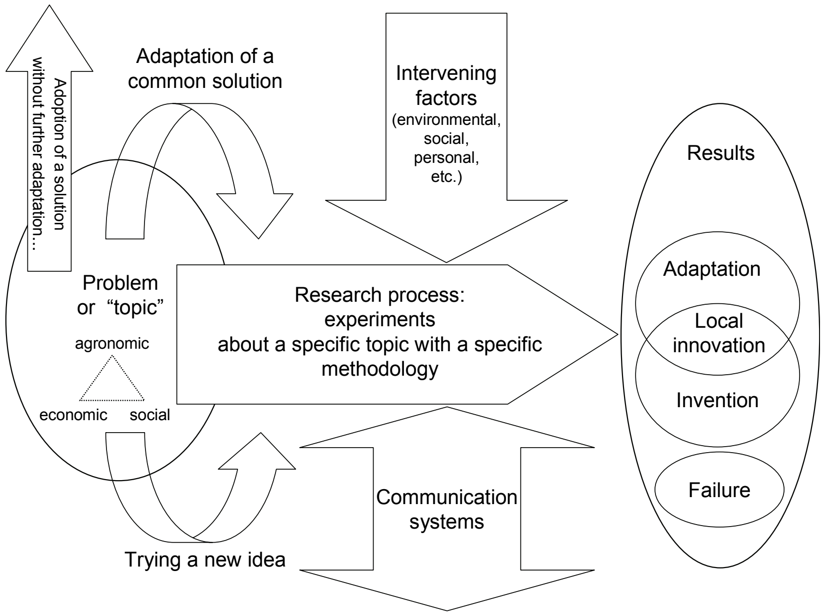

Figure 2: The research process as context to study farmers' experiments

Methods

The research project is conducted in Austria, Cuba and Israel by 3 PhD-students, as well as several master students. The countries were selected to represent organic farmers in i) different environmental conditions ii) different agricultural systems iii) different socio-economic conditions and iv) different phases of the organic farming movement.

The first field research phase of the project was carried out between July and December 2007. In the first field phase, 40 to 50 personal in-depth interviews with organic farmers, as well as several interviews with experts (e.g. advisors of organic farmers' institutions, scientists, etc.) were completed in each country. A purposeful stratified sample, based on maximum variation regarding agricultural zones, farm structure, infrastructural conditions, and types of farmers was applied. Farm walks as well as photographic documentation were realized in the course of the visit on organic farms to complement the interviews. Timelines were used to track changes at the farm level, based on the hypothesis that changes are either triggers for experimentation or the results of experiments.

Recorded interviews were transcribed, coded and analyzed with the help of the software package Atlas.Ti©. This first qualitative analysis is currently going on. Structured quantitative data (sociodemographic and farm data) was stored in an Access Database and facilitates a multivariate analysis with specialized software packages (e.g. SPSS).

Conclusions

Farmers' experiments are one important source of information and knowledge that supports the evolution of agricultural practices and systems (Rhoades and Bebbington, 1995; Sumberg and Okali, 1997). Organic farmers gain practical experience and build up local knowledge by experimenting. Practical experience, accumulated wisdom and traditional knowledge offer valid solutions, tested by time (IFOAM, 2005).

Numerous recent publications draw attention to farmers' experiments and local innovations (e.g. Reij and Waters-Bayer, 2001, Bentley, 2006, ILEIA, 2000), mostly by using case studies of peasant farmers in developing countries. To develop a comprehensive understanding of farmers' research, it is important not only to focus on marginal areas, but to consider diverse social, political and natural conditions. Furthermore, there has been little attempt to look systematically at the nature, characteristics, and the factors associated with the experimental processes of farmers.

Advances and innovations in organic agriculture have so far been done mainly by organic farmers themselves. These processes of experimentation and innovation in organic farming have not yet been assessed scientifically. Understanding which role farmers' experiments play, improves our understanding and knowledge on the complex interactions that organic farmers face in their daily farming practices. Conducting a comparative study about organic farmers' experiments in three different countries permits us to determine the nature of farmers' experimentations. Furthermore the factors associated with variations in the experimental processes, within and among sites are being analyzed. This research contributes to the study of learning processes, and enhances the understanding of the links between organic farmers' experiments and local agricultural communication systems.

Acknowledgments

We acknowledge the funding of this research by the Austrian Science Foundation (FWF). We further want to thank Kendra Leek for her helpful comments.

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Development of organic farming in distant rural Māori communities in New Zealand through successful participatory approaches

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Key words: Participatory research, Māori communities, New Zealand, traditional knowledge, agronomical tools

Abstract

A research partnership was initiated between scientists of Crop and Food Research and rural Māori communities in the Tairawhiti region of New Zealand to help these communities with the transition from extensive agriculture to intensive organic horticulture. Within the project, growers are working together with agricultural scientists, extension specialists and social scientists using participatory approaches, what has proved to be a powerful tool for increasing the relevance and effectiveness of research for these communities. Progress towards original goals has been slower than expected, but mutual trust and developed relationships between the scientists and the community were recognised as the key factor in the project, and both groups were able to learn new and valuable skills. Many hands-on tools and techniques that made a real difference within the context of local organic vegetable cropping were developed and successfully employed.

Introduction

The Tarawhiti district (Fig 1) is a remote and predominantly Māori region with traditionally high unemployment and low rates of economic development.

Figure 1: Tairawhiti district (dark) situated on the East Coast of the North Island of New Zealand

The district covers 8330 square kilometres, almost 5% of New Zealand's total area, with 40,000 ha of rich alluvial river flats, ideal for growing crops with the remainder of the area mainly hill-country, well suited to farm sheep and cattle. The total population of the district is 45,000, a third of which is spread sparsely throughout the rural

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countryside or in small townships along the extensive coastline. In 2000, a joint local and central government taskforce was established to promote the development of the region. They concluded that organic production (already practiced on a small scale by some landholders in the region) represented a viable use of under-utilized Māori land and recommended further research into how organics might be further developed in the district. In addition, around 50 organic, most Māori growers with access to land areas ranging from a half an acre to several hectares, formed the East Coast Organic Producers' Trust (ECOP), based in Ruatoria, Waipiro Bay, Tiki Tiki and Tolaga Bay.

Objectives

The ECOP Trust produced a Strategic Plan which detailed their common agreement to develop their land for commercial organic vegetable production with the goal of increasing employment and improving the well-being of their East Coast community. Together with Crop and Food Research (CFR) an Implementation Plan was developed. ECOP and CFR successfully applied to the Foundation of Research, Science and Technology (FRST) for a programme called "Science for Community Change" was established to aid the development of a profitable and sustainable organic industry on the East Coast using participatory approaches (Kerckhoffs et al, 2006). An additional aim of the project was to improve the ability of scientists to work with rural Moāri communities. The specific goals were jointly finalized (at the start of the project) by ECOP and the science team at a *hui* (formal meeting) in 2003 in Ruatoria: (1) to help East Coast Māori make the transition from extensive agriculture to intensive organic horticulture; (2) to provide scientific, education, and extension services to assist ECOP to develop and implement best organic vegetable farming practices; (3) to design methods to promote beneficial change in rural Māori communities and production systems. ECOP was strongly quided by its original vision to promote values of *tino rangatiratanga*, *kaitiakitanga* and *whanaungatanga* (approximately translated as independence, guardianship, and relationship, respectively) in the East Coast community. There was also a great desire to revive the declining cropping tradition among *Ngati Porou* growers reflected through a mixture of belief in the cultural importance of traditional cropping with a strong desire to provide a positive social and economic example in order to attract back the youth of the community to the region. There was also a strong belief in the health and environmental principles of organics, which are closely aligned to their traditional cropping practiced over many generations.

The project joins ECOP Trust with a team of crop scientists, technicians, a local agricultural consultant complemented by social scientists, and provide agronomic advice to ECOP members while carrying out various organic crop trials on members' land to determine which crops are most appropriate for East Coast conditions. Many (international) students are involved, including several Māori students from the district. The project is also designed to improve the ability of scientists to work with rural Maori communities, and as such ECOP members provide informal and formal advice and training to CFR regarding *Māori tikanga* (protocol and traditions). Most project interaction takes place through workshops and field walks, which are designed in consultation with the local growers and their community with a clear focus on both organics and *matauranga* (traditional knowledge) as guiding principles. Local *hui* (meetings) are held at *marae* (Māori meeting houses) throughout the district (Fig 2). The initial focus was predominantly on many technical soil and cropping issues, like land management and agronomy with topics as soil (fertility), management of weeds, crop selection and winter cover crops. Other topics were subsequently added, and included market access (e.g. interaction with organic wholesalers outside the district), post-harvest and quality issues of their crops (e.g. optimising conditions during curing, storage and transport), 'adding-value' to locally grown products and building viable businesses (including topics like marketing, labelling, food safety). Over the course of the project several topics were revisited to cater for newcomers and for re-newed interest within the original group of growers. Some very practical and hands-on tools are being developed, e.g. a series of cropping calendars (A2-sized wall-planners) for kumara and Māori potatoes (Cropping Calendars, 2006; 2007), the development of a kumara curing cubicle (a low-cost solution to properly cure the kumara after harvest), the development of a mulch-system to enhance kumara growth/yield with additional benefits (e.g. water savings, and weed control). *Hui*, workshops, field-walks and other forms of interaction (e.g. newspapers, radio and TV) are the principal communicating techniques, and are characterized by its interactive and hands-on nature. In addition other scientific information is provided in hand-outs as well as *Te Panui* (newsletters/technical sheets) and on our website of the project (www.panui.org.nz)

Figure 2: Participants of a 3-d hui at Hauiti Marae in Uawa (Tolaga Bay) in August 2007 with topics: "Organic niche markets", "Getting into business" and "Taste of the East-Coast".

Discussion

Despite considerable enthusiasm generated at its inception, the project progressed more slowly than hoped or planned. ECOP's membership had dropped to a current active membership of 10-20 growers, yet at the same time the project has (as planned) attracted other community members not formally attached to ECOP, to its activities. Members of the science team describe an initial slow and sometimes frustrating period of trust-building and the perceived pressure to prove themselves to the growers and the communities involved. During the early stages growers were often reluctant to participate fully in the project, with low attendance at workshops and field-days, which was frustrating as workshops were a costly and time-consuming undertaking involving travel times in excess of 5 hours each way. However, some great achievements have since been made during the course of the project: (1) the emergence (and subsequent empowering) of young Maori entrepreneurs as a result of the exposure of Maori communities to new land use options and market opportunities.

These community leaders are early adopters of the sustainable agricultural practices promoted in this programme and leading others by example. (2) The increased exposure of the science team to *matauranga* (traditional knowledge) and the explicit acceptance by growers and scientists of the need to strengthen and build on mutual experience and understanding. This improved understanding has been instrumental to develop more efficient collaborative research outcomes. (3) The substantial extension of networking beyond ECOP into the wider community, evidenced by wider community participation in *hui* and workshops (29 in total) and field-walks (12 in total); and by individual networking both by Maori growers and scientists. This has significantly empowered local communities into cropping. (4) A major extension of research activity in favour of products targeting high value, niche markets (e.g. promotion of Māori potatoes to the restaurant market, novel products like kumara wine, pickled walnut, and the like). This goes well beyond the original focus on (organic) production of vegetable crops (Māori potato, kumara) alone. The total cropping area has been significantly increased and, on average over the study area, had doubled with many new paddocks now being established for cropping. In addition, the geographic spread of the project has increased the potential of cropping on the East Coast. The volume of produce sold in the East Coast has significantly grown during the period of the programme with niche markets established for many. Both scientists and growers characterize their involvement with the project as profoundly positive. All growers feel the project has greatly improved their ability to grow vegetables commercially. Both parties characterize the understanding, trust, and respect that have developed as crucial and there has been an increasing and ongoing sharing of knowledge amongst all parties (Bruges and Smith, 2007).

Conclusions

In the region the extent of organic cropping has extended along with increased volume of organic produce for the market (within and outside the district). Much more importantly, we have evidence of community development, a much more positive and entrepreneurial spirit, and an expanding level of community interaction with the science team. This reflects substantial capacity building both within the community and within the science team itself. Many meaningful tools and new techniques have been successfully developed by the team and implemented by the local growers.

Acknowledgments

All growers and scientists involved in this project for their shared passion, commitment and dedication. This work is supported by Foundation for Research, Science and Technology (C02X0305). For more information: www.panui.org.nz

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Promotion of Organic Vegetable Production through Farmers' Field School in Chitwan, Nepal

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Key words: Farmers Field School, Biopesticides, Participatory Guarantee System

Abstract

Organic vegetable production is important for economic uplifting of farm community. Research and development activities were carried out to promote organic vegetable production in Chitwan. Activities were carried out in four farmers groups in Chitwan district. Sidhuwa modality of group farming was followed for effective implementation of activities. Farmers' Field School was conducted to evaluate the effect of different organic pesticides on winter vegetables. Different biopesticides had differential effects in yield and disease suppression of winter vegetables but mixture of more than one biopesticide was effective in controlling major diseases and better yield of crops. Thus, this study showed that there is wide scope for use of biopesticides in organic vegetable production. However, this result should be verified by repeating same experiments for at least three seasons.

Introduction

Vegetables are important crops of economic value in Nepal. They are grown in wide range of agro-climatic zones covering 145 thousands hectares of land (CBS 1997). High value crops account for 8 percent of the total cropped area however, contributes for 14 percent of total agricultural GDP. Value of vegetable production is 45 percent greater than that of fruit production (APP, 1995).

Nepal is not self-reliant in vegetable production for its mushrooming population. Major factors for insufficient vegetable production include poor technical knowledge, weak marketing system, ineffective management of farmers' cooperative, post harvest loss, instability of vegetable price and significant pest damage. At the same time, high value crops are often heavily sprayed with chemicals with the consequent danger of pollution (APP, 1995). Unintentional human poisoning by chemical pesticides was as high as one million per year, out of which 20,000 people died in Asia (APO, 1996).

Vegetable demand is increasing year after year due to change in food habit of people with rapid urbanization process. There is about 5% increased in urban population per year and demand of vegetable has been increased with increasing urban population. Dhadhing and Chitwan Districts are major suppliers of fresh vegetable to the country capital. There is wide scope for commercial production of vegetables but serious concern of pesticide use and associated hazards became serious concern.

Organic agriculture deals with identifying the causes of problem rather than treating the symptoms after they appear (IFOAM, 2002). Research and development activities were designed to promote organic vegetable production so that farmers' ability to identify problems, their causes and recognizing relevant solutions can be

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strengthened. This forms base for sustainable agriculture and ultimately the sustainable livelihood of farmers.

Materials and methods

Shukra Nagar and Fulbari VDCs of Chitwan district were selected for research and development activity. Group discussion and strengthening activities were conducted in project area. Altogether four groups of vegetable growers have been formed in project sites of Chitwan. Two groups were formed in Fulbari and two were in Sukranagar. Participatory and collaborative approach was adopted for implementation of project and generation of outputs.

Farmers' Field School approach was followed for organic pest management in winter vegetables in Fulbari VDC, Chitwan. Twenty nine farmers of Organic Agriculture Production Cooperative Limited were involved in field school. The cooperative included members from both of the farmers group we worked for the promotion of organic agriculture. Five treatments were compared in four winter vegetables. Treatments included were use of farmers' practice of using liquid manure, three organic pesticides namely Sanjivani (*Trichoderma viridae*), Daman (*Beauveria bassiana*), Surakshya (*Pseudomonas fluorescens*) and mixture of these three biopesticides in winter vegetables. The vegetables used for comparing effectiveness of organic pesticides were Potato (*Solanum tuberosum*), Cauliflower (*Brassica oleraceae cv. botrytis*), Pea (*Pisum sativum*) and Tomato (*Lycopersicon esculentum*). Effectiveness of the applied treatments was compared for vegetable crops. Each treatment was replicated three times and average marketable yield of each treatment were recorded. The plot size was 2 x 1.5 m^2 for each treatment. Farmers analyzed agro-ecosystem of the research plots and discussed over the problems observed by farmers during field monitoring. Facilitators of the field school assisted group to locate the solution and provided technical support when needed for group.

The project adopted Siduwa modality as farmers co-operative in Sidhua, Dhankuta was the most successful cooperative for production of commercial vegetable in Nepal. They followed group approach in vegetable production and marketing. For promotional pathway, series of stakeholders' workshops were conducted on each project sites. These workshops became helpful in disseminating successful practices relevant for promotion of organic vegetable production in Chitwan. Similarly, district level stakeholders workshops and one inter districts stakeholders workshops were also organized. Participatory Guarantee System for marketing of vegetable was also practiced in Project sites.

Results

Research and development activity revealed that there was significant increase in area under production of organic vegetables. Farmers adopted organic vegetable production practices in their farms after their empowerment through series of consultation meetings, trainings and seminars. Farmers' Field School became effective tool for technology transfer in organic vegetable production. Farmers developed their idea on organic vegetable production through series of empowerment activities like formal and informal discussions, trainings, field visits and tours in vegetable production pockets.

Farmers Field School on organic Vegetable production strengthened farmers toward organic pest management, basic cultural requirements and practices for production of selected vegetables. This approach of activity implementation made farmers able to analyze their agro-ecosystem, interpret them and take relevant action against problems. This became effective tool in sharing experiences of farmers among each other and involved various technical and social components (Table 1) for empowerment of community in organic agriculture and cooperative farming practices.

Tab. 1: Technical and social components of the organic vegetable production strategy adopted in Fulbari, Chitwan, Nepal

Key Technical Components
• Regular field monitoring of growth parameters
• Elimination of infected planting materials by disease
• Rouging and field sanitation
• Preparation of organic pesticides using local materials
• Techniques of pesticide formulation and spraying for organic pest control
• Ecological balance tools for maintaining equilibrium
Key Social Components
• Reaching community consensus on OPM implementation
• Formation of a village level committee for OPM implementation
• Enforcement of community-agreed incentives and sanctions
• Regular monitoring of OPM implementation by community members

Comparison of effectiveness of different organic pesticides in winter vegetables (Table 2) revealed that yield of cauliflower was highest in *Trichoderma* used field followed by *Beauveria*. *Pseudomonas* was most effective followed by mixture of three biopesticides for cultivation of Pea. Tomato and potato yielded highest when mixtures of these three biopesticides were used for disease management.

Tab. 2: Effect of different organic pesticides on yield of winter vegetables

S.N.	**Treatments**	**Crop Yield (Ton ha^{-1})**			
		Cauliflower	***Tomato***	***Pea (Pod)***	***Potato***
1	*Trichoderma viridae*	15.33	49.00	8.67	33.33
2	*Beauveria bassiana*	13.67	44.00	9.33	33.33
3	*Pseudomonas fluorescens*	11.00	46.00	12.67	32.33
4	Liquid manure	10.33	45.00	9.67	40.00
5	Mixture of 1, 2 & 3	12.67	53.67	10.33	43.33

In overall, mixture of various bio-pesticides was effective in obtaining good harvest of crops tested.

Discussion

Adoption of participatory and collaborative approach in dissemination of information, skills and technology to community became effective in implementing research and development activities. Group approach of farming vegetables in wide are helped in development of effective pest management practices, sharing of problems and success experiences of farmers thus minimizing risk of crop failure and marketing.

Comparison of various biopesticides in farmers' field indicated that fungal diseases of Solanaceous crops are better controlled by use of mixture of more than one pesticide than use of single pesticide; however single pesticides were also effective for some other crops. Effectiveness of pesticides was different for legumes, crucifers and solanaceous crops even in same season. Overall effect of mixture of three biopesticides was the best for controlling diseases in winter vegetables.

Conclusions

Promotion of organic vegetable production activities implemented in Fulbari and Sukra Nagar VDCs of Chitwan became effective for empowering community in organic agriculture. Farmers' Field School approach became effective means of technology transfer to the community. Among various treatments compared in farmers' field, the highest yield of cauliflower (12.67 ton ha^{-1}), tomato (53.67 ton ha^{-1}) and potato (43.33 ton ha^{-1}) was obtained when mixture of *Trichoderma, Beauveria* and *Pseudomonas* was applied for pest control. However, pseudomonas became effective in higher pod yield of pea among other treatments.

Acknowledgments

We would like to express thanks to Ecological Services Centre for providing financial support for this research and development activity. We are also thankful to farmers involved in study for their valuable information and active participation in the program.

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Research methodology

Towards cognitive holism in organic research

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Key words: development of organic farming, scientific methods, holistic science

Abstract

In the course of the close interplay between any scientific approach and its object, research has a modifying impact on the latter. The same is true for agriculture as scientific object. This is a particularly evident problem in organic farming, as the worldview of organic farming, arguments in marketing and farming practice seem to be in contrast to contemporary academic science which is, however, of great significance for organic research. Thus, organic research often appears to be carried out on the same theoretical basis which is opposed by organic practice and its ethical and philosophical backgrounds. At various levels, the apparent antagonism between holism and reductionism is part of this problem. This paper discusses whether holistic science is necessarily in contradiction to analytic and reductionist methods, or whether different scientific approaches could be brought together and linked in a cognitive process of building wholeness in thinking and imagination.

The problem

In 1906 a German agricultural scientist published an extensive paper on “Agriculture and Science” (Rümker, 1906), in which he suggested that the only chance for agricultural science to develop is to become specialized in different disciplines. In the same paper the author wrote: “in their practical application on the farm, the branches of agricultural science must intimately interact and harmoniously merge to become a well functioning organism”. Thus, at the beginning of agricultural industrialization, Rümker formulates the concept of a farm organism, but at the same time recommends that agricultural science should take on the disciplinary modes of thinking of academic research. Just a few decades later, agriculture became more and more divided into highly specialized parts, and many of the problems with which the organic movement struggles today derive from this specialization. It is a historical fact that Rümker's scientific vision conquered his agricultural vision, and that the reductionist academic mode of thinking altered agricultural reality rather than the other way round (Zimdahl, 1998; Wieland, 1999). Thus, science has a considerable definition power on what is true and necessary. In the framework of organic farming, however also ethical and philosophical concepts exist about truth and necessity apparently contradicting the contemporary mechanistic concepts of “life” and economics agricultural science is built on. Bearing this in mind, it is important to be aware of the mode of thinking that goes along with today’s organic research.

Organic farming is as well ethically, practically, and concerning its market arguments based on these contradicting concepts – at least partly. But what is currently the relationship between organic farming and organic research? Is practical organic farming, which aims to take account of the complexity and entirety of the agrarian context (e.g. IFOAM, 2005), complemented nowadays by a research practice that

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supports its aims, or not? Or could it be that, although certain research activities appear to support organic farming by proposing helpful solutions to practical problems, they intrinsically contradict key organic ideas and aims? In a major paper about the paradigmatic background of organic agriculture, Wynen (1996) argues that organic farming is based on a markedly different paradigm than conventional farming and, equally, that research focusing on organic farming is just as far removed paradigmatically from conventional agri-science. But is the different practical paradigm necessarily reflected by a different scientific paradigm? Drawing on work by Lockeretz (2000), it seems that organic farming as an object has not significantly influenced research methodology; instead, organic scientists generally adhere to the conventional academic research practice used by colleagues concerned with other areas of inquiry. Following Alrøe & Kristensen (2002), this has an impact on the reality of organic farming practice. If the understanding of nature underlying the concepts of organic farming is not covered by accepted scientific descriptions it will again and again be very difficult to explain these concepts convincingly. At this point, a task of science is involved which is not the applicability of results in practice but rather the applicability for education and gaining of understanding and general awareness. Concerning the organic farming concepts this task appears to be essential for organic research. A clear need exists for closing the gap between ethical claims and scientific understandings about the objectives of organic research. To cover this need can not only be the task of ethical philosophers, but it is rather the duty of the researchers themselves, as long as they make the same claims by calling themselves “organic researchers”.

A cognitive holistic approach?

But could it be, that the contradiction within the suggestions of Rümker (1906) is only apparent and that the core problem is not the disciplinary research itself but the lack of bringing things together into the mode of organism? Our suggestion is that to a considerable degree this organism-understanding has to be built within ourselves, that this organism is a (justifiable!) product (image) of the human consciousness. That requires (i) bringing parts together (maybe, more concisely: thinking parts together) and (ii) involving ourselves and our ethical and aesthetical sagacity into the appreciation of the research results. This means however, describing research objects and processes not only in functional but also in qualitative terms. And qualitative terms have the characteristic that they appear close to semantic meanings added by the describing subject to the described object. In the contemporary scientific framework this is a problem. But we have at least to ask whether any human awareness can be free from (even subtle) personal involvement of the subject with the object. The physicist Fischbeck (2003) argues that “life” and “organism”, as phenomena of self-organization, are comprehensible only when we see them as meaningful systems that rely on communication between the interacting parts. And communication is comprehensible only as transmission of semantic content. This argumentation comes very close to the term “organism” used in organic farming. It means that the term “organism” implies discovering (or ascribing) meanings to natural objects and beings. This is possible only on the canvas of individual involvement, thinking, and awareness.

The suggested approach we will explain by the example of the positive effects of organic systems on healthy milk fatty acids: It is a well established fact that grassland based dairy systems, as they often occur on organic farms increase the concentration of beneficial fatty acids like omega-3 fatty acids (n-3 FA) and CLA in milk (e.g. Leiber et al., 2005) and it has already become a marketing claim for organic milk products.

However, an understanding of this fact and of its real significance (or non-significance) is almost lacking. Farmers are bound to the very simple argument “healthy cows from grassland give healthy milk” and consumers have to accept, that n-3 FA prevent them from heart diseases and occur particularly in organic milk. How is it possible to gain a deeper understanding which also enables practitioners and consumers to be aware of the underlying context? From ruminant physiology it is clear, that the main n-3 FA in milk, α-linolenic acid, stems directly from the plant and appears in milk only proportional to those small amounts which are not converted into other FA by ruminal fermentation. It is a plant substance which “survives” the ruminant digestion (cf. Leiber et al., 2005; Leiber, 2006). From human physiology the n-3 FA can be described as active substances which have particular significance in the development of the central nervous system and the retina of the eye. With these aspects, the term “n-3 FA” can be saturated as to mean a plant-derived substance which is saved throughout the cows’ metabolism and which is important for the nervous system. “Milk fat quality” thus, appears within a larger framework than only the quantitative presence of certain substances. An aspect of milk quality, in this perspective, could be the mediation of plant qualities via the cows metabolism to human nutrition (cf. Leiber, 2006). As well for the organic farm management as also for marketing arguments this perspective could be fruitful to deepen. It does not go without analytical science but it goes beyond.

To follow phenomena of the appearance of an object under different conditions – in this example the appearance of n-3 FA in the plant, in the ruminant digestion and in the endogenous metabolism of animals and man - may discover the nature of the object in a particularly comprehensive way. However, perhaps the precondition for such an approach lies in acceptance that *understanding* is based on imagination and not only on data. This approach can be thought of as a virtual kind of Goethean experiment. As so well described by Stephenson (2005), J.W. Goethe saw the experiment as a means of understanding an object by making it appear under varying conditions and connecting the different appearances in a cognitive-aesthetic process. Thus, Goethe proposes the idea that it is the variation of appearances that indicates the inner nature of things. This approach does not entail a rejection of analysis; what it does imply, however, is that the results of an experiment need to be put back into a context by the cognitive activity of the scientist, and that the meaning of the object becomes clear not in the single analytical result but in the variation of the appearances. The wide range of agri-scientific activities presents an opportunity to bring the variations together.

To bring it back to our example: after viewing the analytical fact of certain FA concentrations within a larger context, the next step could be to ask, e.g. whether there is any affinity between plant characteristics and the nervous system in mammals and whether the milk necessarily mediates this affinity to the offspring, etc. We found the “affinity” on the biochemical level in form of n-3 FA, appearing in the different places but we can also find it in terms of morphological analogies or similarities. Particularly, if we include the bones, covering the central nervous system (spinal column and skull), it has in several respects striking correspondences with the shape and development dynamics of annual herbs (Leiber, 2006). We have to be very careful with such analogies; however, in the organic scientific community, which asks for the “inner quality” of products it should be not too strange to ask cautiously for an inner correspondence between certain plants and the central nervous system. If we consider, that these annual herbs occur particularly frequent in those kinds of pastures which lead to high n-3 FA in milk, this gives a picture. Such a picture, although it is clearly subjective may help to reach a different level of understanding the “whole”. It could help to reach awareness via personal involvement – and that could be an awareness which enables the recipient not only to accept biochemical facts but also to go in to the phenomenon – thinking and imaginating. The compulsory condition, of course, is the permanent possibility to develop or even to falsify any such ascriptions within the scientific and the public dialogue.

Conclusion

If organic research relies on the same scientific mode of thinking that has led to conventional agricultural solutions, it can be expected, in the long run, to catalyze a conventionalization of organic farming practice. Holistic science is repeatedly stated as an alternative, but the relation between holistic and analytical / reductionistic approaches is often considered as oppositional. We have suggested a cognitive approach to holism which can function as a complement to recent research practice rather than as a substitute for it. Our suggestion is to put scientific facts, derived from different methodologies, into common horizons of reflection and into larger and more differentiated cognitive contexts than is usually the case. The suggestions made here are intended to offer a different perspective on holism. They are by no means intended to derogate other, more empirical holistic approaches.

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Research into Practice: Mind the Gap

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Key words: Organic research; dissemination; adoption; advice.

Abstract

The uptake of organic research by commercial producers has been variable due to a number of factors including lack of access to research findings, financial pressures, research priorities, market demands and producer perspectives. Consequently "best organic practice" is not universally applied and apparently intractable problems remain, even though in some cases solutions are available. This paper identifies the role of advisers in supporting organic farmers and the establishment of a system for disseminating the results of research through a number of routes including a web-based archive, advisory leaflets and workshops.

Introduction

Research is a critically important component of the development of agriculture. It provides new insights into all aspects of food production and related impacts on society and the environment as well as guidance to policy makers and support to farmers through the resolution of technical problems and demonstration of new and more effective techniques. During the last 25 years there has been a substantial investment in organic agricultural research in the UK. This paper considers the role and effectiveness of that organic research and investigates mechanisms for furthering the dissemination and uptake of research by farmers.

Materials and methods

The paper is based on the personal experiences of the author, who spent 15 years as Head of the Organic Advisory Service in the UK, working closely with researchers at The Organic Research Centre (ORC) at Elm Farm, and more recently Director of the Institute of Organic Training and Advice (IOTA) — throughout all that time providing technical advice to organic farmers. It draws on some of the experiences of other countries, provides a summary of the impact of research and an analysis of different mechanisms for disseminating the results of research.

Results

During the 1985 Cirencester Organic Conference there was an audacious proposition that one of the Ministry Experimental Husbandry Farms (EHF) should be converted to organic. Some 15 year later there were four of the EHFs with organic units, no less than nine research institutions with organic sites, to say nothing of the five dedicated organic research sites linked to ORC and Garden Organic (GO). Until recently, annual spending on organic research was around £ 4.1 million a year, half of which was

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funded by the Department for the Environment, Food and Rural Affairs (Defra). (Organic Research Centre, 2003)

During this time, organic research has undoubtedly contributed to a better understanding of the farming system, of nutrient flows and the potential for more effective management to minimise pollution and improve productivity. It has provided some hard science on the positive impact of organic farming on the environment and biodiversity and much needed information for determining policy and support, but this has not been of much help to farmers. A great deal of work has been done on farming techniques: varieties, feeding trials, green manures, blight control, parasite control, weed control, mastitis management and so on. However there remain many intractable problems for farmers, for example, yields which in some instances are only 60% of conventional and many unanswered questions (Wynen, 1996).

Not only has the uptake of organic farming been slow but organic practices do not, with some notable exceptions, reflect the results of the considerable research effort of the last 20 years: crop and forage yields have not risen significantly, the fundamentals of closed farming systems are not routinely put into practice, animal breeding is still focused on production rather than health, use of antibiotics in dairy cows seems to have increased and there still remain negative environmental impacts from organic farming which could be eliminated with better management.

Organic agriculture has not been revolutionised in the way that might have been expected from the revolution seen in conventional farming. Perhaps this is because £4 million per year is actually a very small sum in research terms, perhaps it is because it is very difficult to research farming “systems” and concepts of “health and vitality”. Or perhaps it is something to do with the psychology of farmers—those attracted to organic farming are not by their nature at the cutting edge of science?

It may also be because of the research itself. Has it failed to focus on the primary concerns of farmers? Is the research only confirming what commercial farmers have already discovered for themselves? Is it that we have false expectations of research? For example the value of research may be that a new concept or technique, such as stockless systems, is more widely understood and accepted, rather than resolving a technical problem. Organic research certainly needs to recognise that organic agriculture requires a different type of research (Woodward, 2002), tackling different and often holistic issues and it needs to be undertaken in a more integrated manner than is standard practice in conventional research.

Underlying all this is the fact that there is so often a gap between the publication of research and the findings getting adopted by commercial farmers. Sometimes the block is the sheer financial pressure on farming, sometimes market intransigence (demanding stringent cosmetic and processing qualities) and in some cases failure of the organic certification process, but it is frequently also about communication.

There have been valiant efforts at farmer engagement (ADAS, 2002). Some researcher-led projects have involved farmers throughout the process: prioritising issues, developing protocols, discussion of the results and even paying for their involvement, for example, the on-farm ORC cereal variety trials and the much-valued GO participative knowledge exchange in weed control (Turner, 2006). Such approaches have certainly succeeded in engaging farmers in the research and their positive feedback suggests that the work is valued, but how effectively the results are applied is not known.

A more “bottom-up” approach has even more to recommend it. Experience of research initiated and in part undertaken by farmers in the Netherlands (Baars, 2002), Germany and Switzerland is that there is a degree of ownership and engagement in the work which results in application of the findings on farm. Interest in research amongst farmers in the UK is mixed, therefore ensuring their involvement at the initiation stage requires a high degree of stimulation by an adviser working with a research organisation or in some instances by a marketing co-operative, as demonstrated by the Organic Milk Suppliers Co-op.

As advisers, we must take some responsibility here. We play a crucial role in engaging with research and ensuring that it is put into practice. One to one, on-farm advice from experienced organic advisers still provides the most effective means of communicating new ideas or techniques. Advisers typically do not have much time available for attending research conferences or trawling through research papers and the need to earn a living limits their professional development time. So how do they keep up to date? They do it by reading magazines, websites and reference books and perhaps attending 3 or 4 training courses per year. While some advisers are dedicated to organic farming there are many in the UK who advise both organic and conventional farming, so they have an even greater challenge to keep up to date.

In order to facilitate access to research, IOTA has established the UK arm of Organic EPrints—www.orgprints.org—a user-friendly and fully searchable web-based archive, which provides free access to over 10,000 papers from the majority of organic research programmes of Europe. IOTA has uploaded more than 200 papers during the last year, including all the Defra funded work since 2000.

To support advisers in the time-consuming task of pulling together the results of research from a number of sources, IOTA has also commissioned Research Reviews. Undertaken by experienced advisers, reviews of 21 topics are available on the IOTA website www.organicadvice.org.uk. These reviews are common-sense analyses of the research on critically important topics, such as dairy cow nutrition, the benefits of composting, protein crops, stockless arable farming, nitrogen management, energy management and minimal cultivations. The work has really put research results into a practical context of use in advising farmers.

Discussion and Conclusions

With the major shift in UK government research funding away from a dedicated organic programme to the Defra “sustainable agriculture research programme” there are serious issues for ongoing organic research priorities and funding. Private funding of research remains small but it is just as important as in 1985, and good dissemination will be ever more critical.

The establishment of a common archive of research results has been a useful contribution and collation of research results on the basis of subject has further helped overcome the limited time which organic advisers have in keeping up to date with research information. Subject-focused workshops have provided an opportunity for engagement between advisers and researchers and have been a valuable learning process for both parties.

Experience of the ability of research to influence organic farming practice has been mixed. What is clear is that no one means of dissemination will suit all situations. The nature of organic agriculture requires research of both a different type and methodology and a different approach to communication—one where farmers, advisers and researchers are engaged throughout the process. The form of that communication needs to be tailored to the particular needs of the recipients, whether they be farmers or advisers and to the type of information being communicated.

Acknowledgments

IOTA wishes to acknowledge the support of Defra in funding the PACARes project which is disseminating the results of organic research to advisers, trainers and others.

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Meta-evaluation of action plans – The case of the German Federal Organic Farming Scheme

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Key words: Organic farming policy, Policy evaluation, Organic action plans

Abstract

Meta-evaluation can be seen as a quality control measure of policies or programs. For that purpose, a formal methodology is used when assessing the quality of an evaluation work. The presented meta-evaluation is based on an adapted version of the evaluation standards used by DEGEVAL (German evaluation society). The well-balanced design of the DEGEVAL standards makes them widely applicable and useful also for conducting meta-evaluations. This paper presents the results of a meta-evaluation undertaken on the evaluation of the German Federal Organic Farming Scheme. Concerning most sections the quality of the underlying study is excellent.

Introduction

Evaluations have become an expected part of the policy cycle and are a well established technique to solve the problems that arise when implementing programs. However, it is crucial to question the way in which these evaluations are conducted. With this in mind, it could be helpful to take a look at the meta-level and to that effect, conduct a meta-evaluation. According to DEGEVAL (2003) the use of *general standards* can “help to raise transparency of evaluation as a professional code of practice vis-à-vis the general public“. This paper presents the results of a meta-evaluation undertaken on the evaluation of the German Federal Organic Farming Scheme (FOFS).

Meta-evaluation in the political field of organic farming policy has not been applied up until now and this study can therefore be considered to tread on entirely new ground, scientifically speaking. The aim of conducting this meta-evaluation is to assess whether the evaluation of the FOFS is done in accordance to broadly accepted professional standards (in this case according to the adapted DEGEVAL-Standards, referred to here as *general standards*) and whether the findings follow a logical order. According to Widmer (1996), the outcome of a meta-evaluation can provide insights into the design and methodological configuration of evaluation studies (“How is the evaluation study constructed?”), as well as into the classification or the indexing of the standards (“Do the study evaluated meet the criteria?”). The main aim of this study was to investigate the specific methods used in the evaluation study, in order to improve upon future evaluation studies in the field of organic action plans.

Materials and methods

The meta-evaluation presented was conducted between October 2006 and February 2007, and was based on the official evaluation report (Becker et al. 2004). The *general standards* used are the “Standards for Evaluation” of the “Gesellschaft für

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Evaluation" (DeGEval; German evaluation society, 2003), with some adaptations (Stufflebeam 1999 and Stufflebeam 2001)[1]. The DEGEVAL standards are based, in principle, on the standards of the U.S. Joint Committee on Standards for Educational Evaluation. The well-balanced design of these standards makes them applicable in a wide range of situations and useful in conducting meta-evaluations. The *general standard* set is divided into four main categories: *Utility Standards* are intended to ensure that the evaluation is guided by both the stated objectives of the evaluation and the information needs of its intended users. *Feasibility Standards* are intended to ensure that the evaluation is planned and conducted in a realistic, thoughtful, diplomatic, and cost-effective manner. *Propriety Standards* are intended to ensure that in the course of the evaluation all stakeholders are treated with respect and fairness. *Accuracy Standards* are intended to ensure that the evaluation produces and discloses valid and useful information and findings pertaining to the evaluation questions (cp. DEGEVAL 2001). The underlying study was then analysed by the author of this paper with respect to the adapted set of standards.

As this meta-evaluation is planned as a desk study, not all *general standards* and sub-standards listed could be classified. Some of the valuations were not possible due to limited data. Regrettably, several interesting points e.g. concerning reliability and financing could not be evaluated in detail. In any case, the meta-evaluation helped to shed some light on the evaluation method used and accordingly improve the evaluation methodology in the field of organic farming support schemes. One important criterion is the analysis of stakeholder integration in the planning, implementation and assessment of an evaluation.

Every standard listed in Tab. 1 is itemized into some (3 to 22) sub-indicators. To provide an example, for the case of the standard *Stakeholder Identification* these ten sub-indicators are: (1) Clearly identify the evaluation client, (2) Engage leadership figures to identify other stakeholders, (3) Consult potential stakeholders to identify their information needs, (4) Use stakeholders to identify other stakeholders, (5) With the client, rank stakeholders for relative importance, (6) Arrange to involve stakeholders throughout the evaluation, (7) Keep the evaluation open to serve newly identified stakeholders, (8) Address stakeholders' evaluation needs, (9) Serve an appropriate range of individual stakeholders, and (10) Serve an appropriate range of stakeholder organizations. If all 10 sub indicators are quoted positive, the *general standard* would been quoted with 10 ☐.

Results

The meta-evaluation shows that the evaluators[2] have followed most of the applied standards. Concerning the section of *Utility, Feasibility* and *Propriety* standards, the quality of the study is excellent.

Looking at some of the shortcomings, one can point to the fact that not all points regarding *valid and reliable information* and a*nalysis of qualitative and quantitative information* were observed when preparing and conducting the evaluation study.

[1] The detailed list of standards can be requested from the author

[2] C. Becker, S. Ekert, J. Sommer and A. Zorn, see also list of references

Tab. 1: Meta-evaluation of the FOFS according to the prescribed set of standards

	□	□	≈
U1 Stakeholder Identification (max. 10 Pts.)	1	8	1
U2 Clarification of the Purposes of the Evaluation (max. 3 Pts.)	1	2	
U3 Evaluator Credibility and Competence (max. 10 Pts.)		8	2
U4 Information Scope and Selection (max. 10 Pts.)		10	
U5 Transparency of Values (max. 13 Pts.)	3	10	
U6 Report Comprehensiveness and Clarity (max. 14 Pts.)	1	13	
U7 Evaluation Timeliness (max. 10 Pts.)		6	4
U8 Evaluation Utilisation and Use (max. 13 Pts.)	1	10	2
F1 Appropriate Procedures (max. 11 Pts.)	1	6	4
F2 Diplomatic Conduct (max. 3 Pts.)		3	
F3 Evaluation Efficiency (max. 13 Pts.)	1	10	2
P1 Formal Agreement (max. 11 Pts.)	1	10	
P2 Protection of Individual Rights (max. 12 Pts.)		11	1
P3 Complete and Fair Investigation (max. 10 Pts.)		10	
P4 Unbiased Conduct and Reporting (max. 2 Pts.)	1	1	
P5 Disclosure of Findings (max. 11 Pts.)	2	7	2
A1 Description of the Evaluand (max. 11 Pts.)	1	8	2
A2 Context Analysis (max. 11 Pts.)	2	9	
A3 Described Purposes and Procedures (max. 12 Pts.)	1	8	3
A4 Disclosure of Information Sources (max. 11 Pts.)	1	10	
A5 Valid and Reliable Information (max. 22 Pts.)	6	12	4
A6 Systematic Data Review (max. 1 Pt.)			1
A7 Analysis of Qualitative and Quantitative Information (max. 20 Pts.)	10	9	1
A8 Justified Conclusions (max. 11 Pts.)	1	10	
A9 Meta-Evaluation (max. 11 Pts.)	10		1
Total	45	191	30
%	16,9	71,8	11,3
Appraisable (in %)	88,7		

Codes: ⩽ = No (evaluation study is missing the standard), □ = Yes (evaluation study fits the standard), ≈ = No answer (No data available to evaluate that standard)

Discussion and Conclusion

The *general standards* (like the ones established by DEGEVAL) are in fact not precise enough to measure a specific program or project. These need to be supported and concretized by specific, *tailored standards,* such as those used in the FOFS evaluation. Nevertheless, these *general standards* could be seen as a tool for evaluators when preparing an evaluation. The consideration of such standards could help to ameliorate evaluation studies and safeguard utilization of the results by means of a more *user friendly* (or in the words of an evaluator - *stakeholder oriented*) format.

The standards used for this meta-study can be considered as very suitable for this sort of evaluation and can therefore be recommended for other evaluation studies in the field of organic action plans (e.g. the *European Action Plan of Organic Food and Farming*). In order to achieve transparency and guarantee a complete assessment of all standards and sub-standards, it is important to choose an evaluation scheme that includes these considerations. Furthermore, for a complete assessment of a study it is necessary to make sure that all documents and reports prepared during the evaluation (financing, treaties etc.) are accessible and analysed by the meta-evaluators.

As a final recommendation for designing future evaluations, it can be stated that a specific and deliberate set of evaluation standards ("*tailored standards"*) has to be adapted and calibrated in accordance to the examined topic (such as organic action plans). However, it is helpful for evaluators and can furthermore greatly facilitate a worthwhile evaluation study if a set of established and accepted standards (e.g. DEGEVALs *general standards*) are consulted when preparing the evaluation. Such improvements would increase the likelihood that evaluation results will be utilised, encourage greater acceptance of the outcomes and thus justify evaluation itself.

Acknowledgment

This study is based on outcomes of the project "European Action Plan of Organic Food and Farming: Development of criteria and procedures for the evaluation of the EU Action Plan for Organic Agriculture (ORGAP)" and accordingly with financial support from the Commission of the European Community. The views expressed are those of the authors and do not necessarily reflect the views of the European Commission, nor do they in any way anticipate the Commission's future policy in this area.

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The sustainable livelihoods approach: A frame for furthering our understanding of organic farming systems

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Key words: Sustainable livelihoods, organic agriculture, agricultural research

Abstract

The rapid development of organic agriculture on a global scale has led to an increased inclusion of producers in developing and transitional countries in the organic food chain. In order to enhance the theoretical frame for the analysis and understanding of the impact that inclusion in the organic food chain has on producers and their families, an analysis was conducted of the use of the Sustainable Livelihoods Approach (SLA). The SLA provides a holistic and integrative approach which researchers can use as the overriding frame for their research. The application of the approach is recommended as it enables us to maintain important elements of the sustainability vision, yet emphasises that a number of assets influence farmers' livelihoods and it maintains the focus on salience, legitimacy, and credibility in the research.

Introduction

Organic production and consumption has developed markedly on a global scale within the past decade, rapidly increasing the demand for organic products, in particular in the Western world (Yussefi, 2006). Greater demand for organically produced foods has, amongst other impacts, seen an increased reliance upon organic products produced in developing and transitional countries (henceforth termed developing countries). The globalisation of organic agriculture poses a variety of challenges for the direction of its future development, for example the increased global trade of organic products means that organic farming may face many of the same globalization challenges and threats to sustainable development as conventional agriculture (Byrne et al. 2006).

The rapid growth of organic farming in developing countries has brought about increased interest in the potential of organic agriculture to improve the livelihoods of small-scale farmers. This is, in particular, reflected in the increased integration of organic agriculture into the rural development agenda (see for example http://www.fao.org/organicag/). However, organic agriculture initiated under the guise of promoting development and alleviating poverty raises a variety of pertinent questions, for example, whether organic agriculture does, in fact, lead to improved livelihoods, whilst still securing the benefits inherent to organic agriculture.

The investigation of such complex situations requires a multi-scaled integrated approach which can enable the researcher to deal with complexity. One such approach is the sustainable livelihoods approach (SLA). The aim of this paper is to discuss the application of the SLA in investigating the impacts of organic farming on farmers' livelihoods.

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Materials and methods

This paper is based upon relevant literature within development thinking, organic farming and a review of the applicability of conceptual frameworks for livelihood analysis of organic farmers.

Results and Discussion

The Sustainable Livelihood Approach (SLA) was initially architected in a working paper by Chambers and Conway (1992), after which it was developed and applied in the implementation of development projects by international development agencies throughout the 1990's. The sustainable livelihoods framework, presented below, summarises the SLA. Messer & Valarini (2003) describe the aim of the framework concisely as *'a tool for understanding how household livelihood systems interact with the outside environment – both the natural environment and the policy and institutional context*'. Thus, the framework depicts a way in which livelihoods can be understood and analysed. A framework such as this should be considered as an analytical structure for guiding our thinking – understanding the complexity of rural people's lives and understanding the importance of upper level transforming processes and how they interplay with livelihood assets (the five capitals).

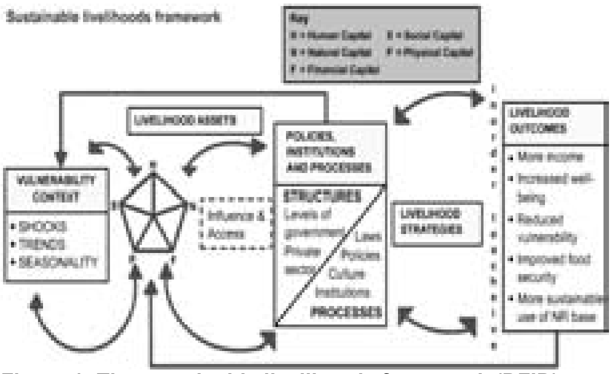

Figure 1: The sustainable livelihoods framework (DFID)

The strength of the sustainable livelihoods framework is that the conceptualization of people's lives assumes a more holistic approach than previously applied in development research, where indicators of project impacts typically accounted for indicators such as food consumption and income. Applying the SLA in an investigation of the impacts of organic farming on peoples' livelihoods forces us to take stock of the five livelihood assets and enables us to relate the status of these indicators with the influence of transforming structures and processes (for example institutions). For example, how do institutional or organizational structures and processes influence the status and access to livelihood assets? Analysis of the context within which people operate enriches our understanding of livelihood strategies.

As briefly discussed in the introduction, the application of organic agriculture as a tool for development may result in trade-offs. For example, improving local farmers' financial capital by linking them to an international market may have detrimental effects upon other livelihood assets, such as natural capital. Is this a desirable trade-off? Consider, for example, this situation vice-verse – restricting farmers' market access to preserve natural capital. This example highlights an important point to take into consideration when conducting research at this level of complexity. The SLA will enable us to provide a thorough analysis of what types of impacts organic farming can bring about within a certain context and how these impacts are interrelated.

In our current research, undertaking farm level studies of the agroecology of organic farming systems and the socio-economic impacts of organic farming in developing countries, we consider the SLA as a highly suitable guiding frame, essentially, using the SLA as a reviewing or impact assessment tool. Here a few examples of the impacts that will be considered using the SLA:

- How the growth of organic farming in an area has affected the livelihoods of different stakeholders. What types of impacts have there been upon the livelihood assets (including the difficult to quantify assets such as social capital) and what are the trade-offs.
- The adoption of organic farming in a village/region – how does this fit with people's livelihoods and who and importantly who are not the beneficiaries and participants.
- The framework enables us to link impacts at various scales and help in understanding causal relationships, for example linkages between household impacts of organic agriculture and policies, institutions and processes.

Rural livelihoods in developing countries are becoming increasingly separated from the actual farming activities (Rigg, 2006). This has important connotations for how we choose to conceptualize, and thus research rural people's livelihoods and emphasises the need to consider new guiding paradigms and new research questions in these contexts. Cash and Buizer (2005) argue that for research to translate into (and thus reflect) real-life situations, then there are three essential components which are necessary to meet: salience, credibility and legitimacy.

Salience relates to the perceived relevance of the information: does the system provide information that the users think that they can use, in a useful form and at an appropriate time? Credibility addresses the perceived technical quality of information: does the system provide information that is perceived to be valid, accurate, tested, or at least as likely to be true as alternative views? Legitimacy concerns the perception that the system has the interest of the users in mind or, at a minimum, is not simply a vehicle for pushing the agendas and interests of other actors. What is it about the SLA that can enhance salience, credibility and legitimacy of research conducted for agricultural development? The application of the SLA approach to scientific research can assist us in asking the right questions. An analysis of a problem situation using the SLA approach helps according to Farrington (2001) in (1) Identifying groups of people according to their main livelihood sources, (2) Identifying the main sources of vulnerability associated with these livelihoods, (3) Identifying the main assets supporting these livelihoods – in particular the inclusion of economic and social assets, (4) Identifying the qualitative aspects of these assets (5) Identifying multiple rural livelihoods – the heterogeneity of poor peoples' livelihoods and their ways of addressing poverty, and (6) The identification of policy areas which can influence and also specifically target certain groups.

The sustainable livelihoods framework provides researchers with a holistic and integrated view and understanding of the components and processes of peoples' livelihoods. This raises the question of the operational prowess of the framework. The usefulness, and thus the manner of application of the framework, is essentially set by the user (Carney, 2002). Therefore, the SLA should be used as a guiding framework for one's research – it is a conglomeration of many theories from various disciplines – the framework enables us to unify thinking that lays the foundation for these theories.

Conclusions

The aim of this paper was to analyse the sustainable livelihoods approach as a research tool within organic farming. The SLA draws together a number of disciplines, providing a holistic approach which researchers can use as the overriding frame for their research. The application of the approach is recommended as it enables us to maintain important elements of the sustainability vision, yet emphasising that a number of assets influence farmers' livelihoods and maintaining focus on salience, legitimacy, and credibility in the research.

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Challenges in Transitioning to Organic Farming in West Bengal, India

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Key words: developing countries, extension, Farmer Field Schools, Green Revolution, organic conversion

Abstract

This paper uses a case study of small-scale rice and vegetable producers in West Bengal, India to argue that some of the same infrastructural and technical roots to problems that plague small farmers attempting to use chemically-intensive farming methods also hinder their ability to fully convert to global-style organic farming. In particular, problems in accessing knowledge and technical inputs are likely to translate into difficulties in adopting and maintaining organic production practices. This case study raises the question of whether the global organic model, which is highly dependent on specialized, knowledge-intensive techniques and expensive inputs, offers a true alternative for the developing country context. A locally developed model based on low-cost, local resources and disseminated through local information networks with substantial farmer participation may offer a more viable alternative.

Introduction

At first glance, organic farming appears to offer a simple anecdote to the problems generated by the Green Revolution model of agriculture, such as decline of soil organic matter and nutrient-holding capacity, over-exploitation of groundwater, pesticide resistance, and toxicity to farmers and communities from pesticide exposure. However, adoption of certified organic farming, as commonly understood in the global context, presents a host of challenges to small-scale Third World farmers. Many of these constraints are similar to those hindering the improvement of chemically-intensive farming systems: inadequate extension capacity, lack of technical training materials, and shortage of capital to purchase costly inputs. The result is that the spread of organic farming in many developing countries has been slow. In India, for example, the International Federation of Organic Agriculture Movements estimates that an area of about 150,790 ha is under organic farming, representing only about 0.1% of the total cultivated land (Willer and Yussefi 2007). Moreover, more than half of India's organic production consists of export crops such as tea, coffee, and spices.

To illustrate the challenges of a transition to organic farming in India and other developing countries, we draw from a case study in West Bengal, India where an effort is being made to spread sustainable alternatives to chemical-intensive farming.

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Materials and methods

Fieldwork was performed in 2006 while based at Swanirvar, a rural development NGO in the district of North 24 Parganas in southern West Bengal. Numerous individual and group interviews were conducted with Swanirvar staff and leaders of farmer groups receiving support in sustainable agriculture techniques from Swanirvar. Also consulted were local, state, and central government officials in charge of agricultural extension, researchers at agricultural universities, and staff of other rural development NGOs. Participant observation was conducted at Farmer Field School-type extension meetings organized by NGOs or the government.

Results

The study site is characterized by a population density of 2,181 persons/sq km (Govt W. Bengal 2002) and approximately 75% of landowning households own less than 1 hectare of land (Dasgupta 2005). Over 60% of the cultivated land is under irrigation, and most of this land produces more than one crop per year. The advent of a dry season rice crop was fostered by the government in the 1970's and 1980's through programs which distributed kits with seeds of high-yielding varieties as well as chemical fertilizers and pesticides. These new technologies initially produced a spike in rice yields which continued for 10-15 years; however, farmers in the study reported 20-50% declines in yields in recent years. Field visits revealed that zinc and iron micronutrient deficiencies are common because of farmers' heavy dependence on commercial fertilizers such as urea phosphate. In addition, farmers require increased applications of pesticides for the same level of pest control, especially in vegetable cultivation. Some farms are even reducing their area under eggplant, one of the highest-value cash crops, due to mounting costs of production inputs and increasing difficulty controlling pests.

The onset of the pesticide treadmill has been hastened by a lack of information about active ingredients and their modes of action. In the absence of adequate government extension capacity, local pesticide retailers are the most common sources for advice on pest management (Jana 2004). Interviews with shopkeepers suggest little understanding about the importance of rotating pesticides based on different active ingredients. Furthermore, the newer generation pesticides that are more selective and have different modes of action are either unavailable or unaffordable. A village-level study showed that the majority of pesticides used on vegetables are still pyrethroids and older-generation organophosphates (Kole and Basu 2005), many of which have been banned or are declining in use in developed countries.

Given this inability of public extension and private sector industry to educate farmers with appropriate information about products that have been used for decades, the information vacuum for farmers trying to convert to organic agriculture is even greater. For example, having depended on broad-spectrum pesticides for more than two decades, farmer understanding of pest identification and invertebrate ecology is rudimentary, especially with respect to predatory insects. None of the NGOs engaged in IPM extension had good quality pest and predator identification guides for distribution to farmers. Government agriculture officials promoting IPM through Farmer Field School-type trainings also admitted to a lack of appropriate educational materials, and noted that the only books containing good photographs for pest identification are published in English.

Moreover, NGOs themselves have difficulty finding locally relevant information on organic methods. One organization, led by an individual with an advanced university degree, relied on contacts with scientists and institutes in New Delhi, over 1300 km distant, to obtain information on organic and biodynamic farming. NGOs without the means or English-educated staff to access scientific articles relied on the experience of their own staff members, who are typically also farmers, and the expertise of other NGOs.

In addition, just as they are unable to access newer generation synthetic chemical pesticides, local farmers have little access to high-tech organic farming inputs commonly used in developed countries, even when they have knowledge of these inputs. For example, a Farmer Field School training session organized by the Kolkata-based, government-run IPM Centre provided farmer trainees with detailed information about the use of pheromone traps and their function to monitor insect pest populations. However, these "natural" pesticides are often as costly or costlier than synthetic chemical pesticides. The cost of one pheromone trap, for example, is Rs 40-50, which is close to a rural labourer's daily income. The price of a litre of a product containing *Bacillus thuringiensis* (Bt), a natural pesticide commonly used by organic farmers in developed countries, cost up to Rs 1,000 (Singh 2002). Moreover, most such products are not sold in local villages. Biopesticides such as Bt break down quickly, especially in high temperatures, making rural distribution problematic. In addition, quality control is lacking in India's biopesticide and biofertilizer industries, often resulting in ineffective products (Narayanan 2005, Singh 2002). One local pesticide shopkeeper who stocked neem-based products was reluctant to aggressively promote them for that reason. Finally, the fees set by accredited organic inspection and certification agencies are prohibitively high for most farmers in West Bengal. Under current government policy, it takes at least two years for a farm to be certified as organic. The cost of inspection and certification for small holder groups is around Rs 5,000/day, not counting travel expenses and other fees. These charges, together with the initial transaction costs of organizing into groups of 25 to 50, place a high burden on small and marginal farmers.

Discussion and Conclusions

The few local farmers who are successfully producing organic commercial crops are innovative individuals who do not use any of the above inputs. Instead, they capitalize on their small size and grow polycultures, use cow dung and urine, and continually experiment with home-crafted products like fermented neem leaf compost. Local NGOs are finding more success by building on the examples of these innovators and following a step-by-step approach that focuses first on eliminating pesticide use and improving soil health with underutilized resources, such as cow urine, crop residues, and tree leaves, before promoting completely synthetic-free production. With the loss of many traditional varieties and indigenous knowledge of earlier farming methods, the NGOs hope to foster a gradual transition to organic farming, built on locally developed and tested techniques. This approach has already proven fruitful in reducing input costs and pesticide use, while also reversing the decline in yields, thereby increasing profitability and safety, especially in the input-intensive dry season rice crop. These results are consistent with other research findings that show that transitions to organic, agro-ecological methods can increase productivity and improve livelihood in developing countries (Pretty et al. 2003).

To overcome extension constraints, the NGOs are also organizing farmers into groups, meeting with them over a whole growing season or longer, encouraging them to learn from each other, and helping them to become volunteer trainers for other farmers. Their approach is loosely based on the Farmer Field School model, widely considered a more successful methodology for introducing complex crop management approaches like IPM (Mattson 2000). By following this approach, Swanirvar staff have helped many local farmers adopt simple seed selection techniques to improve stand development, add micronutrients to the soil, improve plant spacing to reduce disease problems, and use more natural and locally-available materials for pest control. Only by understanding the factors underlying farmers' problems with high-input, chemical-intensive agriculture will we be able to avoid the same types of problems in promoting organic methods in developing countries. Organic farming is not a monolithic model that can be transferred, as is, from one part of the world to another (cf. Parrot et al. 2006). Nor can success be achieved by "reverting" to older farming methods based on pre-existing indigenous knowledge. In many areas of the developing world, especially in Asia, the Green Revolution so drastically altered the agricultural landscape that the only way to move forward with organic farming is to work with local farmers to craft a new knowledge base that starts with key agro-ecological principles and incorporates elements of traditional knowledge and new technology in a process of continuous adaptation and innovation.

Acknowledgments

Field work was supported by the Fulbright Indo-American Environmental Leadership Program. Thanks to Sujit Sinha and the staff of Swanirvar, especially Sandhya Mondol and Nishambu Sarkar, and to Dr. D. Basu and Rupak Goshwami, BCKV University.

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How transgenic crops impact on biodiversity

Kotschi, J.[1]

Key words: biodiversity, developing countries, genetic engineering, transgenic crops

Abstract

Genetic engineering is heralded as key technology to intensify agriculture and the acreage under transgenic crops is increasing. Agricultural diversity, on the other hand, can be considered a global resource base for food and bio-energy that may be vital in responding to unknown future needs. The article discusses the impact of genetic engineering on agricultural biodiversity, concludes that GE crops have amplified the negative impact of farming on biodiversity and proposes alternatives.

Introduction

Genetically engineered (GE) or transgenic crops are increasingly promoted to intensify agriculture. Agricultural diversity, on the other hand, can be considered a global resource base for food and bio-energy, a resource that may be vital in responding to unknown future needs, such as adaptation to climate change. Although both are important issues in agriculture, little attention has been given to their interrelationship. The main question is: How does GE technology impact on biodiversity? Is it beneficial, neutral or detrimental? This will be discussed in the following article.

Material and methods

This article reviews scientific evidence on biological and economic changes from the use of transgenic crops, and investigates their impact on biodiversity. The short article cannot be comprehensive, but it highlights the most important features by presenting a few examples. As the majority of plant genetic resources are located in tropical and sub-tropical regions and are largely preserved by small farmers, the article focuses on smallholder agriculture in developing countries.

Results

Transgenic crops in developing countries. The estimated global distribution of transgenic crops is assessed by ISAAA, a biotechnology-promoting network. The estimations for 2006 are approximately 102 million ha (James 2006). As no other sources are available, the figures cannot be verified, and some consider them to be inflated (Ashton 2003, Robinson 2004, Zarzer 2006, López Villar et al. 2007). The transgenic crops are distributed as follows: Four crops account for 95% of all transgenic varieties planted: soybean, maize, cotton and canola. Most are grown for industrial purposes or as animal feed. Approximately 40% of the total acreage is in developing countries, and this 40% is concentrated in only 6 countries: Argentina, Brazil, China, India, Paraguay and South Africa. A third feature also deserves consideration. Until now, only two genetically-induced traits have gained commercial

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importance: herbicide tolerance (HT) and pest resistance through insertion of a gene from *Bacillus thuringiensis* (Bt).

Transgenes – genetic enrichment or contamination? After a transgenic plant is released from the greenhouse to the field, it cross-pollinates with other varieties and sometimes even with wild relatives. Pollen can spread much further than expected. For instance, Watrud et al. (2004) measured distances of up to 21 km for pollen of transgenic grass *(Agrostis stolonifera)*. Greater distances were assumed but not quantified. This pollination, following "introgression", is irreversible, difficult to limit regionally and makes coexistence of transgenic crops with non-transgenic crops very difficult. The case of transgenic maize in Mexico is a prominent example. Mexico probably has the richest maize gene pool in the world. With the commercial use of transgenic maize varieties in North America, transgenic maize entered the country in various ways, mainly through food imports. In 2001 evidence was produced that GM varieties had introgressed into the genome of landraces of maize in southern Mexico (Quist and Chapela, 2001), a finding that was later confirmed by other research teams (CEC 2004). Until today it remains controversial, whether the introgression of transgenes threaten or enrich genetic diversity. According to CIMMYT (2002) and referring to the Mexican problem, landraces of maize may change as they frequently do through cross-pollination with other (new) varieties. By doing this, they do not disappear and in fact, with the transgenes, they can become even more diverse. On the other hand, all CGIAR Centres are advised by FAO (2007) to do everything possible to avoid unintentional transgenic introgression into their *ex-situ* gene bank collections. Molecular biologists are bringing in new aspects. Genetic regulation is obviously more complex and dynamic than commonly assumed. It goes beyond single genes, beyond DNA and is implemented by a network (Polanyi 1968, Gould 1993, Strohman 1997). Accordingly, a growing number of scientists demand a paradigm shift from genetics to epigenetics. Secondly, its traits appear to be dynamic as they change over time and according to their environment. (ENCODE 2007, Sample 2007). Therefore, the transfer and incorporation of DNA from other species can cause disturbances in cell regulation; unexpected changes of GE organisms are not uncommon. For example, Gertz et al. (1999) found that transgenic soybeans have up to 20% higher lignin content, and they assume that the new gene influences lignin metabolism. The change in lignin content has a negative influence on heat tolerance, which in turn results in lower yields of transgenic soybean under heat stress. Many more unintended effects have been reported (Liebman and Brummer 2000, Haslberger 2003) and may occur with a substantial time lag (Wilson et al. 2006). If this holds true, transgenic crops contain unknown risks and the unintentional introgression of transgenes must be considered a genetic contamination not an enrichment for plant genetic resources.

Does herbicide tolerance have an effect on biodiversity? In the mid-1990s transgenic soybean varieties were introduced in Argentina. Roundup-Ready (RR) soybeans are resistant to the herbicide glyphosate and allow fully mechanized production. With herbicidal weed control, no-till techniques were applied more often, cropping became easier, production risks were reduced and moderate yield increases achieved. But the main reason for adoption was that less agricultural skill is required. "Farming without farmers" became possible and large acreages could be managed by only one person. In a country with an already high share of industrial soybean production, the RR technology accelerated the ongoing drastic changes to land use and farming systems in Argentina. Within the past ten years, the acreage under soybean has increased from 6 to14 million hectares, and the share of transgenic soybean from zero to 99%. And, the Argentine government aims to triple present production by 2010 (Lopez 2003). As a result, the diversity of landscape and farming systems has been reduced significantly. “The rapid shift of land to soybean production eroded two traditional sources of strength in the Argentinean agricultural sector – the coupling of livestock and crop production on the same farm, and second, adherence to diversified rotations needed in order to break pest and disease cycles and sustain soil productivity. […] Farmers are increasingly growing a single crop, soybeans” (Benbrook 2005). According to national statistics, food production in Argentina has fallen significantly. For rice and potatoes a reduction of 40% and 38% respectively has been recorded (Dominguez and Sabatino 2003), even higher losses have been observed with vegetables, and a similar trend has been observed with animal products such as milk, eggs and meat (Jacobson 2005). With regard to biodiversity, it can be confirmed that smallholders and their mixed farming systems are gradually disappearing, and they are being replaced by large mono-cropped fields.

Does Bt-technology reduce the negative impact of cropping on biodiversity? The incorporation of bacterial DNA from *Bacillus thuringiensis* (Bt) into agricultural crops promised to reduce pesticide application and alleviate damage to the fauna of agro-ecosystems. Many studies from the early years of using Bt-crops – cotton in particular – stated that pesticide-use was substantially reduced, costs of production decreased and net incomes were improved (e.g. Qaim and Zilberman 2003, Traxler et al. 2003). A reduced negative impact on insect biodiversity (compared to conventional production) was observed in farm scale field trials by Cattaneo et al. (2006).

Meanwhile the picture has changed. For instance, in a study of 481 farms in 5 provinces of China, researchers from Cornell University (Wang et al. 2006) found that such benefits of Bt-cotton had completely disappeared. “A majority of Bt-cotton farmers cited the fact that they must spray 15-20 times more than previously to kill secondary pests, Mirids, which did not require any pesticide in the early years.” Further, farmers spent the same amount on pesticides as non-Bt growers and about 2-3 times more for seeds. A similar finding has been reported from the Makhatini Flats, the leading Bt-cotton area in South Africa (Hofs et al. 2006), and the authors state that Bt-cotton has not generated sufficient income to achieve a significant and sustainable socio-economic improvement. Finally, a much more comprehensive evaluation of 47 peer reviewed articles on the economic impact of Bt-cotton on farms in developing countries concludes: “…the overall balance sheet, though promising, is mixed. Economic returns are highly variable over years, farm type and geographical location” (Smale et al. 2006).

In summary, it can be concluded that the Bt-gene does not reduce pesticide use in the long term. At best, the impact of Bt in cotton on biodiversity is neutral compared to conventional cropping systems.

Changes in seed supply and access to breeding material. Within the past 25 years an unparalleled concentration of the seed sector has taken place and a worrying shift from the public to the private domain can be observed (GRAIN 2007). “Based on 2006 revenues, the top 10 seed corporations account for 55% of the commercial seed market” (ETC-Group 2007). As far as transgenic crops are concerned, only one company (Monsanto) provides seed, directly or indirectly, for approximately 90% of the total area under transgenic crops. This quasi monopoly creates dependency among farmers. At the same time it leads to genetic uniformity of cropping systems. Needless to say, the monopolization of the seed sector is not caused by biotechnology, but the latter has accelerated und reinforced this process. One main reason for this is that the breeding costs for GE crops are extremely high; the necessary investment can only be borne by larger companies, which are increasingly required to take advantage of economies of scale. A standardized variety or a whole cropping technology has to be distributed as widely as possible. A second aspect is no less worrying: the increasing control of genetic resources by a few companies through patents on genes. In the past, genetic material for breeding purposes has been in the public domain. Today, it is becoming increasingly inaccessible without the permission of patent holders. By granting or withholding their permission, they have a strong influence on breeding programmes and strategies. Monopolized seed supply and growing corporate control over genetic resources probably have the greatest impact on biodiversity.

Discussion and conclusions

Transgenic crops have accelerated the industrialization of agriculture and have thus amplified the negative impact of farming on biodiversity. In addition, biodiversity is now exposed to a new threat: the contamination of genetic resources by transgenes – a risk, which is so far unpredictable. The question in this respect is whether such biodiversity “sacrifices” are really necessary to address future needs. So far most of the promises of GE protagonists – to reduce global hunger, for instance – have not been fulfilled. Most of the progress in plant breeding has been achieved by conventional methods (Meyer 2007). Another question is whether existing transgenic crops have the ability to perform better than non-GE crops. Scientific comparisons often show a bias when selecting an appropriate reference system. The sector of cotton production may illustrate this. Pesticide savings and yield increases through Bt-cotton are measured in comparison with conventional cropping systems. This reference system will automatically give Bt-cotton an advantage. The task should be to compare GE cropping systems with other innovative breeding and production technologies that have emerged within the past 20 years, parallel to the GE cropping technology. Two such innovations can be considered success stories in cotton production. One is Integrated Pest Management (IPM) (Russel and Kranthi 2006 a+b), and the other is Organic Agriculture (Eyhorn et al. 2007, Williamson et al. 2005, Blaise 2006, Lanting et al. 2005). Both IPM and Organic Agriculture are economically competitive and environmentally friendlier; they work with reduced or no synthetic pesticide input, and they enhance biodiversity (FAO 2002). Marker assisted selection (MAS) is the third innovation that merits attention. Gene-markers are used to identify desired traits more easily, a method that is already possible at the seedling stage of a plant. MAS speeds up the selection process enormously, and allows wild relatives to be included more easily. It has upgraded classical breeding and is intensively used by almost every major seed breeding company. The performance and competitiveness of GE technology must always be appraised in comparison with the best technologies at hand and, in addition, be based on thorough risk assessment of GE organisms. In general we must bear in mind that biodiversity is an indispensable resource to meet future challenges (e.g. climate change); agricultural intensification must not proceed at its expense but must harmonize with it. Ecological innovations as described above offer a reasonable chance of achieving this.

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Experimental systems to monitor the impact of transgenic corn on keystone soil microorganisms

Turrini, A..[1], Sbrana, C.[2] & Giovannetti, M.[3]

Key words: GMO, environmental impact, arbuscular mycorrhizal fungi, co-existence, non-target organisms.

Abstract

Risks and benefits of transgenic crop plants should be evaluated not only by assessing pollen flow, but also by considering soil persistence of transgenic products, such as Bt toxins, which can accumulate in the soil and remain active for a long time. Moreover, transgenic plants are often ploughed under as crop residues, representing a potential hazard for non-target arbuscular mycorrhizal (AM) fungi, a group of beneficial plant symbionts fundamental for soil fertility. In this study we monitored the effects of transgenic corn plants (Bt 11 and Bt 176) and their residues on AM fungal growth and root colonization ability. Both transgenic plants decreased mycorrhizal colonization and Bt 11 plant residues negatively affected mycorrhizal establishment by indigenous endophytes, four months after their incorporation into soil.

Introduction

After the approval of the European Community Directive 2001/18 a debate started in Europe about the co-existence, in space and time, of genetically modified organisms (GMO) and organic or conventional agriculture. So far poor knowledge exists on the interactions among the different components of agroecosystems and on the potential hazards posed by unintended modifications occurring during genetic manipulation. The increasing amount of reports on the ecological risks of GM plants stresses the need for experimental works aimed at evaluating the environmental impact of GM crops not only assessing pollen flow, but also considering soil persistence of transgenic products (Stotzky 2004). Major environmental risks associated with GM crops include their potential impact on non-target soil microorganisms, such as arbuscular mycorrhizal (AM) fungi, fundamental for sustainable and organic agriculture, given their important role in soil fertility, plant nutrition and ecosystems functioning. AM fungi are strongly affected by agricultural practices, including treatments with chemical fertilisers and pesticides, and by changes in soil characteristics, thus representing potential key non-target microorganisms to be monitored in studies on environmental impact of GM plants. In this work we describe an experimental system to investigate the potential effects of two *Bt* corn lines and their plant residues on AM fungi.

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Materials and methods

Transgenic *Bt* corn lines (transformation events *Bt* 11 - isogenic to NK4640 - and *Bt* 176) genetically modified to express the *cry1Ab* gene from *Bacillus thuringiensis* and the non transgenic maize NK4640 (wt) were used to study their impact on the AM fungal species *Glomus mosseae*. The experimental system (microcosm) used to study mycorrhizal establishment was described by Turrini et al (2004). Ten replicates were set up for each trial. After 5 weeks growth in the microcosm, the plants were transferred into pots filled with soil from conventional agriculture. Corn plants were cultivated and maintained in a greenhouse for 10 weeks. After 5, 8 and 10 weeks' growth, plant root systems were sampled and the percentage of mycorrhizal colonization was assessed. In a second experiment, corn plants were grown in pots for 12 weeks and then ploughed under: leaves and stems of *Bt* 176, *Bt* 11 and Wt plants were cut into 2-3 cm pieces and mixed with the soil originating from the same pot where they were grown. Levels of colonizations by indigenous AM propagules were assessed on *Medicago sativa* plants grown in residues-amended soil. In order to test the effects of *Bt* plant residues on hyphal growth of *G. mosseae*, 15 sporocarps were placed on membranes in a sandwich system (Giovannetti et al., 2006). Sandwiches were placed onto Petri dishes and covered with soil containing residues. After 21 days membranes were opened and stained with 0.05% Trypan blue. Data on root colonisation were arcsin(sqrrt(x)) transformed and submitted to two-way ANOVA and to Test for the Equality of regression slopes.

Results

The impact of *Bt* plants on AM fungal symbionts was monitored both on the collection isolate and on indigenous endophytes from corn experimental soil. Colonisation in *Bt* corn plants (both *Bt* 11 and *Bt* 176) by the symbiont *G. mosseae* was significantly lower than in wt plants, by slopes equality test ($F=8.59$, $P<0.001$) (Fig. 1).

The impact of transgenic plant residues on AM fungi was assessed by monitoring both pre-symbiotic mycelial growth of *G. mosseae* in the experimental soil and *Medicago sativa* root colonization by AM fungal propagules living in the experimental soil. Mycelial length of *G. mosseae* grown in soil samples containing *Bt* and non-*Bt* corn residues was monitored up to four months and did not show significant differences among lines. Two ways ANOVA showed that indigenous AM fungi were significantly affected in their ability to colonize *M. sativa* roots grown in soils containing different plant residues at different times after ploughing under ($F=45.97$, $P<0.001$). Moreover, regression slopes of root colonisation percentages of *M. sativa* grown in soil containing corn residues were different by the slopes equality test ($F=27.13$, $P<0.001$). Data obtained suggested that indigenous AM fungal colonization ability was affected, by GM corn cultivation, and that it was particularly reduced in *Bt* 11-amended soil (Fig. 2).

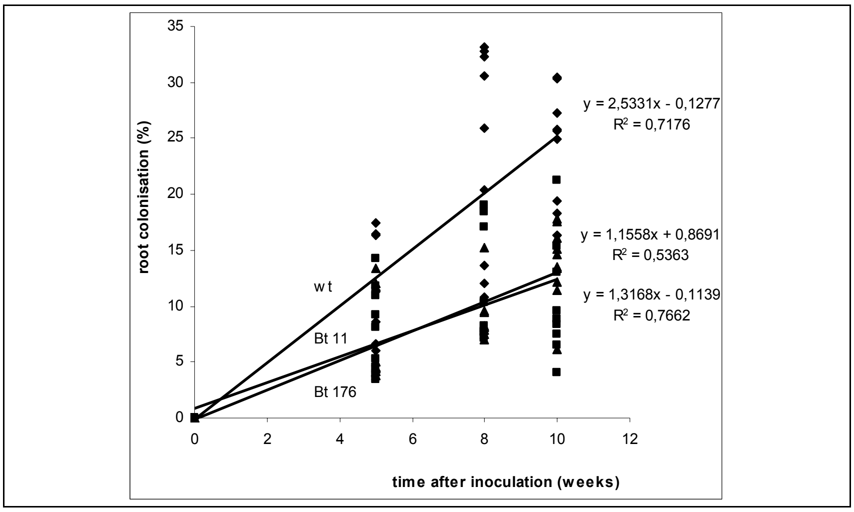

Figure 1: Distribution of data and regression lines of root colonisation by the AM fungus *Glomus mosseae* on *Bt* and wild type corn plants, from inoculation to 10 weeks of culture.

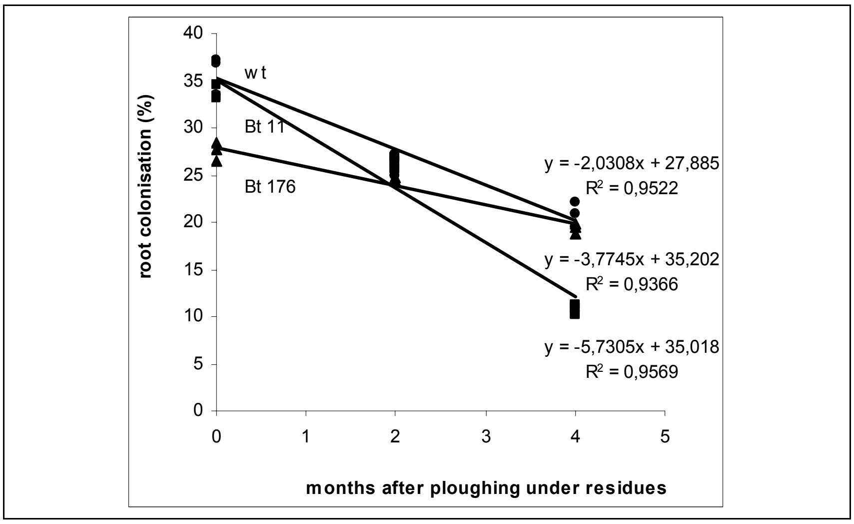

Figure 2: Distribution and regression lines of root colonisation data by indigenous arbuscular mycorrhizal fungi on *M. sativa* during culture in soil samples containing *Bt* and wild type corn plant residues ploughed under.

Discussion

Our experimental systems allowed us to monitor the impact of two *Bt* corn plants and their residues on AM fungi. Both transgenic plants decreased mycorrhizal colonization by *G. mosseae* and *Bt* 11 plant residues negatively affected mycorrhizal establishment by indigenous endophytes after their incorporation into soil. Mycelial growth in the presence of transgenic residues was not affected. Transgenic root exudates and residues incorporated into soil may produce long term effects on soil microbes (Castaldini et al., 2005). Studies on *Bt* toxin persistence have shown that this protein maintains its activity after absorption to clays or binding to humic acids (Saxena and Stotzky 2001) and retains its activity for 234 days (Saxena et al. 1999; Stotzky 2004). Other authors have demonstrated slower litter decomposition for *Bt* compared with non *Bt* lines (Flores et al. 2005). It remains to be established whether mycorrhizal colonization is reduced directly by the *Bt* toxin present in corn litter or indirectely by soil microbial population alterations or by other factors. Moreover, it is possible that prolonged permanence of litter in the soil could significantly affect inoculum potential of mycorrhizal fungi.

Conclusions

Further long-term studies in the field are necessary to evaluate the impact of GM plants on microbial communities fundamental for soil fertility and quality. In particular, the risk posed by GM plant residues to non-target beneficial soil microbes should be thoroughly investigated, since any reduction in their biodiversity might produce long-term effects, in space and time, on crops sequentially cultivated in the same soil in the years to come.

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Index of authors

PROCEEDINGS

16TH IFOAM ORGANIC WORLD CONGRESS
MODENA, 16-20 JUNE 2008

CULTIVATE THE FUTURE.

ISOFAR
International Society of Organic Agriculture Research

CULTIVATING THE FUTURE BASED ON SCIENCE

Proceedings of the Second Scientific Conference of the International Society of Organic Agriculture Research (ISOFAR), held - at the 16th IFOAM Organic World Congress - in Cooperation with the International Federation of Organic Agriculture Movements (IFOAM) and the Consorzio ModenaBio 2008.

18-20 June 2008 in Modena, Italy.

VOLUME 2
LIVESTOCK, SOCIO-ECONOMY AND CROSS DISCIPLINARY RESEARCH IN ORGANIC AGRICULTURE

Edited by Daniel Neuhoff, Niels Halberg, Thomas Alföldi, William Lockeretz, Andreas Thommen, Ilse. A. Rasmussen, John Hermansen, Mette Vaarst, Lorna Lueck, Fabio Caporali, Henning Hogh Jensen, Paola Migliorini, Helga Willer.

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Cultivating the Future Based on Science

Volume 2
Livestock, Socio-economy and Cross disciplinary Research in Organic Agriculture

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ISOFAR

Should the publication of corrigenda become necessary, these will be posted at the conference homepage http://www.isofar.org/Modena2008/

The 2nd Scientific Conference of the International Society of Organic Agriculture Research (ISOFAR) was held June 18-20, 2008 in Modena Italy, in the frame of the 16th Organic World Congress of the International Federation of Organic Agriculture Movements (IFOAM), organised by Consorzio ModenaBio. The 4th Congress of the European Integrated Project 'Quality Low Input Food' (QLIF) was convened as part of the 2nd ISOFAR Conference (see papers in volume 2 of these proceedings).

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Cultivating the Future Based on Science. Volume 2 - Livestock, Socio-economy and Cross disciplinary Research in Organic Agriculture. Proceedings of the Second Scientific Conference of the International Society of Organic Agriculture Research (ISOFAR), held at the 16th IFOAM Organic World Congress in Cooperation with the International Federation of Organic Agriculture Movements (IFOAM) and the Consorzio ModenaBio, 18 – 20 June 2008 in Modena, Italy.

International Society of Organic Agriculture Research (ISOFAR), DE-Bonn; Institute of Organic Agriculture (IOL), DE-Bonn; Research Institute of Organic Agriculture (FiBL), CH-Frick, Danish Research Centre for Organic Food and Farming (DARCOF), DK-8830 Tjele

ISBN: 978-3-03736-024-8

Cover: Officina Comunicazione, Modena, Italy

Layout: Anja Schneider, IOL, Bonn, Germany and Helga Willer, FiBL, Frick, Switzerland

Printed by: Artestampa, Modena, Italy

Distribution: Paper copies may be ordered from FiBL (see FiBL shop at http://www.fibl.org/shop); FiBL order number 1504. A PDF version can be downloaded free of charge for ISOFAR members via the member area of www.isofar.org.

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Table of contents

Understanding the organic consumer 255

Public procurement: constraints and barriers 285

Economics and strategies on organic farms 303

Organic sector relationships 399

Organic Marketing and organisation in developing countries 445

Multi criteria assessment of experiments 695

Methods in organic quality research 713

Preface

To carry home these heavy two volumes of ISOFAR's 2nd Scientific Conference Proceedings might give rise to the question whether these books represent more mass than class and if they are still topical.

After all the author must wonder whether a contribution in a peer-reviewed proceedings volume is worthwhile when there is the alternative of publishing it in a highly ranked scientific journal with the same effort. Moreover, the editors as well as the numerous referees might have felt desperate at times due to the enormous amount of time and strength they invested to compile about 400 selected papers.

I would like to thank all of you for your effort. It was worthwhile since the reader now obtains a valuable overview of the current state of knowledge and research aims of the scientifically based Organic Agriculture which might be important not only for the scientist but also for all other stakeholders interested in the further development of Organic Agriculture.

I owe gratitude to all who contributed to coping with this laborious task. You have all done a tremendous job in contributing to foreseen successful scientific modules held under ISOFAR´s and IFOAM's joined conference/congress umbrella. Our collective hope is that these proceedings will represent a significant milestone on the road towards a better understanding of the potentials and effects capabilities of a scientifically based Organic Agriculture can have.

Prof Dr Ulrich Köpke

President ISOFAR

Dear Reader,

The two volumes of the Proceedings of the Second Scientific Conference of the International Society of Organic Agriculture Research, 'Cultivating the Future Based on Science', represent a considerable part of the worldwide increase in research activities in Organic Agriculture (OA). This observation is in accordance with the overall trend, at least in much of the western world, of increased production and consumption of certified organic products.

In all, 495 four-page papers were submitted to the conference, and all went through a sophisticated review process resulting in 380 papers being selected for presentation at the ISOFAR Conference. Evaluating papers is a difficult task, requiring a sure scientific instinct. It also requires a reasonable judgement of the quality of the language of each paper; since a paper's language is part of what determines its overall quality, even though this gives an unjustified advantage to native speakers of English. Supported by a review form that checked various aspects of the paper's quality, the reviewers tried their best to ensure maximum transparency of the evaluation, which basically reflected the objective of improving the paper's quality.

The first volume deals mainly with various aspects of organic crop production, which traditionally represent the largest share of all papers submitted to conferences on OA. We hope that you will find it interesting to discover the diverse research approaches regarding the management of organic crops. While a tendency to a more problem-oriented approach realized by specialists is evident, as perhaps is to be expected, there is still a strong foundation of papers on traditional agronomy with a systemic approach, which remains a key discipline in OA research. Attentive readers will realize that the diversity of papers also reflects the global differences with respect to an understanding of what OA is.

This second volume gives insights into the increasing research activities on animal husbandry, socio-economics, interdisciplinary research projects, and QLIF workshops, all related to OA. We gratefully acknowledge in particular the increasing interest in organic animal husbandry, which in the past was a poor cousin in OA research. Some topical issues such as global warming and energy supply are discussed in the interdisciplinary sessions.

The scientific committee agreed at the start that cross-disciplinary papers should be given high priority because of the very nature of organic farming and food systems. For many years we have claimed there was a need for a holistic understanding of OA, both because of the interdependencies among sub-systems on the farm (soil-crops-livestock-people) and because of the multiple objectives behind OA (producing wholesome food, conserving soil fertility, maintaining biodiversity, supporting animal welfare, reducing pollution, etc.). However, most often researchers end up meeting and discussing these matters in largely discipline-oriented sessions, even at most organic conferences. Therefore, we wanted to encourage a more cross-disciplinary approach at this ISOFAR event, and we were happy to receive a large number of papers for the cross-disciplinary topics. We hope this tendency will be strengthened in future organic conferences.

Moreover, the great number of papers submitted for the scientific part of the OWC clearly demonstrates the interest in sharing research-based knowledge within the organic sector. To achieve this, it was important to have a section of the OWC where strict methodological approaches are required for participation.

On the other hand, it is a pleasure and an advantage for a scientific conference to be part of a global event that attracts the whole sector and thus allows the researchers to disseminate their findings widely and gain inspiration from other stakeholders in the organic movement.

First and foremost many thanks to all authors who contributed to our joint conference. We also are greatly indebted to the numerous reviewers listed on the next page, who did a first-class job in evaluating hundreds of papers. It was a great pleasure to cooperate with Paola Bonfreschi from the OWC – Organizing Committee, who is the embodiment of reliability and politeness. Last but not least, many thanks to Anja Schneider, of the ISOFAR Head Office, who was mainly in charge of overall communication with the authors and substantially supported the editing of the proceedings.

Managing the review process and editing the proceedings for an international conference is a challenging task in which language difficulties and technical problems may sometimes result in confusion. We kindly ask you to accept our apologies for any problems you may encounter.

We sincerely hope that the Proceedings of the Second Scientific Conference of ISOFAR 'Cultivating the Future Based on Science' will be an important and worthwhile source of information and inspiration for you.

On behalf of the Editors,

Daniel Neuhoff, Niels Halberg, Thomas Alföldi & William Lockeretz

Acknowledgements

Thanks to the following reviewers:

Lucimar S. de Abreu; Brazil; Uygun Aksoy, Turkey; Thomas Alföldi, Switzerland; Hugo Alroe, Denmark; Miguel Altieri, United States of America; Ton Baars; Germany; Saadi Badawy, Egypt; Katja Bahrdt, Switzerland; Beat Bapst, Switzerland; Paolo Barberi, Italy; Stephane Bellon, France; Marc Benoit, France; Marianne Bonde, Denmark; Jules Bos, The Netherlands; Viv Burnett, Australia; Virgilio Caleca, Italy; Enio Campiglia, Italy; Fabio Caporali, Italy; François Casabianca, France; Edward Cocking, United Kingdom; Tommy Dalgaard, Denmark; Christophe David, France; Ken Davies, United Kingdom; Robert Delve, United Kingdom; Henrik Egelyng, Denmark; Gharieb EL-Bana, Egypt; Thomas van Elsen; Germany; Massimo Fagnano, Italy; Maria Finck, Germany; Andreas Fliessbach, Switzerland; Bernd Freyer, Austria; Jürgen Friedel, Austria; Eric Galandt, United States of America; José Granado, Switzerland; Anna-Maria Häring, Germany; Niels Halberg, Denmark; Ulrich Hamm, Germany; Peter Hanson, United States; Yousr Hashem, Egypt; Lene Hegel, Germany; John Hermansen, Denmark; Brendan Hoare, New Zealand; Beate Huber, Germany; Henning Høgh Jensen, Denmark; Todd Kabbaluk, Canada; Manolis Kabourakis, Greece; Lukas Kilcher, Switzerland; Chris Kjeldsen, Denmark; Preben Klarskov Hansen, Denmark; Peter Klocke, Switzerland; Ulrich Köpke, Germany; James Kotcon, United States of America; Ib Sillebak Kristensen, Denmark; Troels Kristensen, Denmark; Paul Kristiansen, United States of America; Stefan Kühne, Germany; Günter Leithold, Germany; Willie Lockeretz, United States of America; Andreas Lüscher, Switzerland; Paul Mäder, Switzerland; Bud Markhart, United States of America; Andrea Martini, Italy; Veronika Maurer, Switzerland; Jochen Mayer, Switzerland; Marcelo Mele, Italy; Alberto Mengi, Italy; Charles Merfield, Republic of Ireland; Ioannis Metzidakis, Greece; Paola Migliorini, Italy; Heidrun Moschitz, Switzerland; Daniel Neuhoff, Germany; Egon Noe, Denmark; Erich C. Oerke, Germany; Frank Offermann, Germany; Jørgen E. Olesen, Denmark; Susanne Padel, United Kingdom; Hans-Marten Paulsen, Germany; Bruce Pearce, United Kingdom; David Pearson, United Kingdom; Carola Pekrun, Germany; Christopher Penhold, Australia; Christine Picard, Italy; Gabriele Pietsch, Austria; Gerold Rahmann, Germany; Jesper Rasmussen, Denmark; Joachim Raupp, Germany; Angelika Riefer, Germany; Christine Rudmann, Switzerland; Jürn Sanders, Switzerland; Ulrich Schmutz, United Kingdom; Kathrin Seidel, Switzerland; Pentti Seuri; Finland; Anet Spengler, Switzerland; Christin Stark, United Kingdom; Ulrike Steiner-Stenzel, Germany; Hanna Stolz, Switzerland; Matthias Stolze, Switzerland; Wijnand Sukkel, The Netherlands; Albert Sundrum, Germany; Bertil Sylvander, France; Lucius Tamm, Switzerland; John Teasdale, United States of America; Concetta Vazzana, Italy; Els Wynen, Australia; Qiao Yuhui, China; Raffaele Zanoli, Italy; Cesare Zanasi, Italy; Christine Zundel, Switzerland.

Welfare indicators and welfare promotion of organic animals

Assessment of skin damages in dairy cows

Smolders, G.[1]

Key words: skin damage, location, housing, assessment period, benchmarking

Abstract

Skin damages were assessed at 48 conventional and organic farms with mainly cubicle houses. Scores from 1 – 9 were given depending on type and size of the damaged skin at 9 locations of the cow: outer hock, inner hock, knee and body all left and right hand side and the neck. Only the highest score per location is recorded and remarks of unusual findings are made separately. The most frequent and most severe affected location is the outer hock followed by the knee. Only 14 percent of all cows did not have any damage, 34 percent had only hairless patches and 24 percent of the cows did have at least one swelling. Correlations of the mean farm score for the left and right hand side are high for the outer hock and low for the body. To have the most impact in advising farmers, assessment should preferably be made at the end of the housing period, the most threatening period in animal welfare in the Netherlands. This system allows benchmarking within and between farms.

Introduction

In animal assessment of welfare, beside lameness, one of the important issues are skin damages of the cows. Hairlessness, wounds, bruises and swelling demonstrate that the animal does not fit in the housing or that the housing system does not fit to the animal (Whay et al; 2003, Klocke and Ivemeyer; 2004; Rousing et al, 2000). In the new EU health strategy (European Commission, 2007) is acknowledge that suitable performance indicators will allow the assessment of progress. In the Netherlands a assessment system for skin damages has been developed in witch it was important to have a link between the location of the damage on the cow and the cubicle housing system. Farmers understand performance parameters as a practical system for assessing skin damages of diary cows and are able and wiling to react with improvements in the housing conditions.

Material and methods

In the period 2005 -2007 in total 2419 cows are assessed for skin damages at 34 conventional farms (con), 11 organic farms (eco) and 3 biodynamic farms (bd). The majority of the herds were Holstein Frisian. At nine farms Meuse Rhine Ijssel was the main breed, at one farm Brown Swiss, one farm Montbeliarde and at one farm Jersey. At 11 farms cows were scored twice (at the end of the stabling period and at the end of the grazing period), at 37 farms cows were scored once during the stabling period. All assessments were carried out by the same person. The scoring system for skin damages is as given in table 1. Scores are recorded separately for outer hock, inner hock, front knee, neck and body. Except for the neck, all locations are score on the left- and on the right-hand side of the cow. If more cows do have comparable

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damages on the body or damages on the same place, it is recorded as an extra remark.

Only the worst damage per location is recorded: a cow with a swollen hairless outer hock with an open wound, will get a score for that place of at least 7 (depending on the size of the swelling). Cows are assessed while standing at the feeding rack. At farms over 30 cows a random sample of about 25 cows is assessed. To ensure a random selection of 1st and 2nd calvers and older cows, instead of selecting particular cows, some more cows than strictly necessary for a good sample are assessed. Selecting particular cows disturbs the cows and takes much time. Assessing cows for skin damages takes about 2 minutes per animal. Together with skin damages body condition and locomotion are assessed and sometimes also teat end callosity.

Tab. 1: Scoring skin damages in assessment system for dairy cattle

Patch	Hairless			Lesions (open or curing)			Swollen		
(Ø in cm)	<3	3-6	>6	<3	3-6	>6	<3	3-6	>6
Score	1	2	3	4	5	6	7	8	9

Results

All farms except three with deep litter housing, kept the cows in winter in cubicle housing. The bedding in the cubicles consisted of deep straw or sawdust or of different types of mattresses, waterbeds or rubber mats with sawdust or grinded straw on top. The average score per location and farm is presented in figure 1 as the mean of the left and the right-hand side of the cow and ranked by the sum of sores by farm type (bd, eco, con). The best possible score is 0 (no skin damage at all), the worst possible score is 45 (max swelling at the 5 assessed locations of the cow).

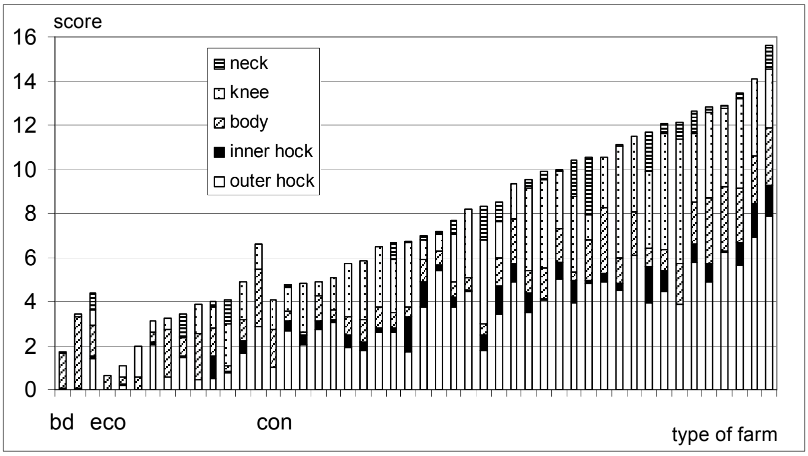

Figure 1: Mean skin damage score per location and total score per farm

The organic farms, even with horned cows at the biodynamic farms, reach good scores compared with conventional farms. The average overall score is 7.4 (table 2).

The absolute score shows that the outer hock is the most affected location of the cow and the inner hock the least affected area. For all assessed parameters there are farms with no damaged cows, but on 15 of the farms there were no cows without skin damages. From the total score, 41% is caused by the outer hock and 30% by damages of the front knee. The maximum percentage of total score shows that up to 100% of skin damages could be caused by one parameter.

Tab. 2: Absolute and relative mean score for skin damages of cows (48 farms)

Location	Outer hock	Inner hock	Body	Knee	Neck	Total score
Absolute score						
Mean	3.1	0.5	1.30	2.2	0.4	7.4
Maximum	7.9	1.7	3.3	5.7	2.6	15.6
Percentage of total score						
Mean	41	6	17	30	5	100
Maximum	76	26	100	73	29	
Percentage of cows						
No skin damage	45	92	77	67	89	14
Hairless	34	5	16	20	8	34
Infected	15	3	6	5	1	28
Swollen	6	0	1	8	2	24

Fourteen percent of all assessed cows did not have any skin damage at all. For the different parameters the percentage of not damaged cows ranged from 45% for the outer hock to 92 percent of the inner hock. In 34 percent of the cows, the damages were only hairless patches while 24 percent of the cows did have at least one swelling somewhere. The outer hock is not only the most severe affected part of the cow, with 55% of cows it is also the most frequent damaged location.

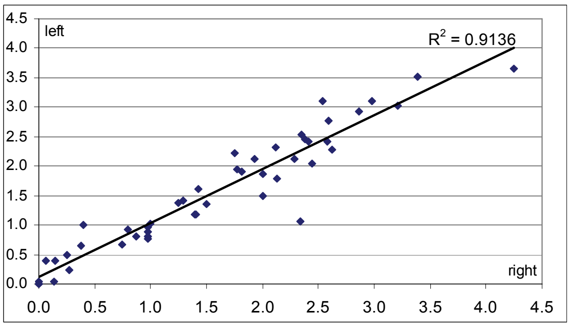

Figure 2: Correlation between mean farm score for left- and right outer hock of the cow

Assessing left and right hand side

Correlation between the left-hand and right-hand side of the outer hock are given in figure 2. The mean scores per farm for the right- and left-hand side of the outer hock are comparable (r^2=0.91). Correlations between the left-hand side and the right-hand side for inner hock, body and knee respectively are. 0.67; 0.39 and 0.74. The skin damages on the body are sometimes typically for the stable on one side of the body especially if they are caused by obstacles in the walking area or at the feeding rack.

Discussion

The assessment system is used to help farmers finding inadequacies in the housing of the cows. To be able to show the farmers the weak points of their housing, at farms were cows are grazing during summer, assessments should be preferably made at the end of the stabling season. Under grazing conditions skin damages are less frequent and less severe than under stabling conditions. Especially for assessing the front knee, it helps if cows can be closed in the feeding rack. Although assessing only one side of the cow would save time, large part of the skin damages at the "body" are missed. Assessing the different locations of the cow makes the system acceptable by farmers for it is easier to link the damaged locations of the cow to specific housing conditions. So there will be a greater chance of improving the situation for the animal (Aerts et al, 2006). As Whay et al (2003) reported, we found that even farms with a low level of animal welfare usually do have one strong point. In assessing more separate locations of the cow the chances of having some positive results on certain locations compared with colleagues are higher and in a positive mood, farmers are more susceptible to improve the weak points in their housing system. For reliable results in various housing systems, between different breeds, between horned and dehorned cows and between farm types more assessments are being made.

Conclusions

The most affected places with skin damages are the outer hocks of the cows. Assessing only one side of the cow gives a good idea of the damages of the outer hock but not of skin damages of the body. Farmers understand the system while there is a link between assessed locations of the cow and the housing system and are able to improve housing based on the assessment.

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Evaluation of Laying Hen Strains for biodynamic Farms

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Poultry, Animal nutrition, Animal health, Animal husbandry and breeding, Performance

Abstract

In biodynamic and organic agriculture mostly the same strains of laying hens as in conventional agriculture are used. These strains require feed with a high nutrition level to tap the full potential of their genetic. When this feed is not available it may lead to health problems and ethological interferences as well as to a deficiency of performance. In this study, four potential adequate strains are evaluated and compared with a commercial strain using health and ethological parameters as well as characteristics of performance under biodynamic conditions. After one laying period the laying performance of Amberlik, Hyline, Sperber and Sussex was high but only the plumage condition of Sussex was acceptable. Therefore this strain will be used for further investigations.

Introduction

In laying hen husbandry normally the same strains are used as well in organic as in conventional agriculture. These strains generally have a high genetic performance potential.

In conventional agriculture, feed supplements are added as for instance chemically synthesized vitamins. These supplements guarantee a high production performance. In guidelines of the Demeter-association (2007) these supplements are not allowed. Therefore it is difficult to meet the needs of the hybrids with a very high performance potential. A lower performance and health and ethological problems as for instance feather pecking may occur when the supply with certain nutrients is insufficient.

In winter 2005/2006 free range husbandry was forbidden in Switzerland because of avian influenza risk. During this time, biodynamic farms had increasing problems with feather pecking, possibly because the hens had not the opportunity to complement their feed with grass and invertebrates in the hen runs. Likewise, Nicol et al. (2003) found a reduced risk of feather pecking with an even use of the hen run. Due to these problems a special approval allowed the use of chemically synthesized vitamins in DEMETER-feed. With this procedure the problems with feather pecking could be reduced. However, the discussion of special breeds for free range and especially organic laying hen husbandry was resumed. Since years the demand for alternative breeds is discussed among experts. Field checking of different breeds under organic conditions has been performed in the studies of Ökoring Schleswig-Holstein e.V. (2003) and Glawatz et al. (2007). However these field studies were only evaluating the laying period and it was not possible to control the rearing conditions. Therefore we decided to evaluate different strains of laying hens, which were reared together.

The aim of the study was to find a laying hen which is suitable for the conditions on biodynamic farms feeding 100% organic feed and no artificial vitamins. The evaluation

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was divided into two phases. The first phase included a comparison of five laying hen strains on a farm. In the second phase the most suitable strain should be chosen to verify the results on several biodynamic farms.

Methods of the first phase

Before starting the experiment we discussed with several experts which strains we should use for the evaluation to be potentially good for biodynamic farms.

In a descriptive study, four strains were tested with a commercial hybrid as control. The brown hen Hyline which is often used on organic laying hen farms in Switzerland was used as control strain. The other chosen lines were Dekalb Amberlink, Sussex D-104, Sperber and a cross of Welsumer (the cock was Welsumer and the hen Hyline) which was recommended by a farmer.

For the rearing period about 125 hens from all five strains were housed together on an organic farm. The commercial organic rearing feed contained the components wheat and maize in Demeter-quality. With 19 weeks the young hens were moved to the laying hen house on the same farm where all strains were kept in separate flocks (5 hens/m^2 in the house and a hen run of 5m^2/hen). The hens were fed with biodynamic laying hen pellets and grains. During the whole laying cycle, feed consumption, laying performance and mortality of all hens were recorded. At the age of 28, 38 and 67 weeks we recorded plumage condition, weight, feather pecking frequency and general activity of the hens on one day. The plumage condition of 10 randomly chosen hens per strain was scored on five parts of the body (head, back, wings, chest and abdomen) from score 1 (plumage without damages) to score 4 (bare parts). The mean scores of the 10 hens per strain were compared. From the same 10 hens per strain the weight was measured. Feather pecking was recorded with all-occurences-sampling observing 30 hens for 15 minutes per strain. The activity (active behaviour: pecking, preening, moving, scratching, dustbathing or passive behaviour: resting, standing) of all hens was recorded with scan-sampling (five scans with an interval of 30 min per day).

Results of the first phase

The laying performance increased as usual in all five strains. However, Welsumer soon had a decline in their laying curve and never reached the performance of the other strains. Therefore they had about 20% eggs less than the normally expected laying performance of commercial hybrids. The laying performance of Sussex decreased faster than the expected performance and this resulted in about 5% eggs less (Table 1). The other strains all performed according to the expected laying performance of commercial hybrids. Only the mortality of Hyline was higher than the normally accepted 10% (Table 1). The feed consumption did not differ between the strains.

At the beginning of the rearing period, all strains had almost the same weight. However, at the end of the rearing period, Sperber were the heaviest hens. At the age of 38 weeks, Welsumer and Sussex had the highest weight and at the age of 67 weeks, again Sperber together with Welsumer were the heavier ones. Sussex seemed to have lost weight.

Tab. 1: Performance Characters of the five strains (in percent)

	Sperber	Hyline	Amberlink	Sussex	Welsumer
Laying Performance	83.27	81.15	83.96	77.26	61.05
Mortality	8.59	11.72	3.91	6.25	4.69

As expected, the plumage condition deteriorated with increasing age (Figure 1). The differences in the plumage condition were small at the beginning of the laying cycle in week 28. Hyline was the strain with the worst plumage throughout the laying cycle. On the other hand, Sussex had the best plumage condition up to the end of the laying cycle. Remarkably, Welsumer had almost the same plumage condition at weeks 38 and 67. Therefore it did not change a lot over this long time.

In the frequency of feather pecking, Sussex had the lowest number of feather pecking interactions (Figure 2). All other strains had a much higher frequency of feather pecking at least at one age of observation. There was no remarkable difference in the activity of the strains.

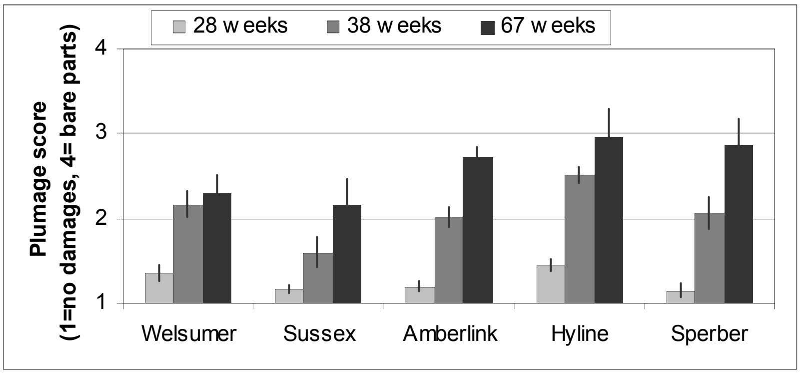

Figure 1: Plumage condition; given is the mean score of 10 hens per strain.

Discussion and Conclusions

The laying performance of all evaluated strains except of Welsumer was acceptable. However, a lower laying performance than usual would be acceptable as it might help to put up reserves for fluctuating nutritional value of the feed and therefore improve health of the animals. As Hyline had the highest mortality, this strain seems to be overstrained in its adaptability to the biodynamic conditions.

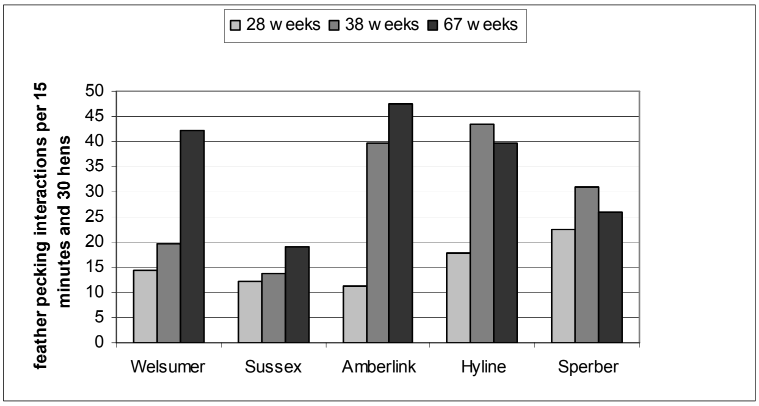

Figure 2: Number of feather pecking interactions per strain at three ages.

In a discussion group with Demeter-farmers it was decided to proceed with Sussex in the second phase of the project. This strain had the best plumage quality up to the end of the laying cycle and the lowest frequency of feather pecking. It seems that for this strain it is possible to adapt to the conditions on biodynamic farms while having an acceptable performance. Therefore this strain should further on be tested on biodynamic farms

Acknowledgments

I would like to thank Susanna Küffer Heer and Albert Lehmann who initiated this project. The project is financially supported by Verein für biologisch-dynamische Landwirtschaft, Demeter, Albert Lehmann Biofutter AG, Verein zur Förderung anthroposophischer Institutionen, Geflügelzucht Hermenhof AG and Animalco AG.

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Risk factors for feather pecking in organic laying hens –starting points for prevention in the housing environment

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Key words: poultry, laying hens, pullet rearing, feather pecking, housing

Abstract

Feather pecking still presents a major problem in organic laying hen farming. In order to identify important risk factors during the laying period as well as during the rearing period in an exploratory epidemiological approach, we followed birds from 23 organic rearing units in Austria and Germany to 46 laying units. Management and housing conditions were recorded during one day visits in the 16th to 18th and 30th to 40th week of age, respectively. As an indicator of feather pecking, feather conditions of random samples of 30 hens per laying farm were assessed. Average feather scores from 0 (best) to 3 (worst) were calculated. The average score of 0.73 (± 0.44) was not significantly different from the score of 0.77 (± 0.33) from 54 conventional farms assessed in the same way (p=0.247). 73 % of the total variance in feather score between the different organic farms could be explained by 6 variables. About 79 % of the explained variation was due to rearing conditions. The major risk factors for poor plumage were little elevated perch space, few drinking places and no regular scattering of grain during the rearing period, as well as poor litter quality during the laying period. It is concluded that these are feasible starting points for improved prevention strategies against feather pecking.

Introduction

Feather pecking still represents a major problem in organic systems. However, the reliable prevention of feather pecking is a challenge, because it is a typical multifactorial disorder. Genetics of the hens, nutritional aspects, as well as housing and management both during the rearing and laying period contribute to risk or prevention of feather pecking. Although there is broad scientific evidence regarding single factors involved, little is known about their relative importance, especially when taking into account both the rearing and consequent laying period. It was therefore the aim of this study, in an epidemiological design to find indications for especially influential risk factors that should be addressed when trying to device a better prevention of feather pecking. It was our underlying hypothesis that factors affecting the hens early in life are of particular importance.

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Animals, farms and methods

Based on literature, own experience and expert advice, a list of 33 potential risk factors for feather pecking both during the rearing and laying period was compiled. Following expert opinion and the literature it was not possible to formulate a well-based hypothesis comprising only a limited number of risk factors of major importance. Therefore, we decided for an explorative approach considering the whole factor list.

Respective data recording was carried out on 23 organic pullet rearing units and 46 laying hen units (each rearing farm provided pullets to 2 laying hen farms) in Austria and Germany during one day visits in the 16th to 18th and 30th to 40th week of age of the birds, respectively. A standardised questionnaire on management practices and recording sheet were used. Housing details were measured, counted or scored, and a random sample of 30 hens per unit was weighed and their plumage condition scored using the system of Gunnarsson et al. (2000), but slightly modified. Bodies of the birds were divided into 6 regions which were each allocated a score from 0 (at maximum 2 damaged feathers) to 3 (naked area ≥ 25 cm²). Mean scores per bird and afterwards per farm were then calculated and, additionally, the prevalence of birds with naked areas or at least single missing feathers. In the same way data from 27 conventional non-cage rearing units and 54 laying units were collected, but not reported here, except for a comparison of overall results with the organic farms using the Mann-Whitney-U test. All birds were brown egg layer hybrids from in total 8 different lines. Potential risk factors were expressed as either continuous or dichotomous variables. Their explanatory value regarding the total variation in feather score or quality between units was analysed using a regression tree (Breimann et al. 1984) in Jump 5.1.2. The contribution of risk factors during the rearing period relative to those during the laying period was calculated as proportion of the total explained variation on the basis of the respective sums of squares (Table 1).

Results

On average 47.1 % (± 36.4) of the assessed organic laying hens were lacking one or more feathers (n=46 farms). This was not significantly different from the 54 conventional farms with 46.7 % (± 35.3) of birds (p=0.948). The average feather score was 0.73 (± 0.44) on organic compared to 0.77 (± 0.33) on conventional farms (p=0.247). Of the total variance in plumage condition (feather score) between the different organic farms, 73 % could be explained by 6 variables (Table 1). One of the variables (‘age at feather scoring of laying hens in days’) was only introduced to control for possible confounding due to the fact that it was not feasible to score all herds at exactly the same age. Excluding this variable from the further calculation, about 79 % of the explained variation was due to factors affecting birds during the rearing period. These factors were: (i) provision of sufficient elevated perches and (ii) drinkers, and (iii) regular scattering of grain onto the litter (Table 1).

Discussion

Published data comparing organic and conventional herds are to date not available. However, earlier reports from practice indicated that problems with feather pecking were greater on organic farms. Therefore, matters might have slightly improved, as the condition of organic and conventional hens was similar. However, it should be mentioned that in Austria (= 26 laying units) also the conventional hens had intact beaks. Otherwise, organic rearing differed in many aspects from conventional rearing, e.g. in terms of day light provision, smaller herds or lower stocking densities, to name only a few.

Despite the similar average feather condition in organic and conventional hens, results were far from satisfactory. Improvements in organic farms are necessary, and our results provide some feasible starting points. For an epidemiological study we could explain a relatively large proportion of the total variance between farms, additionally considering that it was not possible to take genetic background and nutritional imbalances into account. We only found one ambiguous result with regard to the weight of the laying hens. Regression tree analysis successively subdivides the dataset into sub-datasets using those independent variables that generate the greatest decrease in variation regarding the dependent variable. In one of these sub-datasets of farms a mean weight of more than 105 % of the target weight was associated with a deteriorated plumage, in another subset, however, it was the opposite, with better plumage on farms with higher weights of 108 % or more of the target weight. This issue needs further investigation. However, the other identified risk factors match existing knowledge. This is true for the most influential factor, elevated perch space for pullets (Huber-Eicher & Audigé 1999), for the scattering of grain (Blokhuis & Van der Haar 1992), as well as the importance of friable litter in the laying period (e.g. Green et al. 2000). The significance of sufficient drinkers for pullets that we found is very interesting and not otherwise investigated, yet. However, water provision is especially important for birds. Therefore, stress may result from lack of water or competition around drinkers, with stress being known to contribute to feather pecking in general (El-Lethey et al. 2000).

Tab. 1: Risk factors for feather pecking (indicated by feather score) as identified by regression tree analysis; limits and sums of squares calculated in the regression tree procedure, and status quo at the farms

Risk factor	Feather score higher (= quality worse) if:	Sum of squares	Status quo on farms (n=46)[1]			
			Mean	Median	Min	Max
Elevated perches[2] in cm/pullet	< 5.6	2.7556	7.8	8.9	0.8	13.7
Weight of laying hens in % in relation to target	< 108; ≥ 105	1.1218	106	105	89	120
Drinking place/pullet ratio[3]	< 0.9	1.1179	1.0	0.9	0.2	2.5
Age at feather scoring of laying hens in days[4]	≥ 238	0.8698	237	233	208	272
			% of farms with risk factor present			
No regular scattering of grain for pullets[5]	No scattering	0.4743	65.2			
Poor litter quality in laying unit[6]	Poor quality	0.0563	28.3			

1 rearing farms = 23, but each rearing farm provided pullets to 2 laying farms; 1 laying farm was conventional, but received organic pullets; **2** at least 20 cm distance downwards, 30 cm to next perch, 20 cm to wall and 45 cm upwards; **3** 1 drinking place/bird = 1 cm round drinker/bird or 0.1 nipple drinker/bird or combination of both in cases where both drinker types were provided; **4** only included as confounder (see also text above); **5** at least every second day; **6** wet and caked or litter being absent; fields in grey relate to the laying period

Particular attention should be paid to the relatively high importance of rearing factors on the later feather condition of the laying hens. The EC-regulation currently does not contain any provisions regarding the rearing of laying hens. Some organic associations such as Bioland, Demeter, Naturland and others have set own private standards for the rearing period. Probably, the slight improvement discussed above is already a consequence of these activities. However, in the private standards there is no provision on drinkers, and only a minimum of 4 cm elevated perches is required.

Conclusions

Our epidemiological analysis of possible risk factors for feather pecking was of exploratory nature. Therefore, conclusions should be drawn with caution. However, the way how pullets are reared appears to play an important role with respect to the later risk of feather pecking in layers. Although the factors identified deserve further investigation, it appears advisable for laying hen farmers to pay attention that pullets during rearing had sufficient elevated perches and drinkers available, and were regularly stimulated to forage on grain in the litter. Maintaining the litter in good conditions during the laying period is another potentially effective measure that contributes to the prevention of feather pecking.

Acknowledgments

We are very grateful to the participating farmers. This research project was funded by the German Ministry of Food, Agriculture and Consumer Protection (BMELV) through the German Federal Agency for Agriculture and Food (BLE). Furthermore it has been co-financed by the European Commission, within the 6th Framework Programme, contract No. FOOD-CT-2004-506508. The text represents the authors' views and does not necessarily represent a position of the Commission who will not be liable for the use made of such information.

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Monitoring the welfare of sheep in conventional and organic farms using an ANI 35 L derived method

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Key words: sheep, welfare monitoring, organic farming, reliability

Abstract

The present study was undertaken to evaluate the inter-observer reliability of a welfare monitoring scheme to be applied to sheep, and compare the welfare state of the animals between 10 organic and 10 conventional sheep farms. No significant differences were observed between organic and conventional farms in terms of housing characteristics and animal based parameters (P>0.10). This result may be due to the fact that most of the farms, both conventional and organic, based their farming systems on an extensive use of the land by grazing animals. The monitoring protocol proved to be feasible (the mean time needed to perform the assessment of welfare was 45 min per farm) and reliable: a significant correlation between observers was observed for total score and all sheets (P<0.001), while the correlation was significant for all animal based parameters (integument alterations, animal dirtiness, hoof overgrowth and lameness; P<0.001), apart from lesions (P>0.10).

Introduction

Organic farming promotes high standards of animal welfare as a means to increase health and longevity of the animals and fulfill consumer ethical needs. However, the general belief that organic systems always provide the best conditions to the animals has been recently challenged (Athanasiadou et al., 2002). Therefore, in organic systems the need of reliable tools for monitoring the welfare state of the animals at farm level is urgent (Knierim et al., 2004). Due to a lack of welfare monitoring schemes for small ruminants a protocol scientifically validate for cattle, the ANI 35L 2000, was fitted to sheep. The Animal Needs Index proposed by Bartussek *et al.,* (2000) relies on a graded point system that allows assessing five aspects of the housing relevant to animal welfare. These aspects are scored through 5 corresponding assessment sheets, namely: Locomotion, Social interaction, Flooring, Environment, and Stockmanship. Two main problems are associated with the ANI protocol: (a) it mostly relies on design criteria with a lack of animal based variables, therefore, it may not sufficiently indicate the actual welfare state of the animals; (b) it allows compensation between poor and good conditions. However, this index, at least in cattle, has proven to be valid (Ofner *et al.,* 2003), reliable (Amon *et al.,* 2001) and to have some common criteria with consumer perception of animal welfare (Napolitano *et al.,* 2007). The

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present study was undertaken to evaluate the inter-observer reliability of the scheme when applied to sheep and compare the welfare state of the animals in organic and conventional sheep farms.

Materials and methods

Recordings were performed in 10 organic and 10 conventional sheep farms located in Basilicata (southern Italy) at an average altitude of 844 m above sea level. The mean number of heads per farm was 350 and Merinizzata Italiana the most common breed. The average milk yield was 80 kg, including the amount ingested by the lambs. Observations were conducted on lactating animals from January to March 2007. Two trained observers performed assessments. Four preliminary sessions, conducted in different non-experimental farms, were used to standardize assessments: observers thoroughly discussed the score attributed to each parameter and, if different scores had been attributed, further discussion allowed to reach an agreement. No additional discussion was conducted between assessors before, during and after the experimental recordings. The protocol used in the present study relies on five sheets derived by the Animal Needs Index (ANI 35 L), mainly based on resource-based parameters (Bartussek et al., 2000), and a sixth sheet where animal-based parameters, deemed relevant to animal welfare, are taken into account. In particular, in Sheet 6 were included the following animal-based variables recorded on at least 20% of lactating animals: integument alterations, animal dirtiness, hoof overgrowth, lameness and lesions, which where scored on the basis of their prevalence (number of affected animals/numbers of observed animals), longevity (years) and mutilations (de-horning, caudotomy, etc.). The final score can range from 81 to -9.5, the higher the score the better the sheep welfare. Data on housing characteristics and animal based parameters were analysed using ANOVA with one factor. Data on the presence of the outdoor paddock and hospital pen were analysed using the χ^2 test. For each sheet and each qualitative parameter inter-observer reliability was computed using the Spearman coefficient of correlation (r_s).

Results and Discussion

The mean time needed to perform the assessment of welfare was 45 min per farm. No sophisticated equipment was necessary in both time consuming and economical terms. The main housing characteristics of the sheep farms are depicted in Table 1, whereas in Table 2 the animal related variables monitored in this study are shown. The mean total scores of the sheep farms (48.4±1.7 and 47.7±1.8 for organic and conventional farms, respectively) were well above the central point of the scale (81-9.5/2=35.75), which indicated an overall satisfactory level of welfare. The application of the scheme showed that the most critical aspects of sheep farms were the low indoor and outdoor space allowance and the lack of an outdoor paddock in several farms (67 and 55% in conventional and organic farms, respectively). However, these aspects were compensated by the frequent access to the pasture, which was not allowed only in very bad weather conditions. In addition, pasture was steep in most of the cases, thus allowing a good physical exercise to the animals. As to animal based parameters, the prominent aspect to be improved was dirtiness, as it affected the highest percentage of animals. This aspect is obviously dependent on the low space allowance offered to the ewes in the barn and also related to the fact that the animals were observed in the early morning, before access to pasture. No significant differences were observed between organic and conventional farms in terms of housing characteristics and animal based parameters (P>0.10). Accordingly, no marked differences in terms of welfare were observed between organic and conventional sheep by Braghieri et al. (2007), whereas in Germany organic dairy cattle farms showed higher welfare conditions than conventional farms (Hörning, 2000). The results obtained in this study may be attributed to the fact that farms, both conventional and organic, based their farming systems on an extensive use of the land by grazing animals Therefore, the decision to certify their products as organic was dependent on market constraints (lack of distribution channels for organic products, which are often sold in local markets as undifferentiated) rather than on obstacles to the conversion dependent on the farming system (most of the conventional farms could become organic with little or no changes).

Tab. 1: Mean (± SE) of the main housing characteristics of the sheep farms

	Indoor space allowance (m^2/head)	Outdoor space allowance (m^2/head)	Space at manger (m/head)	Presence of outdoor paddock (% of farms)	Presence of hospital pen (% of farms)
Organic	1.2±0.15	1.7±0.4	0.28±0.03	45	27.3
Conventional	1.0±0.17	1.2±0.5	0.26±0.03	33	44.4

Tab. 2: Mean (± SE) of some animal related variables

	Longevity (years)	Integument alterations (%)*	Hoof overgrowth (%)*	Lameness (%)*	Lesions (%)*	Dirtiness (%)*
Organic	8.0±0.56	19.2±7.0	1.0±0.55	6.6±2.4	1.35±0.93	28.3±8.9
Conventional	8.5±0.61	17.0±6.9	0.40±0.52	3.5±2.0	1.79±0.93	35.3±8.9

*(Number of affected animals / number of observed animals) x 100

Spearman correlation coefficients were significant for total score and all sheets (P<0.001). Inter-observer reliability of animal based parameters is displayed in Table 3. A significant correlation between observers was observed for all parameters (P<0.001), apart from lesions (P>0.10). However, the level of statistical significance of the correlation says little about the degree of reliability, as significance also depends on the sample size, whereas the value of the correlation coefficients is much more informative on the strength of the association. Martin and Bateson (2007) suggest that, although acceptability of coefficients depends on several factors, a satisfactory threshold can be considered 0.7. In this study the r_s of total score and all sheets exceeded this value, whereas only 4 (integument alterations, hoof overgrowth, lameness and dirtiness) out of 5 animal based parameters showed coefficients higher than 0.7. This latter result may be due to the fact that lesions were often small and hidden by the fleece. The problem could be approached by monitoring only wide and evident lesions, while observers should also perform more training.

Tab. 3: Inter-observer reliability (r_s) for each qualitative animal-based parameter

	Integument alterations	Hoof overgrowth	Lameness	Dirtiness	Lesions
r_s	0.85	0.82	0.81	0.84	0.22
P<	0.001	0.001	0.001	0.001	NS

Conclusions

No marked differences were detected between organic and conventional sheep farms, using the ANI 35 L derived protocol possibly because most of the farms, both conventional and organic, based their farming systems on an extensive use of the land by grazing animals. The present monitoring protocol proved to be feasible and reliable, although more studies are needed to test the scheme on a larger sample size and assess its validity.

Acknowledgments

This study has been conducted within the project E.QU.I.ZOO.BIO. (Efficienza, Qualità e Innovazione in Zootecnia Biologica – SP10).

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Development of animal health and welfare planning in organic dairy farming in Europe

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Abstract

Good animal health and welfare is an explicit goal of organic livestock farming, and will need continuous development and adjustment on the farms. Furthermore, the very different conditions in different regions of Europe calls for models that can be integrated into local practice and be relevant for each type of farming context. A European project with participants from seven countries have been established with the aim of developing principles for animal health and welfare planning in organic dairy farming, based on a process where knowledge about the status within a given herd will be included as background for taking decisions and planning future improvements. An important part of the planning process is communication with other farmers as well as animal health and welfare professionals (veterinarians and advisors). Other principles such as systematic evaluation of how the improvements work in the farm ensure the continuity of the planning process. This presentation gives an overview over the current animal health and welfare planning initiatives in the participating countries and lines up the principles which are being gradually implemented in partner countries in collaboration with groups of organic farmers and organisations.

Introduction

Livestock farming is an important part of organic farming systems, and it is an explicit goal of organic farming to ensure high levels of animal health and welfare (AHW) through proactive and appropriate management of breeding, feeding, housing and species specific husbandry. A goal in organic livestock farming is to minimise the use of veterinary medicines to improve food quality and protect the environment, and to do this by improving livestock living conditions rather than using alternative medical treatments. Key values influencing organic livestock production are naturalness, harmony at all levels of production, use and recirculation of local resources and the precautionary principle. The concepts of "positive health and welfare" are incorporated in EU Regulation 2092/91 on organic production. The farmer must ensure that farm animals as much as possible can perform natural behaviours and live natural lives, but at the same time he/she must intervene when necessary and at first signs of disharmony in the herd.

High levels of AHW are not guaranteed merely by farming to organic standards. This is a conclusion from two EU network projects, “Network for Animal Health and Welfare in Organic Agriculture (NAHWOA), and “Sustaining Animal Health and Welfare in Organic Farming” (SAFO). Therefore, both networks recommended implementation of farm individual animal health plans to make organic farmers work towards AHW

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promotion and disease prevention. A good planning process of animal health and welfare should be built on an identification of the current state of the art in the particular herd and farm, and the farmer's own prioritisation of what issues should be worked with at the farm. One very relevant way of gaining insight into the herd's current state is to carry through an animal health and welfare assessment. Systems aiming at assessing animal health and welfare have been developed and used in organic dairy herds in the UK, Austria, Germany, Switzerland, Norway and Denmark, *e.g.*, in research and development projects or in relation to certification.

If animal health plans are to gain widespread use among organic farmers, communication with the farmer community is crucial. A creative dialogue with the individual farmer is also necessary when identifying goals and planning how to reach them. Communication regarding the role and benefits of benchmarking or AHW assessment systems may be the catalyst needed to get farmers thinking about health and welfare planning. It can take place within health advisory systems or in farmer groups. Current research and development activities in Denmark, Norway, Switzerland, and the Netherlands show the benefits of such a dialogue.

Based on these various project experiences and results and research questions from different European countries, a research project titled 'Minimising medicine use in organic dairy herds through animal health and welfare planning', with the acronym ANIPLAN, was initiated in mid-2007 with the aim as indicated in the title. The aim of this presentation is to present the project and the first results of the work towards an identification of what is an animal health and welfare plan, and a development of common principles for animal health and welfare planning in a diverse, European context.

Presentation of the project

The main aim of the project is to minimise medicine use in organic dairy herds through active and well planned animal health and welfare promotion and disease prevention. This objective is met through the following intermediate objectives:

Develop animal health and welfare planning principles for organic dairy farms under diverse conditions based on an evaluation of current experiences.

Application of animal health and welfare assessment based on the WelfareQuality parameters in different types of organic dairy herds across Europe. This will result in an overview of the herds and allow for potential adaptations for the organic situation (e.g. pasture systems, longer cow/calf contact). For calves, a special system will be developed by the Norwegian partners, and combined and tested together with the WelfareQuality assessment system.

Develop guidelines for communication about animal health and welfare promotion in different settings. This can be part of existing animal health advisory services or farmer groups such as the Danish Stable School system and the Dutch network program.

The ANIPLAN project aims at minimising medicine use in organic dairy farming through animal health and welfare promotion in ways which meet the common organic goals and at the same time is adjusted to the individual farm context. This calls for an on-farm approach, and a strong collaboration with the end-user environment. The participating institutions in this project come from Austria, Switzerland, UK, Norway, The Netherlands, Germany and Denmark, and they all have a strong on-farm research and development experience and focus, and our common research facilities are the private farms. We aim to combine epidemiological research based on farm-data, different qualitative research approaches and systemic thinking seem to be well implemented in all institutions, and we all seem to work with topics which are related to the ANIPLAN project. The research approach will basically be action research oriented.

Animal health and welfare plans and planning

The starting point: what is the current state of art in Europe regarding animal health and welfare plans?

Perspectives on animal health plans and animal health planning in the UK form a starting point for this project, since animal health plans are mandatory in UK. In no other participating countries than the UK, formalised animal health planning is taking place. This does not mean that organic dairy farmers do not work with animal health and welfare in a more or less systematic way. Various approaches to the assessment of animal health and welfare specifically for organic animals have also been taken in Norway, The Netherlands, Denmark, Germany, Austria and Switzerland. Likewise, initiatives to farmer group formation and animal health advice through veterinary practices have been taken in many places. Much of the ANIPLAN project is based on national on-going activities, and is designed to transfer, jointly analyse and discuss the results of this work.

A clear difference between animal health plans and planning

One key point that became strongly apparent based on experiences from UK is that there is a big difference between the on-farm presence of an animal health and welfare plan versus animal health and welfare planning. The first is viewed by many farmers solely as a 'document', where the latter is the process involving the farmer in making a plan for improvements in the herd and implementation of this plan. In this project, we focus on the animal health and welfare process.

Dealing with diversity

In this project, very different farming conditions are represented – e.g. from mono-cultural intensive and high yield production in Danish, Dutch, German and British farms to alpine farming in Austria and Switzerland, as well as mountain farming in Norway. We aim at developing concepts which refer to the organic principles and ideas and at the same time possible to adjust to national conditions. This is a part of the working conditions for research and for daily practice in the farming systems – since we are partners from so many different countries – and as such a challenge. Clearly, each project participant is responsible for create the connection between the national organic dairy farming environment and judge what is possible there, and the project group, so that no principles are included in the common platform, if they are not approved and thought into the national conditions. This should be seen as a great advantage for the project outcome, since the common developed principles are then tested possible to use under many different conditions.

Animal welfare assessment as a part of animal health planning

The various elements of the project all form parts of an animal health and welfare planning process. A plan necessarily has to be based on knowledge of the animal health and welfare status on the farm, and therefore tools for assessing animal health and welfare on-farm have to be well developed and trained. In this project, a number of parameters from the European project WelfareQuality will be applied, including management information, assessment of the housing system, clinical conditions of the cows and behavioural observations both on individual level (e.g. flight distance to humans) and flock level (social behaviour and interactions). It also has to be evaluated, in order to find out whether the planned and implemented improvements on the farm work in the way they were expected, and in order to ensure continuous improvements.

Communication about animal health and welfare a part of a planning process

Communication is considered a necessary part of making an animal health and welfare plan; the farmer needs to direct the process him- or herself, but will also need to be challenged, have the right questions at the right time and to be stimulated and guided at times. Therefore, one of the work packages in this project aims at identifying appropriate ways of communicating in relation to the animal health and welfare plan.

Development of common principles

It is a vision of this project to develop a process of animal health and welfare planning which can be implemented in all different types of farming environments, e.g. large scale dairy farming as well as alpine, smallholder and diverse farming systems. By developing a method of analysing the context of the farming environment, and include this in the process of animal health and welfare planning, we hope and expect that other research groups and countries outside the partnership in this project also can benefit from research results. The national teams feed the acquired knowledge back to their national partners, and the European (and international) community benefit from the joint effort to develop practices, which meet core areas of organic livestock production (animal health and welfare through non-medical approaches). In the project, the development of common principles for the animal health and welfare planning process have started and will be further developed and adjusted along the project, based on practical experience from the dialogue with farmer groups in different parts of Europe. Furthermore, an active process will build on the establishment of a dialogue with external partners, and this could be advisors, veterinarians or other fellow farmers. Based on experience, farmer ownership is identified as another crucial principle of any on-farm planning process.

In conclusion

Whilst the necessity for a form of health planning on organic farms is recognised, the means by which this is best achieved is still under development and discussion. Formal health plans provide a framework, but these require a sense of farmer ownership and need to reflect actual farm and regional variation. Further, there is a requirement for dialogue in order to achieve a balance between farmer needs, animal needs and the wider societal perception of health and welfare whilst also satisfying the multiple objectives of organic farming. During the course of the collaborative project it is envisaged that practical and research experiences from a range of European settings will contribute to this process of development and discussion with the aim of providing clear guidelines for the use of animal health and welfare plans on organic farms.

Knowledge Transfer in the Animal Health Planning Process: Putting Research into Practice

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Key words: Animal health plan, knowledge transfer

Abstract

Animal health plans are now widely accepted as a tool that can provide a structured approach to health promotion and positive welfare. This requires a partnership between farmer and veterinary advisor as well as a good knowledge of organic farming practice by animal health professionals.

This paper describes an electronic compendium of information relevant to animal health and welfare in organic farming, the main aim of which is to provide resource material and a training tool for those working with organic livestock farmers. The approach involved an extensive and detailed literature search, synthesis to provide advisory material and the development of a website. The compendium is divided into species specific sub-sections covering Disease Management, Veterinary Management and Health and Welfare and includes over 2500 references and web-site links. The compendium covers 45 cattle, 44 sheep, 32 poultry and 27 pig diseases and conditions as well as extensive sections pertaining to each species' behavioural requirements. Throughout there are links to relevant elements of organic farming legislation.

By providing information on new research and practical solutions to treating and avoiding disease it is expected that the compendium will contribute to improved knowledge amongst farmers, veterinarians and advisors and thereby enabling the development of animal health plans that promote high standards of animal health and welfare in organic farming.

Introduction

Organic farming places strong emphasis on the achievement of high standards of animal health and welfare and EC Regulation 1804/99 outlines the key principles and practices that are designed to meet these aims. However, in practice, achievement of these aims is not guaranteed and in many cases the health and welfare of organic animals is similar to that found on non-organic farms (Sundrum *et al.,* 2006).

Animal health plans are now widely accepted as a tool that can provide a structured approach to health promotion and positive welfare although the most effective means by which these are defined and implemented have not yet been developed. The UK organic standards emphasises the desirability of a partnership between farmer and

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veterinarian as a key element in the development of a health plan on an organic farm (Defra, 2006). However, the limited exposure to organic farming experienced by many veterinarians (Hovi *et al.,* 2002), and the commonly expressed concern over the welfare benefits of organic farming by the veterinary profession (Hovi, 2003), may be a factor influencing the success of such a partnership and the ensuing health plan. To this end, a requirement for the improved dissemination of knowledge about organic farming to veterinarians has been recognised (Vaarst *et al*., 2006).

This paper describes an electronic compendium of information relevant to animal health and welfare in organic farming, the main aim of which is to provide resource material and a training tool for advisors, inspectors and veterinarians who work with organic or converting farmers. The compendium succeeds a version first produced in 2000. The original was based on knowledge available at the time. Since its completion there have been considerable changes in organic farming practice, research and legislation.

Materials and methods

The approach to the development of the compendium involved five distinct processes: a literature search; a review of the original compendium; synthesis of the literature,; development of a website and an expert review of the material.

a) Literature search

Key word literature searches were conducted drawn from a number of sources, including scientific publications, conference and workshop proceedings and the dedicated organic farming database OrgEprints. Internet searches were used to supplement these literature sources. The overarching criteria applied to the literature search was a) relevance to organic cattle, sheep, pig and poultry production and b) potential application as practical advisory material.

b) Review of the original compendium

A review of the original compendium was conducted so as to identify any existing technical and legislative inaccuracies, inconsistencies and omissions. The review process also included the presentation of the technical information and recommendations for improvement.

c) Synthesis and incorporation of literature

A synthesis of the scientific literature involved the transformation of key scientific conclusions and recommendation into a format relevant and appropriate to organic farmers, advisors and veterinarians.

d) Development of a web-site

Using the basic design of the original web-site, a new site was created with additional features and sections. The web-site design included introductory sections for each species covered and links to all referenced material and web-sites.

e) Expert review of the material

Expert reviewers were selected to represent knowledge of organic cattle, sheep, pig and poultry production, organic farming expertise, advisory experience and legislative knowledge. The review process included an evaluation of the comprehensiveness of the literature review, the quality of the synthesis and the presentation of the material.

The review also included expert opinion on the relative risk to organic systems of all of the diseases covered.

Results

The compendium is divided into species specific sub-sections covering Disease Management, Veterinary Management and Health and Welfare. For each of the common diseases, the material is presented into appropriate parts covering The Condition (describing causes, symptoms and risks), Treatment, Control and Prevention, Welfare implications and Good Practice. The compendium covers 45 cattle, 44 sheep, 32 poultry and 27 pig diseases and conditions respectively.

Literature pertaining to animal welfare is presented in sections appropriate to each species, all aimed at the promotion of the organic approach to health and welfare. For example, the poultry Health and Welfare section covers positive welfare, welfare pros and cons of free-range production, a comparison of organic welfare standards, The Organic Standards, features of organic poultry systems, understanding behaviour, the Five Freedoms, promoting outdoor access, health, housing, breeds and breeding, nutrition and feeding and rearing replacements. In turn, these are divided into appropriate pages with more detailed information. For example, the poultry housing section includes pages on types of housing, building design, litter management, perches, injury, ventilation, lighting and nest boxes.

Literature pertaining to Veterinary Management is summarised as sections covering the organic standards, health promotion, animal health plans and biosecurity, vaccine usage, the responsible use of veterinary medicines, homoeopathy and other alternative treatments.

Throughout the compendium there are links to relevant elements of organic farming legislation. The compendium includes over 2500 scientific and other literature references and web-site links. A full list of all references is provided.

Discussion

The inclusion of the requirement for animal health plans within the UK organic standards, coupled with the emphasis on preventive health care and the promotion of positive health heralds a significant opportunity for the veterinary profession and the organic farming community to work together. The content of the compendium described in this paper provides an important resource for farmers and veterinarians in their attempts to meet the high health and welfare standards aspirations of organic farming and to aid in the health planning process. By providing information on new research and practical solutions to treating and avoiding disease the compendium should aid in the aim to use health planning as a positive disease prevention tool rather than simply a list of issues present on any particular farm.

The increasing interest in organic farming has stimulated more research into, and provided more information on, the impact of organic management on the health and welfare of livestock. Much of this information points to a requirement for greater support for organic farmers in health management and planning. In addition, animal health management, associated food safety and food quality issues in organic and conventional farming have increased the demand for specific advice (Hovi and Vaarst, 2004). Animal health plans have been proposed as a means by which organic farmers can work in partnership with veterinarians to create a tool for meeting the aspirations set out in the legislative framework for organic farming and the perceptions of society.

Health planning needs to be more than a treatment strategy. Reducing dependence on veterinary medicines, whether for legislative reasons, for philosophical reasons or because of the development of drug-resistant disease agents, requires a greater understanding of disease patterns and the interaction between the various elements that make up livestock farming systems, whether that be management, choice of breed, choice of system or preventative measures. Epidemiological knowledge needs to be combined with ethological understanding within the context of a complex ecological system (Vaarst *et al.,* 2004). By bringing together scientific results from a wide range of perspectives, and presenting them in a practical format, giving, amongst other information, methods of control and prevention and good practice based on current knowledge, the compendium contributes to the achievement of this goal.

Conclusions

It is expected that the compendium will contribute to improved knowledge amongst farmers, veterinarians and advisors and therefore the evolution of systems that encourage the responsible use of veterinary medicines, utilise herd/flock health plans, enable effective biosecurity, promote high standards of animal welfare and operate through agri-environmental principles.

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Effects of different stocking rates with dairy cows on herbage quality and milk production in organic farming

Schori, F.[1]

Key words: stocking rate, milk production, organic farming, herbage quality, dairy cow

Abstract

In order to identify the optimum stocking rate for grazing dairy cows in organic farming, grazing experiments were conducted from 2004 to 2006. Cows of one herd were divided into two groups during vegetation periods. The paddocks of the rotational pasture were split in a way that the low stocking rate group (SR_L) had 15% more pasture area than the high stocking rate group (SR_H). Post grazing sward height for SR_H, was decisive for the simultaneous change of the sub-paddocks. Annual stocking rates for SR_H were 2.0, 2.3 and 2.3 cows per hectare (ha). In the offered herbage mass for SR_L significant lower ash-, CP-, APDE- and APDN values as well as higher NDF values were detected. Sugar- and NEL values were unaffected. No significant differences were found for milk production per cow, but milk production per ha was significantly higher for SR_H. Apart from two exceptions (lactose 2005 and urea 2006), no significant differences were identified for milk composition. The attribution of more pasture area without topping leads to a lower pasture quality. Increasing the stocking rate, within limits, slightly reduces the milk yield per cow, but clearly improves the utilization of grown herbage.

Introduction

In Switzerland, pasture based milk production systems offer an optimal possibility to take advantage of the climate providing ample and regular grass growth as well as minimizing the impact of topographic disadvantages. It is also well established that grazed grass is a low cost forage with a high nutrient density. The directives of Swiss organic farming prescribe, during the vegetation period, to keep ruminants on pasture to ensure a natural feeding system as well as animal welfare. The efficiency of pasture use under organic farming which in most cases implies restricted nitrogen supply still can be improved.

The objective of this research was to study the effects of two different stocking rates with dairy cows on herbage quality and milk production as well as milk composition in organic farming.

Materials and methods

The investigations were conducted in the years 2004, 2005 and 2006 on the farm “l’Abbaye” in Sorens (Switzerland, 46°39.767' N, 7°3.143' E). In 2003 the conversion of this farm to organic farming started and was officially finished in 2005. During the three vegetation periods (April to November) means of temperature (Payerne, 490 m asl (MeteoSwiss), approximately 2° C higher than around the farm) and sums of

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precipitation were: 13.2° C, 819 mm; 13.3° C, 748 mm and 14.2° C, 991 mm. All lactating dairy cows were divided into two groups during the three vegetation periods. The paddocks of the rotational pasture system (800 to 900 m asl) were split such that the SR_L had 15% more pasture area available than the SR_H The post grazing sward height (SH_{PoG}) for SR_H, measured with a rising plate meter (Filip's folding plate pasture meter, Jenquip) was decisive for the simultaneous change of the sub-paddocks for both groups.

Every two weeks in 2004 and once per week in 2005 and 2006, respectively, two grass strips per stocking rate were cut (average cutting level 8.7 Units, 1 unit correspond to a compressed sward height of 0.5 cm) and sampled in the paddock to be grazed next to evaluate the pre-grazing herbage mass and herbage quality. Ash, crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF) and total sugar were analyzed. Net energy for lactation (NEL) and absorbable protein at the duodenum based on energy (APDE) or nitrogen (APDN) available in the rumen were calculated according to RAP (1999).

Each year 14 pairs of Holstein dairy cows, whereof 6 primiparous pairs, were selected for the comparison of milk production (Flo master pro, Delaval) and milk composition data (CombiFoss, Foss). The criterions for pair building were the calving date, the milk production, the milk composition, the number of lactations and the live weight. At the beginning of the experiment respectively at turnout to pasture dairy cows were 178 ± 104 (2004), 116 ± 75 (2005) and 97 ± 86 (2006) days in milk. The milk data recording started at turnout to pasture and finished at the end of August. Concentrate distribution (7.0 MJ NEL kg^{-1}, 115 g CP kg^{-1} in fresh matter) on pasture for multiparous cows started at 22 kg (2004, 2005) and 24 kg milk production (2006). For primiparous cows concentrate distribution began 2 kg earlier. The distribution frequency was 1 kg concentrate for 2.2 kg (2004, 2005) or 2.5 kg additional milk production (2006). During the months of June, July and August the cows received in principle no forage supplements in the barn. Exceptions were made when pasture herbage mass was not sufficient.

The signs test for paired samples was applied to compare pre-grazing herbage mass (HM_{PrG}) and herbage quality data. Milk production and composition data per cow were submitted to a variance analysis with repeated measurements. The milk production per ha results were compared with a paired T-test.

Results

From 2004 to 2006 the average stocking rates during the vegetation periods were for SR_H 2.0, 2.3 and 2.3 and for SR_L 1.7, 2.0 and 1.9 cows per ha. The average SH_{PoG} for the SR_H were 10.7 (2004), 9.7 (2005) and 9.0 Units (2006) Proportions of grasses (71% versus 72%) legumes (12% versus 15%) and herbs (5% versus 6 %) in the sward were and remained similar in both treatments. The strongly varying HM_{PrG} and the herbage quality data are shown in Table 1. No differences were revealed concerning the $HM_{PrG.}$ In SR_L pasture significantly lower ash- , CP-, APDE- and APDN values as well as higher NDF values in the offered herbage were detected. Sugar- and NEL values were unaffected by the different stocking rates.

The milk production and composition data are presented in Table 2. Although no significant differences were found for effective and energy-corrected milk (ECM) yield per cow, in every year the milk yield for the SR_H was numerically lower. The energy-corrected milk yield per ha per day was significantly higher in the $SR_{H.}$ Concerning the milk composition no significant differences between the two stocking rates were found. Two exceptions were significant differences for lactose in 2005 and urea in 2006. Both differences are not explainable and, for lactose in 2005, may be accidental. The SCC showed no significant differences.

Tab. 1: Pre-grazing herbage mass and herbage quality 2004 - 2006

	High stocking rate (SR_H)			Low stocking rate (SR_L)			
	Median	Min.	Max.	Median	Min.	Max.	
HM_{PrG} (kg DM[a] ha^{-1})	1235	317	2774	1165	382	3234	
Ash (g kg^{-1} DM[a])	106	81	197	101	84	167	**
NDF (g kg^{-1} DM[a])	459	352	534	475	325	592	*
CP (g kg^{-1} DM[a])	174	132	229	161	113	224	*
Sugar (g kg^{-1} DM[a])	68	42	146	66	41	134	
APDE (g kg^{-1} DM[a])	103	91	120	100	86	116	*
APDN (g kg^{-1} DM[a])	115	87	152	107	74	149	*
NEL (MJ kg^{-1} DM[a])	6.0	5.4	7.1	6.0	5.0	6.8	

* significant at P<0.05 and ** significant at P<0.01
[a] DM: dry matter

Tab. 2: Means of milk production and composition

	2004				2005				2006			
	x_{SRH}	x_{SRL}	se[f]		x_{SRH}	x_{SRL}	se[f]		x_{SRH}	x_{SRL}	se[f]	
Milk[a]	19.7	20.2	0.6		23.0	23.5	0.4		23.5	23.8	0.5	
ECM[a]	18.8	19.2	0.5		22.2	22.2	0.4		21.0	22.0	0.5	
ECMha[b]	37.5	32.7	1.4	**	51.0	44.3	1.9	***	47.6	42.4	2.3	**
Fat[c]	3.74	3.64	0.12		3.76	3.68	0.06		3.59	3.76	0.10	
Protein[c]	3.29	3.26	0.05		3.21	3.19	0.02		3.13	3.17	0.03	
Lactose[c]	4.80	4.88	0.04		4.88	4.80	0.02	*	4.73	4.79	0.06	
Urea[d]	24	24	0.6		22	22	0.5		21	25	0.9	*
SCC[e]	4.9	4.8	0.07		5.0	4.8	0.05		5.0	4.9	0.08	

* significant at P<0.05, ** significant at P<0.01, *** significant at P<0.001
[a] average yields in kg day^{-1} cow^{-1}; [b] average yields in kg day^{-1} ha^{-1}; [c] mean in %; [d] mean in mg dl^{-1}; [e] mean of somatic cell counts in log ml^{-1}; [f] standard error of the mean

Discussion

As concentrate feeding is limited in organic farming, forage respectively herbage quality is extremely important for covering the requirements of dairy cows for milk production. The average nutritive value of herbage for SR_H was, with 174 g CP kg^{-1} DM, 459 g NDF kg^{-1} DM and 6.0 MJ NEL kg^{-1} DM, relatively high, but considerable seasonal variations appeared. The CP- and NDF- values were comparable with the data from Kuusela *et al.* 2002 and Kuusela 2004. Lower CP-, APDE- and APDN-values as well as higher NDF- values of offered herbage in the SR_L show a decreasing herbage quality with too lax grazing without topping respectively too low stocking rates. Lax grazing during spring produces, according to Hoogendoorn *et al*. 1992, swards in early summer with lower proportions of grass leaf and higher proportions of grass stem and senescent material.Increasing the annual stocking rate by 1 cow per ha in conventional farming, reduces average milk production per cow and day by 1 kg (Peyraud *et al.* 2005). Although in the present study no significant differences concerning milk production per cow were found, the effective and energy-corrected milk yield was slightly lower for SR_H as described by Peyraud *et al*. (2005). With the higher stocking rate the efficiency of herbage mass utilization was improved, as it was confirmed by the milk yield per ha (Leaver *et al.* 1985, Hoden *et al*. 1991). As it would be expected (Houssin *et al.* 2005) the milk composition was unaffected or only slightly affected by the different stocking rates.

Conclusions

Higher pasture area allowance without topping leads to a lower herbage quality. Increasing the stocking rate, within limits, slightly reduces the milk yield per cow, but clearly improves the utilization of herbage mass. Milk composition remains unaffected by the different stocking rates.

Acknowledgments

I thank the staff of “L’Abbaye” farm, of the Agriculture Institute Grangeneuve and of Agroscope Liebefeld – Posieux, who helped to carry out the investigations.

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Broilers welfare, health and production in organic and conventional systems

Ferrante, V.[1], Baroli, D.[2], Lolli, S.[3] & Di Mauro, F.[4]

Key words: organic poultry, broilers, behaviour production, reactivity.

Abstract

Animal welfare, product quality and organic or niche production system rise to more and more interest. Organic farming has grown rapidly in European and Italian agriculture during the last decade. The aim of the trial was to compare five organic and five conventional broiler farms from the productive, health and behavioural point of view. The productive performance showed that conventional broilers (CB) consumed significantly less feed then organic broilers (OB) and the first got a better FCR (Feed Conversion Ratio). These different figures could be due to the different environment and life style. OB are more exposed to natural climate, they can move much more and then they increase feed consumption and FCR become worsen.

The different age at slaughter determined the significant difference observed for the final body weight of g 2943±441 CB vs g 4486±346 of OB (P=0.0003). The same trend was observed for carcass and chest weight using the slaughtering age as covariate. The first weighed g 3530±581 for CB vs g 4410±219 for OB (P=0.01) and the second g 2450±432 for CB and g 3150±206 for OB (P= 0.01).

The mortality was similar and the main cause was SDS (Sudden Death Syndrome) related to genetic factors.

From the behavioural point of view the result might indicate that less intensive farming and the presence of an enriched environment, as in organic farming, seems to promote a better adaptation of animals, both to the environment and to man presence, ensuring better welfare conditions.

Introduction

The topic of animal welfare, product quality and organic or niche production system rise to more and more interest. Organic farming has grown rapidly in European and Italian agriculture during the last decade. The establishment of organic farming next to conventional intensive farming has been made possible by the willingness of increasing number of consumers to pay premium prices for organic food and by government subsidies for more sustainable production systems (Bennet R.M., 1996). In organic farming, animal welfare is viewed with regards to naturalness and animals should be able to express their species-specific natural behaviour. Poultry welfare can be considered in relation to the housing and management conditions to which it is subjected (Puppe 1996, Rushen and de Passillé, 1992). Welfare is good when all

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needs associated with the maintenance of good health and needs to show that certain behaviours are met. Health is an important part of welfare and behaviour is important in many regulatory systems. It is also clear that many needs involve the necessity for the animal to express different behaviours (Jensen & Toates 1993).

Although genetic factors play a major role in behaviour, the specific behaviour patterns shown by an individual animal result from the interaction of those factors with the environment experienced by that animal during its lifetime. Fearfulness which many birds display towards humans provides a good example of this interaction. The level of this fear is very high in jungle fowl, but selection during the course of domestication has considerably reduced it in modern strains. It can be reduced still further by environmental factors, such as human handling (Jones, 1987) and evaluated by behavioural tests, such as immobility test, open field test and emergency (Ferrante et. Al, 2005).

The research aim was to investigate the difference between organic and conventional broiler production in terms of productive, health and behavioural traits.

Materials and methods

For this trial five organic farms (flock size from 4.800 to 5.100) and five conventional broiler farms (flock size from 11.600 to 62.000) have been compared.

The poultry houses were located in the same geographic area and rearing the same commercial hybrid (ROSS 508®).

Birds density was different between organic poultry house (OPH) and conventional poultry house (CPH): organic farms, respecting as established by law, did not exceed 10 birds/m2, while conventional were about 15.4-17.6 birds/m2.

Concerning the management, the five organic farms were characterised by natural ventilation and natural lighting, while conventional farms used forced ventilation and combined lighting program: natural light with artificial illumination. About temperature in OPH there was a mean value of 20°C (19.2°C min and 21°C max) lower than in CPH characterised by a mean of 23.2°C (22°C min and 25°C max). Feeders and drinkers availability were homogeneous: OPH had 2.36 feeders/100 birds and CPH had 2.23 feeders/100 birds. All the drinkers were nipples and they were available to birds with a mean density of 11.5 nipples/100 birds in CPH and 11.3 nipples/100birds in OPH.

Concerning the open run of OPH the area available to birds was 4 m2/birds respecting such established by the law. The grass recycle and the presence of shade area were generally sufficient.

Two check list have been prepared to collect information. The first concerning birds during the rearing period and data related to the characteristics of poultry houses and management (microclimate, light programme, drinkers, feeders and density). Organic poultry houses were also evaluated for the open run available to birds.

The second list concerned birds number and age, feed consumption, feed conversion ratio (FCR), diseases, therapy and mortality. Birds reactivity was scored from 0 (birds escaping the observer) to 2 (birds approaching the observer with curiosity). Birds plumage condition was also scored on neck, back and vent, from 0 (very damaged, lesions and total absence/lack of feathers) to 4 (any lesions or damages). A random sample of 100 broilers for each experimental farm was observed at the slaughterhouse to evaluate rate of breast blisters, foot-pad dermatitis, haematomas related to the rearing period or handling and transport. Footpad lesions, mortality during transport e body weight were also recorded. Univariate analysis was conducted on feed consumption, FCR and carcass weight using system (conventional vs organic) as factor and the age at slaughter as covariate. Reactivity, plumage condition and carcass lesions were analysed using the Kruskal-Wallis test. The results of approaching test, the plumage condition in different body locations and the weight at slaughtering were also analysed using multivariate analysis (PCA; Jackson, 1991).

Results

The productive performance showed that daily feed consumption and FCR were significantly (P=0.0003) different between OPH and CPH. Conventional broilers (CB) consumed significantly less feed then organic broilers (OB) (Fig. n. 1) and the first got a better FCR (Fig. n. 2).

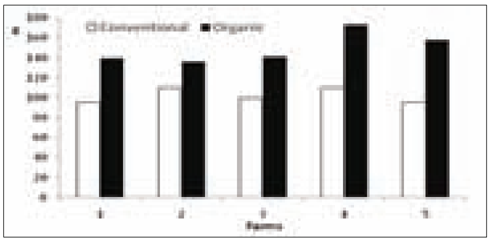

Figure1: Feed Consumption

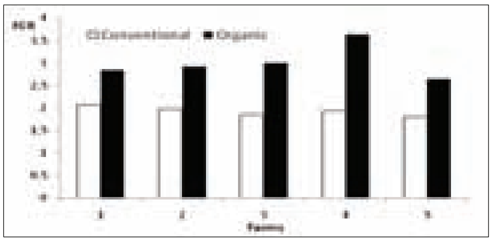

Figure 2: FCR

The different age at slaughter (56 d for CB *vs* 91 d for OB) determined the significant difference observed for the final body weight of g 2943±441 CB *vs* g 4486±346 of OB (P=0.0003). The same trend was observed for carcass weight and chest weight even using slaughtering age as covariate. The first weighed g 3530±581 for CB *vs* g 4410±219 for OB (P=0.01) and the second g 2450±432 for CB and g 3150±206 for OB (P= 0.01). The mortality was similar (5.8%±1.03 conventional *vs* 6.1%±1.67) and the main cause was Sudden Death Syndrome (SDS) related to genetic factors (28.9% conventional *vs* 30.8% organic). From the PCA analysis poultry in conventional farms seems to be characterized by good plumage conditions on the back and by higher reactivity approaching man. On the contrary the organic farms, are located on the floor projection of Loadings in a position that corresponds to low reactivity towards man.

Discussion

Results related to broiler performance such as final weight, carcass weight and chest weight confirm that organic broilers being characterised by a longer rearing period reach higher value also considering the slaughter age as covariate. Feed consumption and FCR are higher in organic broilers probably due to the possibility to move more and to the exposure to natural climate (Castellini *et al.,* 2006). The good plumage condition showed by organic poultry (Hermansen, 2004) and the absence of fear in the approaching test seems to indicate that less intensive farming and the presence of an enriched environment promote a better adaptation of animals, both to the environment and to man presence, ensuring better welfare conditions. Similar SDS incidence both in organic and conventional farms seems to confirm the importance of genetic factors for this pathology (Druyan,2007); most likely the slower growth in OB is not enough to delete genetic effects. The alternative could be to rear for organic farms only rural chicken characterised by a slow growth rate during all the 120d rearing period. It could be interesting to investigate the effects of a longer rearing period for conventional birds and to compare performance and meat quality (nutritive value, fat depth and tenderness) with organic broilers.

Conclusions

The research showed interesting results concerning the observed behavioural traits: organic broilers were characterised by a lower reactivity towards human. It seems to indicate a better adaptation to environment and to humans and can be translated in a higher broilers welfare.

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Veterinary treatment in organic husbandry

Koopmann, R.[1], Ganter, M.[2] & Link, M.[3]

Key words: animal health, animal husbandry and breeding, animal treatment

Abstract

The organic farming regulations put emphasis on the preservation of animal health by prophylaxis in the agriculture. The No 5 of the regulation EC 1804/99 (EC organic regulation) Appendix I B defines the veterinary treatments in organic animal husbandry. The veterinarian can use any medicine, which is effective for the indication and the animal species. If possible, effective homeopathics, phytotherapeutics or the like should have priority. Problems of implementing the EC organic regulation into the daily farm practice arise mostly from the doubling of the withdrawal period and the restriction of the numbers of treatments. The strict ban on prophylactic treatments is not mentioned any longer in the new regulation 834/2007, which shall apply as from 1st January 2009. Clarification of the guidelines for animal treatments in organic farming seems to be useful for farmers, veterinarians and boards of control.

Introduction

Recommendations regarding a husbandry, appropriate to the animal species, consider causal connections between health and husbandry. For organic farming the objectives for animal husbandry were aligned in the year 2000, when the EC regulations [*Council Regulation (EC) No 1804/1999 of 19 July 1999 supplementing Regulation (EEC) No 2092/91*] concerning livestock production came into force. The appendix I B No 5: *"Disease prevention and veterinary treatment"* defines that the animal health shall be based on principles like the choice of appropriate breeds and of animal-fair husbandry practices, high-quality feeds, regular use of outdoor-run and pasturage. The new regulation (EC) No 834/2007 mentions additionally "hygienic conditions". The principles should limit animal-health problems so that they can be controlled mainly by prevention.

This is possibly until today an unrealistic perception. No constant better flock health in organic farming could be shown so far in the reality. Apart from other problems, the outdoor husbandry arises the risk of the occurrence of endoparasites, livestock infections and even zoonotic infections (Conraths et al., 2005, Hovi et al.,2003). Problems in animal health are usually various. A larger variation in the status of animal health is found in between individual organic farms than in between the conventional and the organic system (Sundrum, 2004). Presumably good animal health depends very much on the personal priority and skills of the farmer and it overlaps with other farm options like labour capacity, personal interest, surface area indoors and outdoors, and equipment supply.

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Other causes for insufficient animal health in organic farming may be e.g. the restrictions of the number of treatments and the lack of medical prevention. In some cases there is to be a substantial deficit in knowledge of the veterinarians concerning strategic problem-solutions in organic systems. There is a certain scepticism in some veterinarians concerning the organic farming. Others are unassure about restrictions of therapy. Unsatisfactory interaction between farmer and veterinarian is described as well (Hertzberg et al., 2003, Hammarberg, 2001, Leeb and Baumgartner, 2000, Sundrum, 2004, Vaarst et al., 2003). The presentation of some problems, -information gaps and misunderstandings is the aim of the following paper, as well as the promotion of the scientific discussion.

Regulations and problems

Most important current EC organic regulations for the animal treatment are:

- First of all there is a treatment requirement. Sick animals must *"immediately"* get treated. Thus, a farmer acts adversely to the regulation, if he does not give treatment to his ill livestock.

- Secondly, the organic farming favours complementary medicine, because these are to support the defence mechanism of the organism, without leaving chemical residues in dung and food. Homeopathic and phytotherapeutic products are to be preferred provided that they actually have a therapeutic effect on the animal species and the illness. But: *“chemically-synthesised allopathic veterinary medicinal products or antibiotics may be used under the responsibility of a veterinarian”* if the alternative treatment “*is unlikely to be effective”*.

Particularly the effectiveness is pointed out. If the efficacy is not given free of doubts, the familiar remedies are to be used. E.g. the vets in Sweden are not allowed to use homoeopathics (Hammarberg, 2001).

The opinion that the treatment of organic livestock is permitted exclusively with "alternative remedies" is far common. This cannot be deduced from the EC regulation. Otherwise the organic husbandry gets a reputation of not treating sick animals in an appropriate way (Hammarberg, 2001). The use of chemotherapeutics is currently inevitable to prevent animals from suffering or distress in organic farming.

However the use of chemical medicine is to be limited to the indispensable minimum. The principles of "good veterinary practice" contain a similar passage. The demanded effectiveness of alternative medical treatments may also depend on the experience of the therapist. Advanced training in complementary medicine for veterinarians is possible, but in each regard costly and time-consuming.

The farmers already broadly apply various forms of the complementary medicine. Although the scientific proof for the effectiveness could not be offered so far, in the perception of the farmers many different remedies and concepts “proved” its efficacy (Leon et al., 2006). If farmers prefer to use unlicensed “alternative remedies” rather than treating their animals with licensed chemical drugs this is not acceptable in food producing animals.

- Thirdly, the "*preventive administration of chemically synthesised allopathic veterinary medical products or from antibiotics"* is clearly forbidden in the current regulation. The drying-off of cows with antimicrobial mastitis-syringes is not regarded as a preventive measure, if a high risk of mastitis infection is documented. It is a therapeutic treatment in cases of subclinical chronic mastitis. More new infections at calving were found in untreated cows. The “prophylactic treatment” of newly bought calves with antibiotics may also be therapeutic if the probability of already being in incubation of illness is high. The new EC-rules do not mention any longer a ban of prophylactic treatment.

Certainly by the organic farmer a particularly intensive awareness is demanded, because if a chemical-synthetic treatment begins too late the objective of reduced use of medicine is missed. Since then often treatment has to be longer and more intensively and in many cases no complete restitution is possible. This is conscious to most organic livestock farmers.

- Fourthly, hormones may be given only in the context of a therapeutic veterinary treatment of single animals. Induction or synchronisation of oestrus or shots of Oxytocin without prescription are prohibited. Vaccines and e.g. paramunity inducer (also genetically manufactured) are permitted. Farmers must document batch-specifically or animal-individually all applied *“veterinary medicinal products”*. 30% of organic layer-farms had missing drug-reports.

- Fifthly, the doubling of the legal withdrawal period for chemical drugs in the organic farming is to improve the desired consumer protection: *“The withdrawal period… is to be twice the legal withdrawal period or, in a case in which this period is not specified, 48 hours.”*

The duplication of the withdrawal period and the 48-hours rule only concerns the *allopathic veterinary* remedies, thus everything that is not ranked among the homoeopathics. This would concern also the phytotherapeutics. The registered 70 plants were intensively examined and possible residues were classified as without risk for humans. The 48-hours rule concerns as well medicinal products with a legal withdrawal period of 0 days. This affects e.g. the use of physiological NaCl infusion solutions. This is considered as “absolutely useless” (Tiergesundheit im Ökolandbau: Rechtliche Grundlagen,2007).

The constant documentation of this kind of animal treatments and reliable adherence to the withdrawal period of at least 48 hours may be doubted.

The duplication of the withdrawal period is problematic also for the owners of "minor species" e.g. goats. The withdrawal time is at least 2 x 28 days on meat and 2 x 7 days on milk, if the used medicine is not registered for the species which is treated. The double withdrawal period is particularly difficult also in connection with mastitis treatment. 85% of the mastitis treatments in organic farms were allopathic and at least 14 % of organic farmers usually treat with intramammary syringe at drying-off. Milk of treated cows has to be withdrawn for 10 days; but if the birth takes place too early, the withdrawal period is for e.g. 94 days, depending on the remedy. In reality the withdrawal of milk for more than 4 to 6 weeks after parturition has to be questioned.

- And finally, the number of *“chemically-synthesised allopathic veterinary“* treatment courses is restricted. This means: Two treatment courses in fattening pigs and fowl inhibits the marketing as an organic product. A cow and its milk only get disqualified with the fourth treatment course per year. This regulation does not apply to vaccinations and treatments against parasites. A “treatment course” covers the period of the first application of chemical-synthetic medicine within a therapy up to the recovery of the animal. In case of a relapse of the same illness a second treatment may be summarized with the first treatment to one “treatment course”. A daily practice’ problem is e.g. the treatment of farrows which completely utilize the number of legal treatments, without the knowledge of the following fattening farm.

The current regulation could perhaps prevent a reasonable early, chemical-synthetic treatment. It may lead possibly to delayed, animal-protection-relevant disease pictures and accumulated mortality, if the farmer underestimate the problem in view of his financial loss. This section is discussed increasingly critically (Tiergesundheit im Ökolandbau: Rechtliche Grundlagen, 2007), because such conditions would run diametrically against the intentions of organic livestock production.

Conclusion

Clarification of the guidelines for animal treatments seems to be useful for farmers, veterinarians and boards of control. The problems of the use of chemical-synthetic animal drugs in the daily practice of organic farming have to be discussed critically. The new Council regulation (EC) No 834/2007 defines only goals. The detailed rules for application will get fixed later by a "Committee on Organic Production". Feasibility of the rules and their impact on animal welfare is to be considered carefully.The organic farming is in danger to lose the reliability in the consumer's perception, if the facts about outdoor keeping, animal health and medical treatment are left ignored. The correlation between costly labour and animal health and welfare should be proved scientifically and communicated to the consumer. He would achieve a better perception of the organic process of production and the required prices may become more reasonable to him. Doubtless the objective of "less drugs" in organic animal farming could be reached in the future by long-term adaptation of hygiene, feed and husbandry-methods rather than by drugs. But denying today the necessity of chemical veterinary treatments will not help. Animal welfare has to be the major goal in organic farming.

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Principles and practicality of organic dairy cattle breeding: different options and implications

Nauta, W.J.[1] & Roep, D.[2]

Key words: organic breeding, dairy cattle, organic principles, strategies of development

Abstract

As yet there is no set of generally acknowledged rules for organic animal breeding. Most organic farmers depend on conventional breeding programmes, which conflict with organic principles. Do we need a separate, distinct organic breeding system? And how can we support the development of organic breeding? These questions were explored in a PhD study. In general organic farmers and other interest groups express the need for a separate, fully organic breeding system, particularly in view of the modern reproduction technologies used in conventional breeding. Also the difference in the magnitude of GxE between organic and conventional milk production indicates that a separate breeding program might be needed. In practice, however, organic farmers respond to different, and sometimes opposing, strategic and practical considerations. In this situation three options are identified in the development of organic breeding: adaptation of conventional breeding, an organic breeding program and improved natural breeding. Each path has its own implications and demands. Organic breeding is the subject of experimentation and learning on the one hand and of social debate on organic principles on the other. This process needs to be enhanced and interconnected, before well-founded decisions can be taken on further development of organic breeding.

Introduction

At the majority of organic farms animal breeding is not organic since most farmers depend on bulls from conventional breeding programmes. This is because there is no official organic supply of breeding bulls. Does organic production need a (selective) organic breeding system distinct from conventional breeding? If this is the goal, what kind of organisation and structure should this selective breeding be based on, and how can the development of such a breeding system be supported?

To answer these questions, three aspects of breeding were explored in a PhD study: farmers views on organic breeding (Nauta et al., 2005); differences and the magnitude of GxE between conventional and organic milk production (Nauta et al., 2006a + 2006b), and the demand for breeding among organic dairy farmers (Nauta et al., 2007). In general farmers favoured the development of a breeding system based on the principles of organic farming, which they see as an obvious extension of their own preference for organic production (Nauta et al, 2005). Interest groups also see a need for organic animal breeding to improve the image of organic farming. This is mainly a

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reaction to the artificial reproduction technologies used in conventional breeding, such as embryo transfer (ET) and IVF.

Breeding bulls from conventional breeding schemes are selected based on estimated breeding values. The reliability of these breeding values is different for organic farmers due to the difference in GxE between conventional and organic production. A first exploration of the magnitude of this GxE showed a genetic correlation of 0.80 between organic and conventional milk production. This means that this magnitude is of “considerable” importance (Mathur & Horst, 1998) and that conventional breeding values are less reliable for organic farmers.

The demand for breeding among Dutch organic dairy farmers is very diverse. Farmers are experimenting and searching for a suitable type of cow (Nauta et al., 2007). This may be due to the lack of suitable information and the more multi-purpose use of animals, including their cultural and historical values. Cross-breeding with robust breeds is also popular among organic dairy farmers (Nauta et al., 2006a).

The question is how to support the development of organic breeding. In this paper we will focus on three possible options for the development of organic breeding and describe considerations affecting the decisions farmers make concerning cattle breeding. We further describe how to deal with and support this process of development of organic breeding.

Material and Methods

The results of these three studies were used to develop three possible options for further development of dairy cattle breeding in organic farming and to describe how to deal with and support this process.

Results: Different options for organic breeding.

From those three studies, three main options for dairy cattle breeding can be identified:

1. Adaptation of conventional breeding and service based on insights into G x E and specific organic needs.
2. Additional organic breeding program based on the organic population (selection of animals within organic herds).
3. Improved natural breeding (farm or regionally based).

The first option is still close to conventional breeding since it uses the same breeding programs and animals. For this option the breeding values of bulls can, when needed, be adapted to the organic production system based on information on GxE, as Interbull does when adapting breeding values for different countries (Interbull, 2007). Female reproduction with super ovulation, oocyte pick up, in vitro fertilisation, embryo culture and ET will be restricted by using ET-free bulls.

For the second option, the entire breeding program should be organic using animals exclusively from organic farms. Bulls will be tested and selected based on the performance of daughters on organic farms. There will be no use of multiple ovulation, ovum pick up and IVF and/or ET. However, the use of AI must be used to estimate breeding values in a testing scheme.

The third option is based on natural mating and selection of animals at the farm level. This system needs a totally different structure compared to the AI structure. The bulls can, for example, be selected from a kin-breeding scheme on a farm or group of farms (Nauta and Cazemier, 2005). Other farms can purchase bulls from breeding farms. Such 'user farms' will make use of the breeding progress on the breeding farms, and also have the option of crossbreeding. These three options for breeding can be seen as a stepwise development towards a natural breeding system.

Discussion: Considerations concerning organic breeding

Between the three options, there are barriers which prevent farmers and other stakeholders from taking steps towards breeding that is more in line with the organic principles (Nauta et al, 2003). However, other farmers just make the transition towards 'organic' breeding. An important barrier is the keeping of bulls at the farm. Bulls are dangerous and special housing is needed but space is limited at many farms. It is the ease of ordering an AI from a bull by phone that keeps farmers to using conventional breeding (Nauta et al., 2005). At the same time more and more organic farmers are taking the opposite view and starting natural service (Nauta et al., 2007). Many farmers see benefits to keeping bulls on the farm: it is good for the image of their farm, often economically rewarding and increasing the fertility of the cows.

All three options raise questions about genetic progress. Due to effects of GxE (Nauta et al. 2006b, Bapst and Stricker, 2007) a separate breeding program might be justified (Mulder and Bijma, 2005). However, in a closed organic breeding program, with far fewer animals than the national population (in the Netherlands about 20,000 dairy cows), less genetic progress can be made (Harder 2002). But the indirect use of modern reproduction technologies might just force the sector towards a distinct organic based breeding program. If also AI might become limited of forbidden, breeding must be based on natural mating and will become based at farm level. Selection within the organic population or farm herd will however, result in less effect of GxE and genetic progress may not be as fast as in a (world-wide) testing scheme, but will still be possible (Rendel and Robertson, 1950).

For the whole sector, the main issue is whether the organic sector should continue to depend on conventional breeding, or whether it will opt for a separate, distinct organic breeding system, either at farm level or in a structure similar to conventional breeding. The objectives are clear; generally it is proposed that organic production should be based on natural integrated processes of animal and crop production using local resources and closed cycles. Animal health and welfare are also important issues for the organic sector, and animals should be able to adapt to the local environment (EU, 1999; IFOAM, 2006). However, current animal breeding practices in conventional breeding programs are in conflict with the rules and objectives.

Conclusion: Development and support of organic breeding

There is still a lack of information for farmers about all the different activities farmers are in to with their own breeding activities: information on GxE, suitability of (cross)breeds, excluding ET, breeding at the farm. In our opinion, all these activities should be supported by providing information to farmers to enable them to make their decisions on breeding. Also further discussions are needed with farmers, researchers and breeding organizations to determine what the organic sector needs in the future .

A start has been made with this PhD, but more information and support are needed. Also new technologies for selection (marker assisted selection and genome wide selection) and reproduction (sperm sexing) are being introduced in conventional breeding programs. These developments may take the use of conventional breeding to a whole new level. The organic sector still has to develop a view on the use of these technologies. World-wide they might lead to a further erosion of genetic variation and harm the integrity of the animals. However, at farm level, in a family breeding scheme, the new tools like marker assisted selection and sperm sexing may help farmers to select and breed animals more efficiently.

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Livestock Production Practices of Registered Organic Farmers in Uttarakhand State of India

Subrahmanyeswari, B.[1] & Chander, M.[2]

Key words: Organic standards, animals, organic farmers, Uttarakhand, India

Abstract

The authors studied 180 organic farmers, randomly selected out of 4459 organic farmers registered with Uttarakhand Organic Commodity Board (UOCB), in the North Indian state of Uttarakhand (77⁰ 34′ and 81⁰ 02′E longitude and 28⁰ 43′ to 31⁰ 27′ latitude). These farmers were interviewed during 2006-07, using semi-structured Interview schedule, so as to know their Knowledge, Attitude and Practices (KAP) in context of their livestock production activities in particular. All the farmers had maintained some animals under crop livestock subsistence mixed farming system, mainly to meet household requirements of milk and more importantly cow dung for use in crop field. These farmers were mostly focussed on organic crop production activities, with active technical and marketing support from UOCB. The animal husbandry practices were mostly traditional but very close to organic livestock production systems when contrasted with the organic livestock standards. It was concluded in the study that conversions to organic livestock production systems would be much easier for these organic farmers, if technical and marketing support is extended beyond crops to cover livestock.

Introduction

The organic land in India is 1,50790 hectares spread over 1,547 farms constituting 0.1% of total agricultural land (Willer and Yussefi, 2007). India exported 35 organic products worth US$ 21 Million during 2004- 05 (Gouri, 2006), but these products did not have any item of animal origin except honey. The Indian authorities managed to acquire both, United State Department of Agriculture (USDA) equivalence for the National Organic Programme (NOP) and the European Union (EU) third country listing in 2006, indicating significant progress India has made regarding organic farming (Wai, 2007). Indian agriculture is characterized by small scale (<2ha), subsistence farming operations under low input low output production systems, where, livestock are essentially integrated with crop farming. Thus, alongside organic crop production, the prospects for organic livestock production are bright though yet to be explored (Chander & Mukherjee 2005, Chander et al 2007).

In India, Uttarakhand is the pioneering state in organic agriculture, since it is the first state declared as organic. Here, the state government has identified “organic farming” as a thrust area for agriculture development and promoting organic farming through establishment of an institutional mechanism named as Uttarakhand Organic Commodity Board (UOCB). The UOCB was created on 19 May 2003, to promote, co-

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ordinate, centralize and decentralize the dispersed organic activity in the state. Achievement of sustainable rural development through organic farming and also to make 'Uttarakhand the Organic capital of India' are the mission and strong visions of UOCB, for which it acts as a nodal agency to enhance organic activities in agriculture and allied sectors like horticulture, medicinal and aromatic plants & herbs, milk production and animal husbandry throughout the state. The technical and marketing support for different activities of UOCB is provided by the Center for Organic Farming (COF). Thus, UOCB is working to promote organic farming in the Uttarakhand by bringing all the organic initiatives under one umbrella; to provide a single window access to market, industry and other stakeholders, by working as a bridge between farmers and government, as well as to access funds, grants and other finances for the different organic activities. As such, the Uttarakhand state is moving systematically towards organic farming development with full government support. UOCB could facilitate sale of certified organic products worth Indian Rupees (INR) 198.3 Lakhs (4,63,746 US$) during 2003-06 (Shah, 2006). The registered farmers are currently motivated mainly due to the expectation of price premiums followed by other reasons. The state targets for certification of more than one hundred thousand farmers over similar number of hectares by the year 2010 (Subrahmanyeswari & Chander, 2007). Though the activities at the moment mainly focus on organic crop production but the interest in organic livestock production is also increasing (Subrahmanyeswari, 2007).

Materials and methods

In north Indian state of Uttarakhand, 4459 organic farmers were registered with Uttarakhand Organic Commodity Board (UOCB), by the time of the study. Out of the 4459 registered farmers, 180 registered organic farmers were selected randomly at the rate of 10 farmers from each purposively selected village (total 18 villages, 2 from each block), 9 randomly selected blocks (3 from each district) and 3 purposively selected districts from the purposively selected state of Uttarakhand. As such, the total sample consisted of 110 registered organic farmers from hill region and 70 farmers from plain parts. The sample also represented both male (111) and female (69) groups. An interview schedule was developed consisting questions relating to general profile of farmers, their knowledge, attitude and production activities, with special emphasis on their animal husbandry practices. While designing the interview instrument, the organic standards developed by Government of India were considered so as to contrast their practices with the standards, for which a knowledge test was developed based on the standards. To measure their attitude towards organic livetock farming, an attitude scale was also developed. The selected farmers were personaly visited by the researcher during 2006-07 to interview and observe their production activities.

Results

Agriculture land in Uttarakhand is scattered, fragmented and land distribution is inequitable. Individual holdings are very small; more than 50 per cent of the holdings are sub-marginal (< 0.5 ha), the average holding size being only 0.93 ha, compared to the national average of 1.34 ha. Net sown area was 7,84,117 ha, of which, nearly 3,42,283 ha (44%) were irrigated crops and the rest rain-fed. Mixed-crop livestock farming is the predominant farming system in Uttarakhand with wide variation in the species of livestock held like cattle, buffalo, goat, sheep, pigs, horses, pony, mules and poultry. Large population and low productivity are the hallmark of livestock in the state, yet agriculture along with livestock is the single largest employer in the state and

80 per cent of the rural households in the state earn over a third of their income from livestock. Contribution of livestock sector accounts for over 9.5 per cent to the gross domestic product of the state. The major resources of feed and fodder in the state are crop residues, cultivated green fodder and edible herbage and permanent pastures. Collection of fodder leaves and local grasses is a normal practice in the hilly areas, whereas, the proportion of livestock maintained on grazing is very small in the agriculturally developed and irrigated areas of the state.

The General profile of the organic farmers of the study has been discussed by the authors elsewhere (Subrahmanyeswari & Chander 2007). More than three fourth of the respondents were having 3-6 years of experience in organic farming, followed by 15 per cent of farmers having 6-8 years of experience in organic farming. Total land holding with 180 organic farmers was 176.62 ha, with 34.97 per cent of land under organic cultivation. Of the total land, 87.14 per cent of land was rain-fed. Most of the farmers (48.33%) were with low level of awareness followed by 41.33 per cent of respondents with medium level of awareness about the organic animal husbandry standards, whereas, very few farmers (10.56%) were found to have high level of awareness. Majority of the farmers (76.67%) were with low level of knowledge, followed by 23.33 per cent of the respondents with medium level of knowledge regarding organic livestock standards. More than 60 per cent of organic farmers were having favorable attitude towards standards of organic livestock farming.

Organic farmers' livestock farming practices were in consonance with some of the organic production standards viz. diversity of farms, local breeds and traditional practices, which are given due importance in organic production systems. Farmers treat livestock as part of their family and were paying due care to their welfare. Animals' physiological and ethological needs were being fulfilled in the present rearing systems of organic farmers. Organic farmers who were in conversion to organic livestock farming were in the requirement of certain resources both at community and individual level like technical, infrastructural and financial resources. The majority of the farmers felt need of training in different areas of organic animal husbandry. UOCB effectively rendered training to organic farmers through Master Trainers in aspects like compost making, crop rotation, Integrated Pest Management (IPM), Internal Control System (ICS) measures, certification etc. Currently, organic farmers were marketing organic agricultural produce through UOCB, but in conversion to organic livestock farming, they perceived risks like uncertain product demand and consumer preferences, limited resources options, animal epidemic diseases etc. To overcome these risks, farmers suggested risk management strategies like wider publicity regarding organic products, production at the lowest cost possible, technical support in the form of risk reducing technologies, diversifying the production and group certification through ICS etc.

Discussion

UOCB appeared to be successfully implementing the organic agriculture development programme in the state of Uttarakhand through registering the farmers and providing the necessary inputs and training for carrying out the organic farming activities. Farmers seems to have gained some confidence in organic crop production activities due to the training and marketing support provided by the UOCB, but the activities concerning organic livestock production such as training, marketing facilities for organic products and disease in livestock and reduced prospects of export of livestock products from India may be considered as potential risks coming on the way of expansion of organic livestock production in the state. Nevertheless, farmers were ready to give a try to organic livestock production, mainly looking at the prospects of high premiums on such products even in domestic markets.

Conclusions

Prospects of organic animal husbandry are bright in the state of Uttarakhand, especially due to its hilly terrain, favourable government policies and likely expected increase in demand for organic livestock products in future. Moreover, most of the existing livestock production practices of the organic farmers were in consonance with most of the organic standards. The UOCB may find it much easier to motivate farmers for organic livestock production due to the variety of favourable conditions.

Acknowledgments

We thank officials of UOCB, the organic farmers and the Director, Indian Veterinary Research Institute, Izatnagar for facilitating the research work towards the PhD dissertation, 'Knowledge Attitude and Practices of Organic farmers with special reference to livestock farming: An exploratory study in Uttarakhand state of India' submitted by the first author.

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Handling of animal welfare and disease challenges

A Longitudinal Study of Mastitis on an Experimental Farm with Two Herds, One Managed Organically, the other Conventionally

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Key words: mastitis, organic, bulk milk somatic cell count, Staphylococcus aureus

Abstract

Mastitis in two herds managed as a comparison between organic and conventional dairy farming systems was monitored for 4 years utilising regular bacterial culture of milk samples, individual and bulk somatic cell counts and observation by farm staff. The objective was to develop strategies for the control of mastitis in organic cows without the use of antibiotics. The herds showed differences in clinical mastitis incidence, subclinical mastitis prevalence and bulk milk somatic cell count. Despite these differences, the level of mastitis in the organic herd remained manageable.

Introduction

In 2001, Massey University set up its Dairy Cattle Research Unit (DCRU) as a system comparison between organic and conventional farming. It is the only comparative grassland-based open grazing dairy study in the world. The farm is a seasonal producer with calving from late July until mid October. All cows are dried off by the end of May, the exact date depending largely on pasture availability.

The DCRU was split into two similar units. The organic unit covers an area of 20.4Ha and the conventional 21.3Ha, carrying typically 46 organic cows (2.27cows/Ha) and 51 conventional (2.39cows/Ha), respectively. In 2003, the organic unit achieved its full AgriQuality (New Zealand) organic certification. From August 2006, all organic dairy suppliers to Fonterra NZ Ltd were required to meet the standards set by the USDA National Organics Program. Each of the two units is managed individually according to "best practice" for its particular type of management system and environmental conditions. Thus, no attempt is made to replicate on one farm what is done on the other. The project has been described in detail by Kelly *et al* . (2006).

Mastitis control for the conventional herd is based on the Seasonal Approach to Managing Mastitis (SAMM) Plan, a nationwide scheme administered by the National Mastitis Advisory Committee. Control in the organic herd is based on the same principles excluding (since 2005) the use of antibiotics. An iodine-based teat spray is used on both herds post milking. Treatment of clinical (CM) and sub-clinical mastitis (SCM) in the organic herd generally relies on homeopathy along with supportive therapy. Financial penalties apply to bulk milk submitted with a somatic cell count (SCC) exceeding 400,000 cells per mL. The predominant major mastitis pathogen in

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New Zealand is *Streptococcus uberis* followed by *Staphylococcus aureus*. The most commonly isolated minor pathogen is Coagulase Negative *Staphylococcus* (CNS) (McDougall, 1998). Incidence of CM and prevalence of SCM are important pre-requisites to estimating the cost of mastitis to the dairy industry. This study presents the incidence of CM, prevalence of SCM, and describes the bulk milk somatic cell count (BMSCC) from both herds involved in the system comparison.

Materials and methods

In November 2003, a sampling regime began whereby milk from each cow in both herds was submitted for bacterial culture. Sampling occurred 4 times per season; at calving, 14 days after calving, at mid lactation and at drying off. Culture and classification of organisms was initially carried out by a post-graduate student (Silva *et al*., 2005) and subsequently by New Zealand Veterinary Pathology Ltd (NZVP). Additional data was gathered from monthly individual somatic cell counts (ISCC) carried out by the Livestock Improvement Corporation as part of routine herd testing and daily BMSCC provided by Fonterra. Episodes of CM were recorded by DCRU staff.

Results

Clinical mastitis

Of the total 402 cow-lactational seasons included in the study, 61(15.2%) had at least one episode of mastitis. The incidence of CM varied significantly between herds, from 14.2 cases/100 cow-lactational seasons in the organic herd to 16.9 cases/100 cow-lactational seasons ($p<0.001$) in the conventional. In 34 of the cases (27.2%), more than one quarter was affected at the same time. There were 19 (33.3%) cases with multiple quarters in the organic herd and 15 (22.1%) cases with multiple quarters in the conventional herd.

Each affected organic cow averaged 1.5 quarters diagnosed with CM per episode and for each front quarter, 2.2 rear quarters were affected. Each conventional cow with CM averaged 1.4 quarters per episode and for each front quarter there were 1.8 rear quarters affected.

Subclinical mastitis

Milk samples were collected from a total of 5004 quarters – 2365 from the organic and 2639 from the conventional herd. 69.9% of organic quarter samples did not grow causative organisms. The most frequently isolated organisms were *S. aureus* (41.8% of all isolates), CNS(29.8%), and *S. uberis* (11.1%). 74.2% of conventional quarter samples did not grow causative organisms. The most frequently isolated organism were CNS (39.5% of the isolates), *S. aureus* (26.6%) and *S. uberis* (12.3%). A total of 1392 (27.8%) quarters were affected by subclinical mastitis, based on culture results, in 1251 tests of 391 cow-lactation seasons. For each front quarter there were 1.2 rear quarters affected by SCM with 1.3 and 1.1 rear quarters affected in the organic and conventional herds, respectively. The differences in the incidence of isolation of *S. aureus* or *S. uberis* between herds and quarters were significant, whilst differences of *S. uberis* isolation between different quarters were non-significant throughout the study period. Differences between the two systems for *S. uberis* isolation were also generally non-significant whereas differences for *S. aureus* during the first three seasons were generally highly significant (Figure 1).

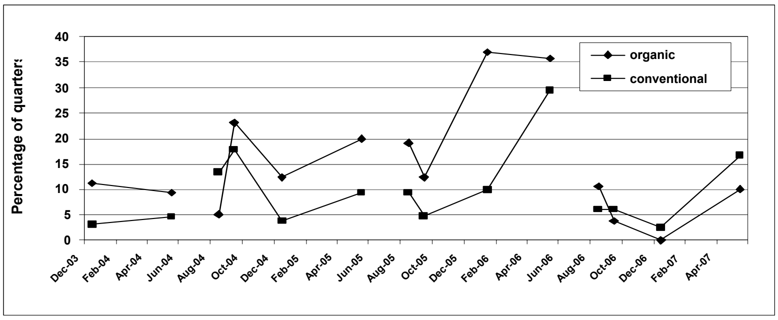

Figure 1: Proportion of *S. aureus* isolates among herds over 4 seasons

BMSCC data are presented in Figure 2. While the conventional herd demonstrated typical U-shaped curves each season, the organic herd demonstrated irregularities in the curve shape and generally higher values. Most of the daily collections had significantly different BMSCC.

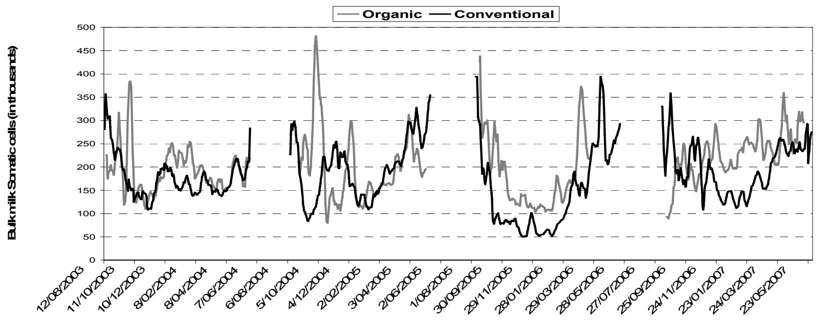

Figure 2: 10-day rolling average of BMSCC unadjusted for milk volume

A large proportion of the somatic cells appearing in the bulk tank originate from a relatively small proportion of cows (Table 1).

Tab. 1: Percentage of cows with ISCC >400,000 cells/mL two or more times per season

Season	2003/2004	2004/2005	2005/2006	2006/2007
Organic	17	24	17	23
Conventional	20	17	8	15

Discussion

Both herds have exhibited a number of unusual trends throughout the course of the study. The incidence of clinical mastitis is relatively high as is the prevalence of *S. aureus* isolated at culture. Although the herds are milked into two separate bulk tanks, the same milking machine is used, the conventional cows being milked immediately after the organic. Thus there is potential for the spread of *S. aureus* from the organic to the conventional herd. The structural limitations of the soil type mean careful management is required during wet periods and it was initially considered that its poor drainage characteristics may enhance the survival of environmental pathogens. The numbers of *S. uberis* recoverable from the environment of pasture-based systems are related to moisture levels and inversely related to ambient temperature and solar radiation. A number of initiatives were undertaken to keep contamination of teats to a minimum during critical times of the year and these appear to have been largely successful. Moreover, throughout the project, the bulk of quarters from which *S. uberis* was recovered at calving were negative at the 14 day test. Management of BMSCC has tended to focus on the relatively small proportion of chronic SCM cases, identified by ISCC and monitored on a daily basis using the California Mastitis Test. Changes in management procedures targeting the incidence of *S. aureus* in the organic herd were instigated at the start of the 2006/07 season, including oral dosing with apple cider vinegar, an intensive homeopathy programme and improved teat spraying. Although there has been a decline in the incidence of *S. aureus* and CNS recovered from milk samples and in the incidence of CM in the organic herd, BMSCC has remained relatively high.

Conclusions

Control of *S. aureus* is likely to be the most important factor in managing mastitis in a pastoral-based organic herd, while environmental pathogens are easier to control with adequate management of the cow's surroundings. The difficulty in eliminating *S. aureus* once well established in the udder means BMSCC may remain relatively high despite minimal spread of infection between cows.

Acknowledgements

The project is funded by Dairy InSight. For their support (and patience) the staff at DCRU, NZVP and Homeopathic Farm Support, along with Natalie Butcher and Nicola Shadbolt are gratefully acknowledged.

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Effect of colostrum type on serum gamma globulin concentration, growth and health of goat kids until three months

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Key words: goat production, goats kids, colostrum, immunity, immunoglobulin

Abstract

In this study the effect of three colostrum types; goat, cow and artificial colostrum, on serum gamma globulin concentration (GGC), growth and health of goat kids during the first three months of the rearing phase was measured. Thirty newborn goat kids were randomly assigned to three experimental groups; goat colostrum (GC), cow colostrum (CC) and artificial colostrum (AC). At 2, 28, 56 and 86 days serum GGC and live weight were measured. The three colostrum types were analysed on immunoglobulin G (IgG). Goat colostrum contained twice as much IgG as cow colostrum and artificial colostrum. At 2 and 28 days GC kids had a higher serum GGC than CC and AC kids. At 56 and 86 days no significant differences in serum GGC between the groups were found. No effect of colostrum type on daily weight gain was found. Eight out of thirty goat kids under study suffered from health problems. Health problems and mortality were heavier among the AC kids. It can be concluded that for a successful passive transfer of immunity goat colostrum is necessary. When it is not possible to provide goat colostrum because of health reasons (disease transmission), cow colostrum is the best alternative. In that case good farm management is even more important.

Introduction

In ruminants, the placenta impedes the transfer of immunoglobuline from mother to foetus. Consequently, the consumption of colostrum by the progeny plays a fundamental role in the building up of immunity. O'Brien and Sherman (1993) concluded that failure of passive transfer of maternal antibodies to kids via colostrum leads to increased morbidity and mortality from infectious disease in young goats. In practice each farm carries its own variety of pathogens. Colostrum originating from the own farm, consists out of farm specific antibodies that cause immunity against disease agents but also against ubiquitous bacteria's and protozoa. For organic dairy goats it is important that the immunity during the rearing phase is well developed. However, beside a source of useful elements, colostrum can also cause transmission of diseases as *Caprine Artritis Encefalitis* (CAE), *Caseous Lymphadenitis* (CL) and paratuberculosis from mother to goat kid. Prevention against these diseases is necessary for animal welfare and prevention of economical damage. To prevent transmission of diseases from mother to kid, farmers provide artificial colostrum or cow colostrum in stead of colostrum originating the own goats. Zadoks et al (2000) showed that artificial colostrum contains insufficient immunoglobulin to develop immunity. An experiment of Orsel et al. (2000) with cow colostrum resulted in higher values of antibodies compared to artificial colostrum but lower than goat colostrum.

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The objective of this study was to evaluate the effect of three colostrum types; goat, cow and artificial colostrum, on serum gamma globulin concentration (GGC), growth and health of goat kids during the first three months of the rearing phase.

Materials and methods

All kids in this study were born on an organic commercial dairy goat farm in the south of The Netherlands. Thirty newborn goat kids were randomly assigned to one of the three experimental groups; goat colostrum (GC), cow colostrum (CC) and artificial colostrum (AC). All goat kids were fed 200 ml colostrum, 100 ml within one hour after birth and 100 ml four hours after birth. All colostrums were given by hand through bottle feeding. Four millilitres of blood was obtained from each kid at birth by jugular venapuncture. At the same time, the animals were weighted. Sampling was repeated at 2, 28, 56 and 86 days. All samples were analysed by the National Animal Health Service on protein spectrum and total protein. From these parameters the GGC was calculated.

The goat colostrum used for this experiment was collected from four goats, which had recently kidded for the first time. Cow colostrum was obtained from two dairy farms that were free from Para tuberculosis. The used artificial colostrum was of the brand Colobis. By preparing this colostrum 25 grams of powder was dissolved in 100 ml warm water. All colostrums were individually analysed by the National Animal Health Service on immunoglobulin G (IgG).

Data were analysed with GenStat Release 9.1 2006, Lawes Agricultural Trust (RothamstedExperimental Station). The ANOVA unbalanced design procedure was used for measuring significance.

Results

On average, goat colostrum contained twice as much IgG (58 g/L) as cow colostrum (26 g/L) and artificial colostrum (23 g/L).

Serum GGC of the goat kids was at birth on average 0.8 g/L. GC kids had at birth a slightly higher GGC compared to AC en CC kids ($P<0.05$). Two days after birth GC kids had a significant higher GGC compared to CC kids and AC kids ($P<0.01$). Twenty eight days after birth, the average serum GGC in GC kids was still significantly higher than in CC kids ($P<0.05$). GGC in AC kids differed not significantly with the two other groups. At the age of 56 and 86 days no significant differences in serum GGC between the groups were found (figure 1).

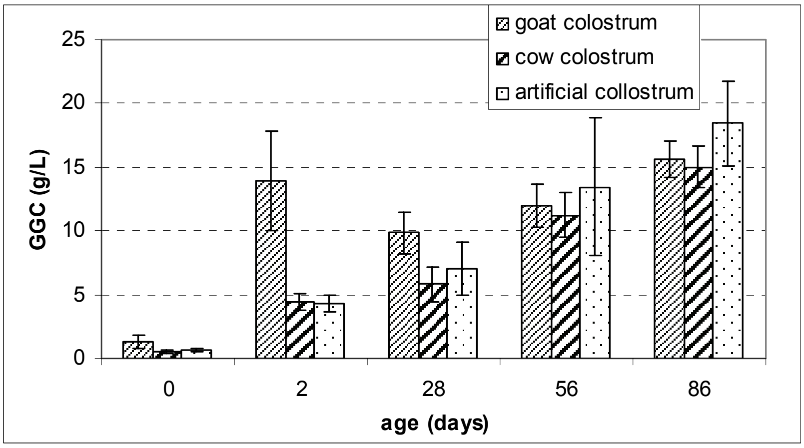

Figure 1: Average GGC and st. dev. in blood of the three groups of goat kids at 0, 2, 28, 56 and 86 days.

No significant effect of colostrum type on daily weight gain was found. At 56 days, the GC kids and the CC kids weighted more than the AC kids. At 86 days no significant difference in weight between the three groups was found. Variation in and between groups was high.

Eight out of 30 goat kids under study suffered from health problems. Six of them died during the study. One of the GC kids died due to severe caprine arthritis, two of the CC kids due to unknown reasons and three of the AC kids due to lung problems, meningitis and unknown reason.

Discussion

In literature several values are mentioned as minimum value for serum GGC of goat kids. Sherman (1990) mentioned 5.0 g/L as minimum value, while O'Brien and Sherman (1993) suggested that a minimum of 12 g/L of serum GGC should be achieved in newborn kids to help insure good health and survival to weaning. The National Animal Health Service suggests a minimum of 5 g/L in calves and piglets and preferably 10 g/L gamma globulin. When serum GGC is lower than 5 g/L the passive immunity of the animal is insufficient (Counotte, 2007). Ten percent of the CC in this study and also ten percent of the AC kids had at 48 hours a serum GGC higher than 5 g/L, whereas all GC reached this level. 60 percent of the GC kids had at 48 hours a serum GGC higher than 12 g/L and none of the CC and AC kids reached this level.

Constant et al. (1994) showed that with good farm management low GGC does not have to cause mortality. Mortality in the goat kids in our study was higher than normally encountered at farm level. Probably due to frequent blood sampling and weighting the goat kids suffered a higher stress level than normally. Under these circumstances morbidity and mortality was the highest within the AC kids group, followed by the CS kids group. Only one kid died in the GC group.

Although not significant, GGC in the AC group was at 56 and 86 days higher than in GC and CC group (figure 1). At the age of a couple of days GGC in the blood of a goat kid is an indicator for passive transfer of immunity. When older, high GGC can be an indication that the kid has formed immunoglobulin against infectious diseases. Therefore a high GGC can be negative in that stage.

No effect of colostrum type on daily weight gain was found. Variation in weight gain was high. O'Brien and Sherman (1993) did also not found a relation between GGC and average daily weight gain.

Conclusions

Goat colostrum gives in general a higher serum GGC of goat kids than cow and artificial colostrum. For a successful passive transfer of immunity goat colostrum is necessary. When it is not possible to provide goat colostrum because of health reasons, cow colostrum seems to be the best alternative. In that case good farm management is even more important.

Acknowledgments

The authors thank Carin Lammes and Gerrit and Carla Verhoeven for their substantial contribution to this research.

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Control of bovine sub-clinical mastitis by using herbal extract during lactation

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Key words: sub-clinical mastitis, phyto-derived, dairy cow

Abstract

Objective of the study was to evaluate the effects of feeding administration of herbal extracts for the control of bovine subclinical mastitis during lactation. A total of 36 Italian Friesian lactating cows with subclinical mastitis were randomly divided into three homogeneous groups: phyto-treated group, placebo-treated group, and control group. In phyto-treated group, cows received 5 gr. of standardised fluid extract of Spirea ulmaria L. and 6 gr. of standardised extract of Astragalus membranaceus BUNGE, administered orally as complex once daily for 15 days. Milk samples were collected from the mammary quarters before the beginning of the experiment, and then 14, 28 and 56 days after for analysis of bacteria, and somatic cells count (SCC). Milk flow and production were also recorded. The treatment positively influenced the health status of mammary glands, resulting particularly effective against Coagulase Negative Staphilococci. A reduction of infected quarters was highlighted in treated group (16.7% vs 30.2% and 37.5%, respectively in control and placebo groups; P<0.05). Further studies are needed to ascertain some aspects of herbal extracts action in ruminants and their effectiveness in different experimental and practical conditions.

Introduction

Subclinical mastitis represents one of the most severe and common disease in dairy cow farming, affecting animal health and profitability (Fetrow et al.2000,). Mastitis therapy accounts for very large proportion of antibiotic drug use in dairy production systems (Sawant et al. 2005). The usage of antibiotics is not totally effective in curing all types of existing udder infections during lactation (Erskine et al.,2003), and it results highly expensive due to the cost of treatments and to the sub-sequent withdrawal time. Moreover the usage of antibiotics during lactation increases the risk of residues in milk and dairy products (Hady et al. 1993) and there are global concerns for the development of antimicrobial drug resistance (Witte, 1998; Ungemach et al., 2006). The EU- Regulation (1804/99) suggests complementary therapies, such as homeopathic and phyto-derived remedies, to treat animals reared under organic farming, in preference to allopathic chemically synthesised products. Such alternative medical approaches are under debate, either from a scientific point of view, due to the scarcity of appropriate and comparable research trials, or from a practical point of view, since their efficacy and validity is not always reproducible. The aim of the present work was to evaluate, in field conditions, the efficacy of herbal extracts for the control of dairy cow sub-clinical mastitis.

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Material and methods

The study was carried out in a commercial dairy cow farm located in the province of Roma. For a preliminary check of mammary glands status, individual quarter milk samples from 80 Italian Frisian lactating cows were collected 15 and 7 days before the beginning of the experiment, to determine somatic cell count (SCC). Thirty-six cows with two consecutive SCC over 200.000 cell/ml in at least one quarter and no evidence of clinical mastitis were considered affected by sub-clinical mastitis (Bradley and Green, 2005) and selected for the trial. Three groups of twelve cows were randomly formed, balanced for days in milk and parity: phyto (PH) (days in milk 177 ± 22, parity 3,7 ± 0,48), placebo (P) (days in milk 161 ± 27, parity 3,5 ± 0,44), and control (C) (days in milk 169 ± 23, parity 3,1 ± 0,46). Cows from PH group received 5 gr. of standardised fluid extract of *Spirea ulmaria* L. and 6 gr. of standardised extract of *Astragalus membranaceus* BUNGE (Biorama), administered orally as complex once daily for 15 days. Cows from P group received the same quantity of physiological solution. Herbal extract and physiological solution were given orally using a disposable syringe. For animals treated with herbal extract, a precautionary withdrawal time of 18 days was planned (15 days of trial, and 3 days after). Aseptic milk samples were collected from quarters of each cow during the evening milking at day 1 (beginning of experiment), and then after 14, 28, and 56, according to the International Dairy Federation guidelines. All samples were processed for bacteriological analyses. A portable milkmeter Lactocorder (WMB AG, CH Balgach) was used to record milk production and to measure milk flow. Milks samples (10 µl) were spread on blood agar (5% defibrinated bovine blood) and Edward's medium modified plates. The plates were incubated aerobically at 37°C and examined for growth after 24 and 42 h. Mastitis status of milk samples was determined by diagnostic procedures recommended by National Mastitis Council (National Mastitis Council, 1987). Milk samples were analysed for somatic cells content (SCC) by fluoro-opto-metric method with Fossomatic 5000 (Foss Electric, HillerØd, Denmark). Data analysis was performed by using Chi-Square and Student-t statistical significance tests (MedCalc, 2006). Results were considered statistically significant when $p<0.05$. Results are presented as mean ± S.E.M.

Results

During the entire period, none of the cows showed clinical signs of mastitis. The most prevalent pathogens were environmental streptococci,mainly Streptococcus uberis and Streptococcus dysgalactiae, isolated in 109 quarters (55,6%). Coagulase negative staphylococci (CNS) were isolated in 76 quarters (38,8 %), while Staphylococcus aureus was isolated only in 6 quarters (3,1%). The prevalence of Gram negative bacteria was very low (5 quarters, 2,5 %). At the beginning of trial, 16 quarters (32.7 %) resulted infected in PH group, 20 quarters (41,7 %) in P group, and 17 quarters (35,4 %) in C group. In PH and P groups two cows showed infection by S. aureus in a single quarter. Percentage of quarters infected resulted quite variable during the trial. The bacteriological status did not differ significantly among groups at day 0, 14, and 28, while a significant ($P<0.05$) reduction of quarters infected was observed in PH group at the end of the experiment (day 56) (Table 1).

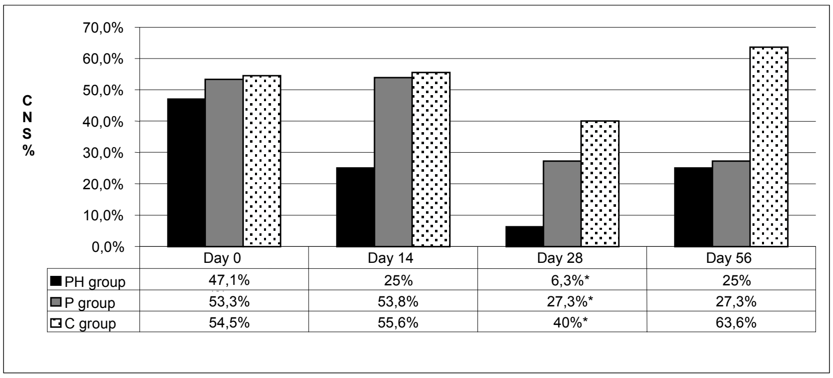
Tab. 1: Relative percentage of quarters infected during the experiment

	PH group	P group	C group
Day 0	32.7	41.7	35.4
Day 14	23.1	36.1	25.0
Day 28	28.6	30.6	13.9
Day 56	16.7(*)	37.5(*)	30.6

(*) P<0.05

Considering single species of intramammary gland pathogens, an average reduction of infections induced by CNS was observed in PH group (figure 1), with lowest values (P<0.05) at third control (day 28). No differences among groups were detected for infection induced by environmental streptococci. Quarters infected by S. aureus, at 28 and 56 days after treatment resulted negative in PH group, while remained positive in P group.

Figure 1: relative percentage of quarters infected by CNS during the experiment



(*) P<0.05

The phyto-derived treatment induced in PH group a progressive, but not significant, reduction of SCC in the quarters infected (table 3). A variable trend of SCC was observed in P, and C groups.

Tab. 3: Mean values ± E.S. of SCC in infected quarters during the experiment.

	PH group (SCCx1.000/ml)	P group (SCCx1.000/ml)	C group (SCCx1.000/ml)
Day 0	2.030 ± 1.159	430 ± 131	3.944 ± 2.254
Day 14	1.185 ± 513	640 ± 415	862 ± 676
Day 28	482 ± 117	2.038 ± 1.483	1.837 ± 1.495
Day 56	426 ± 198	942 ± 468	1.567 ± 1.484

Regarding milk production and milk flow parameters, better results were observed in PH group, although non significant. In detail, at the end of trial the milk yield resulted higher in PH group (10,73±0.83 kg,), compared with P group (10,68±0.82 kg) and C group (10,16±0.82 kg). The average milk flow during time resulted greater in PH group

(2,56 ±0.12 kg/min), than in the P group (2,29 ±0.12 kg/min) and C group (2.32 ±0.15 kg/min).

Discussion

Results obtained from the study indicate beneficial effects of phyto-derived remedies against subclinical mastitis of lactating dairy cows, particularly against forms caused by CNS. Our data are not comparable with results obtained by other authors, due to differences in active compounds chosen for the experiment. The positive effects may be related to the specific anti-inflammatory actions of *Spiraea ulmaria L*., and immunomodulatory actions of *Astragalus membranaceus BUNGE* (Campanini, 2004). The scarcity of results against environmental streptococci, highlighted also in previous experiments with intramammary antibiotic therapy (Bramley,1997), is probably due to the presence of chronic unresponsive infections. For a perspective of application in the livestock farming system, potential useful herbal extract need to be properly assessed for quality of production, concentration and use. The process of licence should also evaluate specific withdrawal periods.

Conclusion

Phytotherapy may represent, together with other complementary therapies, an useful tool to control the incidence and negative effects of subclinical mastitis in lactating dairy cow. Phytotherapy can not substitute the application of good management practices, such as a good health program to enhance animal health and welfare. Further studies are needed to ascertain effectiveness in different experimental and practical conditions.

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Mastitis incidence and milk quality in organic dairy farms which use suckling systems in calf rearing

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Key words: udder health, suckling systems, mastitis, somatic cell count

Abstract

In order to identify important factors influencing animal health and general disease resistance, detailed qualitative and quantitative farm data were collected from 99 organic dairy farms in the Netherlands. Mastitis incidence and milk quality were focal points of the data collection. In this paper the results of a group of farms which rear dairy calves in suckling systems (n=11) are presented. It was found that compared to other farms in the study (n=88), suckling systems in calf rearing had no clear adverse effects on mastitis incidence and milk quality. In 2006 average clinical mastitis incidence on suckling farms was 14%, on other farms 20%. The percentage of cows with a somatic cell count less than 250,000 at drying-off was lower (60 vs. 66%) at suckling farms. Also immediately after calving the percentage of cows with a somatic cell count less than 250,000 was lower (65 vs. 75%) on suckling farms. Between other farms and suckling farms, but also within suckling farms, distinctively different attitudes to disease management prevailed. Most suckling farms recently introduced suckling systems in calf rearing. Only 1 or 2 generations of suckled heifers had been introduced into the herds up to now. In order to judge whether suckling systems have a potential to improve udder health in future dairy herds, evaluation should be carried out again once suckled heifers constitute the majority of the herd.

Introduction

Farmers consider mastitis and high somatic cell count (SCC) in milk the most important health related issues which cost them money in terms of production loss and rejection of marketable milk. Also in organic dairying, curative treatment with antibiotics is an important treatment of udder infections. In organic dairying the use of antibiotics is bound to strict regulations. Moreover, farmers are stimulated to decrease the use antibiotics.

The search for alternative strategies to improve udder health is important. Wagenaar and Langhout (2007a, 2007b) described how some farmers try to decrease mastitis incidence and high SCC by rearing calves in suckling systems. By exposing calves to farm specific germs in early life, farmers expect the calves to have fewer problems with mastitis and SCC once they become dairy cows. Besides, suckling calves frequently "milk" their mothers, which might have a direct positive effect on udder health.

This paper describes mastitis incidence and milk quality in organic dairy farms which use a suckling system in calf rearing. The collected baseline information will be used for future evaluation of dairy cows raised in suckling systems.

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Materials and methods

All 350 organic dairy farms in the Netherlands were approached to participate in a study on animal health and general disease resistance. One hundred and thirty farms responded and provided basic data, including data on calf rearing, mastitis incidence and milk quality. They also gave permission to access digital farm data e.g. production and milk quality records and breeding data. Out of 130 respondents, 32 farms indicated they allowed calves to suckle their dams or a nurse cow after birth. Out of these 32 farms only 11 qualified for the “suckling” group. Qualifying farms applied a suckling system which allowed calves to suckle for 75 to 105 days after birth (on average 3 months), started using the suckling system before 2005 and had digital farm data over the period 2004-2006 readily available. From the remaining responding farms, 88 qualified to serve as a reference group (“other”).

A questionnaire was developed to collect additional quantitative and qualitative information from the selected farms, e.g. information on animal health and treatments. The questionnaire was completed by a researcher during a 3 hours farm visit. Up to October 2007 fifty questionnaires (farms) were completed, including all 11 “suckling” farms. Available data and information were processed and analysed.

Results

No big differences in cow breed exist between the 2 groups of farms. In both groups the main breed is Holstein Frisian (75%), in the “suckling” group followed by Blaarkop (7%) and in the “other” group by MRY (7%). Jersey, Brown Swiss, Flekvieh, Belgian Blue and Montbeliarde are also present, but make up less than 4% of the herd.

In table 1 the average production performance in the period 2004-2006 is presented. There is a clear difference between the milk yield of “suckling” farms (n=11) and “other” farms (n=88). Because some farms use nurse cows in suckling, milk consumed by calves only partly explains the difference.

Tab. 1: Average lactation information: milk yield, fat and protein, 2004-2006

Farm type	N cow	Days	Kg Milk	Kg FPCM	% fat	% protein
Suckling	1301	399	6534	6481	4.44	3.53
Other	10989	351	7479	7146	4.36	3.43

In 2006 average clinical mastitis incidence in “suckling” farms was 14% ± 6.3%. On “other” farms this was 20 ± 13.9%. Farmers said they treat animals with clinical mastitis with antibiotics (30%), homeopathy (30%), frequent milking and/or manual milk removal (30%), mint cream (5%) or drying-off the infected quarter (5%).

Cows with a SCC of more than 250,000 cells per ml of milk are considered to have a high SCC. In the period 2004-2006 on average 28.1% (± 8.0%) of the cows on “suckling” farms had a high SCC. For “other” farms this was 22.5% (± 6.4%).

Table 2 presents the average SCC of cows in the last milk recording pre-drying and the first milk recording post-calving for the different SCC classes in the period 2004-2006. The data give an indication how animals from different SCC categories get through the dry period. Table 2 shows that a higher percentage of cows from “suckling” farms are found in the higher SCC classes (>250,000), both before and after the dry period. In the category 250,000-500,000 the dry period has a positive effect on SCC, in the category above 500,000 a negative effect.

Compared to cows, heifers had lower SCC in first milk recording post-calving: 84 ± 12.4% and 87 ± 6.3% for "suckling" and "other" respectively. At the "suckling" farms the difference between heifers and cows was larger than at "other" farms.

Tab. 2: Average percentage of cows per SCC class pre-drying and post-calving in the period 2004-2006

SCC-class		<250,000		250,000-500,000		>500,000	
Period	N cow	Dry	Calving	Dry	Calving	Dry	Calving
Suckling	1301	61	66	28	16	11	18
Other	10989	66	75	22	11	12	14

Only 3 out of 11 "suckling" farmers said to treat animals with high SCC before drying-off. In 2006 they on average treated 8% of the cows before drying-off using antibiotics (35%), super mastidol (30%), milk removal (30%) and homeopathy (5%).

Figure 1 shows the average SCC in bulk tank milk of "suckling" and "other" farms. "Suckling" farms on average have a higher bulk tank milk SCC.

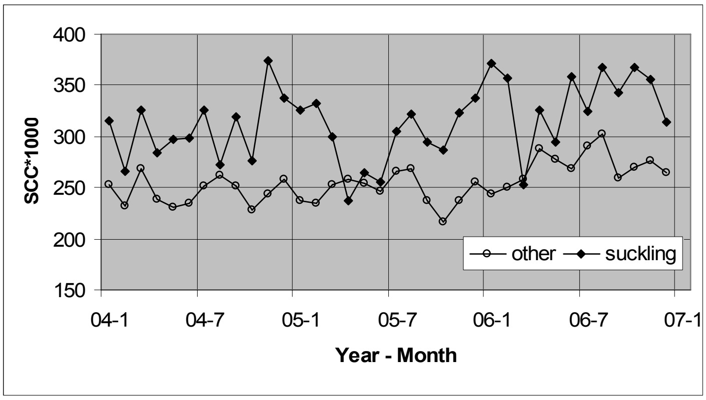

Figure 1: Average SCC in bulk tank milk

Discussion

Although attempts to come up with effective alternative treatments improve udder health are plentiful, progress is slow. In a Swiss study (Klocke *et. al.*, 2006) two antibiotics reduction measures, a teat sealer and homeopathic treatment, were not found to effectively treat mastitis. Smolders (2007) described animal health and management on organic farms which do not use antibiotics in the Netherlands. He concluded that, depending on the farmer's attitude to preventive measures, housing and feeding, many farmers should be able to drastically reduce the use of antibiotics.

Because of the multi-factorial nature of mastitis, it is not easy to identify single factors determining mastitis incidence in a wide range of practical dairy farms. Also in this study it became clear that farmers use different strategies or different combinations of measures to avoid problems with mastitis and high SCC. While not all elements of a strategy might work, farmers always have 1 or 2 elements that do something towards controlling high SCC. Farmers and veterinarians should focus on these positive elements in further attempts to adjust the strategy to tackle high SCC.

It should be realised that farmers do not use one standard suckling system in calf rearing, but adapt a suckling system to their own need and situation. Compared to the attitude of farmers on “other” farms, the attitude of farmers on “suckling” farms towards animal health and welfare, preventive measures and treatment therapies could also be fundamentally different. But also between “suckling” farmers attitudes differ. This becomes clear if we look at the way “suckling” farmers treat mastitis or high SCC before drying-off. While some farmers are persistent in not using antibiotics, others consequently do use antibiotics. This complicates the evaluation of suckling systems.

Conclusions

Based on the results presented in this paper it is hard to judge whether suckling systems have a potential to improve udder health in future dairy herds. Udder health and milk quality on “suckling” farms are not as good as on “other” farms. It is however too early for evaluation. Most “suckling” farms started a suckling system between 2004 and 2005 and are now introducing second and third generations of heifers into their herds. The increasing number of cows raised in suckling systems over the next couple of years, will improve the circumstances to evaluate the full potential of suckling systems. While evaluating calf rearing systems, farmers’ attitude towards dairy management in general and animal health in particular, should be included.

Acknowledgments

We would like to thank all the farmers that participated in our study.

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Dry cow therapy in an organic dairy herd of a milk and a dual purpose breed

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Key words: mastitis, dry cow therapy, monitoring udder health

Abstract

According to the EU-Regulation for organic farming breeds chosen for the organic production should have the capacity to adapt to the local conditions to reduce the risk of diseases. The study compared the udder health status and the necessity of application of dry cow therapy (DCT) on cows of a dual purpose and a milk breed (Red and White Holsteins vs. Holstein-Friesian) kept under the same management conditions. Data records of one and a half year and 49 cows were analysed. 132 of 203 udder quarters were treated with an antibiotic at drying off. The treated quarters had significant higher readings for electrical conductivity, California Mastitis Test and the somatic cell count during lactation than the untreated group. Red and White Holstein cows received significantly more often a DCT than Holstein-Friesian cows. Thus, the results of our study do not support the presumption that older breeds are more robust against diseases and therefore fit better into organic dairy farming. Discussions about this topic should consider that the term "local condition" includes not only the climate but also the management conditions of the organic dairy farm.

Introduction

Mastitis is still an important disease in organic dairy production and antibiotic dry cow therapy (DCT) is an effective method to avoid intramammary infections during the dry period. However, organic dairy farming aims to reduce the use of drugs, especially allopathic products, and prophylactic antibiotic treatment of animals is not permitted. DCT is limited to cows with symptoms of mastitis: an increase of the somatic cell count (SCC) in the milk or pathogens cultivated in an aseptically gained fore-milk sample. One recommendation given by the EU-Regulation (No. 2092/91) to prevent diseases is to choose adapted breeds for the organic production. In this context, the presumption that older breeds better fit in the organic system than the high yielding breeds used in conventional farms is widely spread. This study compared DCT applied to a dual purpose and a milk breed.

Materials and methods

The investigation was carried out at the experimental organic farm of the Institute of Organic Farming, Trenthorst. The dairy herd contains cows of two breeds: Holstein-Friesian (HF) and the dual purposed type of Red and White Holsteins (RW). The breeds are kept separate in identical cubicle housing systems and under the same management conditions. In 2006 the mean milk yield per cow and year was 5,596 kg and 4,937 kg for the HF and the RW, respectively.

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Cytobacteriological analyses of quarter foremilk samples were carried out according to the standards of DVG (2000) during the first ten days after calving and three times per year. Electrical conductivity (EC) of quarter foremilk prior to milk ejection was measured monthly by means of a handheld conductometer. After EC measurement the California Mastitis Test (CMT) was carried out using the same sample. All data relevant for the health status of the udder quarters of each cow were documented and were used for the decision whether a cow would receive a DCT or not. Cows with at least one positive result of all cytobacteriological analyses and/ or high somatic cell counts (SCC > 100,000 cells per ml) recorded for at least one quarter were selected for DCT. In addition, cows with a high variability of EC readings were treated, too. Animals were dried off 45 days minimum prior to the expected date of calving.

Orbenin-DC (Cloxacillin, Pfizer AG) was used for the DCT. Each quarter of the cow was treated regardless of the health status of that particular quarter. Cows which fulfilled the requirements of drying off without treatment received no other treatments. Milking was cut off at the calculated day for drying off. During the dry period the cows were kept within the herd, moved two times per day through the milking parlour but no teat dipping was carried out.

All cases of dry off between January 2006 and July 2007 were included in the statistical analysis which was carried out using SPSS 12.0 for Windows®. The means of EC, CMT results and SCC (common logarithm) for the lactation were calculated. The results of the cytobacteriological analysis after calving were evaluated following the standards of DVG.

Results

Data of 49 cows (54 lactations) could be included in the analyses. Five cows were part of the study twice. Most of the cows were in their second and third lactation (table 1) and on average at the 372nd and 331st day of lactation (DIM) HF and RW, respectively. The dry period lasted 55 and 67 days on average for the HF and the RW, respectively.

Tab. 1: Frequency of the lactation numbers depending on the breed

	Number of lactation			
	1	2	3	4
Holstein-Friesian (n = 28)	4	11	14	2
Red and White (n = 21)	2	14	7	-
Total (n = 49)	6	25	21	2

132 quarters were treated with the antibiotic. RW cows were significantly more often treated than cows of the HF breed ($\chi^2 = 4.273$, $p = 0.05$, table 2). The RW cows had higher EC readings and were higher scored at the CMT. There were no significant differences of SCC between the breeds. As expected, the lactation means of EC, CMT and SCC were different for the treated and untreated animals (table 3).

Tab. 2: Frequency of udder quarters with or without DCT

	without treatment	DCT	Total
Holstein-Friesian	47 (41.6 %)	66 (58.4 %)	113 (100.0 %)
Red and White	24 (26.7 %)	66 (73.3 %)	90 (100.0 %)
Total	71 (35.0 %)	132 (65.0 %)	203 (100.0 %)

Tab. 3: LSM of data used for the decision on application of DCT

	DCT	Holstein Friesian	Red and White
EC [mS cm^{-1}]	without	$6.0 \pm 0.1^{a,A}$	$6.3 \pm 0.2^{b,A}$
	with	$6.4 \pm 0.1^{a,B}$	$6.8 \pm 0.1^{b,B}$
CMT Score	without	$0.2 \pm 0.1^{a,A}$	$0.6 \pm 0.2^{b,A}$
	with	$0.9 \pm 0.1^{a,B}$	$1.2 \pm 0.1^{b,B}$
lgSCC	without	4.41 ± 0.08^{A}	4.56 ± 0.11^{A}
	with	4.86 ± 0.06^{B}	5.04 ± 0.06^{B}

^{a,b} significant differences ($p=0.05$) within the row; ^{A,B} significant differences ($p< 0.05$) within the column

Pathogens were revealed at least once during the lactation in milk samples of 67 quarters, these are 33 % of all quarters. In 49 cases the infection was caused by coagulase-negative staphylococci (CNS). *Staphylococcus aureus* was found in 8 quarters. After calving in 163 samples (80 %) no pathogen could be detected. In 10 quarter samples *S. aureus* was present, 6 of these quarters had no infection during the previous lactation. CNS were detected in 18 of the 40 positive tested samples. Streptococci were of little importance in this herd.

Although the number of normal secreting quarters was reduced after the calving in the non-treated group (table 4), the calculation of Odds ratio revealed no effect on the incidence of suspicious quarters due to the omission of DCT. The antibiotic was successfully applied in the RW-herd where 32 of 47 quarters showed a normal secretion after calving.

Tab. 4: Frequencies of quarters with normal secretion* and quarters suspicious for mastitis or latent infection before and after the dry period**

			previous lactation			
			Holstein Friesian		Red and White	
			normal	suspicious	normal	suspicious
after calving	without DCT	normal	24	3	14	5
		suspicious	15	5	4	1
	with DCT	normal	25	13	13	32
		suspicious	12	16	6	15

*No pathogen detected and SCC ≤ 100,000 cells per ml
**Pathogen detected and/ or SCC > 100,000 cells per ml

Discussion

Although a rating of breeds should base on a broader data set, the comparison of breeds under the same management and environmental conditions offer the opportunity to keep the influence of these conditions as equal as possible. Thus, our results can only extrapolated to animals kept under the conditions of a relative intensive organic dairy production: animals had no access to the pasture, but to a free-range area located between the feeding and the lying area.

The observed differences of the mean EC and CMT readings during lactation might be explained by the shape of the udders. The udders of HF cows had a better form than that of RW cows. In case of machine milking this is an advantage, which should not be underestimated. The risk of milk droplet impacts caused by vacuum fluctuations during milking increases with uneven udder halves or quarters, and vacuum fluctuations or sudden air admission lead to a higher risk of intramammary infections (Baxter et al. 1992). In addition, twisted milking units may lead to tissue damages and increasing EC readings during lactation (Barth, 2005).

The increased number of suspicious quarters after calving in the non-treated group points to new infections which occurred during the dry period or a few days *post partum*. However, some of the healthy quarters treated with the antibiotic showed symptoms of subclinical mastitis or a latent infection after calving, too. Thus, in this study, DCT did not protect healthy quarters against an infection if the evaluation is based on udder quarters. Berry et al. (2003) investigated the interdependence of quarter and recommended the application of dry-cow strategies at the cow and not at the quarter level to limit the risk of healthy quarters of a cow with mastitis to become infected.

A second reason that DCT failed in the HF group, might be the great number of quarters with unspecific mastitis. The use of another strategy such as the application of an internal teat sealant might offer a solution.

Conclusions

The presumption that older breeds are more robust against diseases and therefore fit better into organic dairy farming can not supported by the results of this study. More research on this field is strongly recommended. The capacity of animals to adapt to local conditions should be discussed not only from the point of the origin of the breed but should also take into account the management conditions and accordingly the type of organic farm where the animals are kept.

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Incidence of anthelmintic resistance in cattle farms in Northern Germany – first results

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Key words: animal health, cattle, animal husbandry and breeding, gastro-intestinal nematodes

Abstract

Anthelmintic resistance (AR) is an increasing problem worldwide especially for small ruminants and it is also rising in cattle. To maintain the efficacy of anthelmintics is an important objective. The current project aims at the investigation of the current efficacy of macrocyclic lactone anthelmintics for strongylid nematodes in first season grazing (FSG) calves in Northern Germany. On 8 participating farms in Northern Germany faecal egg count reduction tests (FECRT) with ivermectin (IVM) were performed. On 3 farms the efficacy of IVM was found to be ≤90% and on only 4 farms it was > 95% at 14 days post treatment (d.p.t.). Only 2 farms showed a reduction ≥ 95% at 21 d.p.t.. This survey reveals a rising problem of AR. The problem of drug resistance places the welfare of animals at risk. In organic farming, without a preventive treatment, livestock may harbour high worm counts. Therefore it is necessary to maintain powerful anthelmintic drugs to guarantee the welfare of animals that need salvage treatment. To investigate the AR problem in cattle more surveys with different anthelmintic drug classes are urgently needed.

Introduction

Animal husbandry on pasture requires a concept to avoid gastro-intestinal parasites. The main gastro-intestinal nematodes (GIN) in Northern Germany for FSG calves are the strongylids *Cooperia oncophora* and *Ostertagia ostertagi.* Depending on the level of infection GIN may cause parasitic gastroenteritis with apparent disease symptoms like diarrhoea, reduced feeding and significant production losses. Although optimized grazing management systems can contribute to lower pasture infectivity, the use of anthelmintics is still essential to control gastro-intestinal parasites in cattle.

AR in cattle has been reported mainly in the southern hemisphere. Reports showed resistance against benzimidazoles (Mejia et. al 2003) and macrocyclic lactones (Anziani et. al 2001, Waghorn et al. 2007). Until now in Europe AR was only described for IVM in England (Coles et. al 2001).

The object of this survey is to evaluate the efficacy of IVM against GIN in cattle in Northern Germany.

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Materials and methods

To evaluate the situation of IVM resistance FECRTs (Coles et al. 2006) were performed on 8 farms in Northern Germany in 2006. The participating farms had at least 24 FSG calves on pasture. The calves were naturally infected by grazing on pasture. During grazing season pooled faecal samples were collected in order to find the point of treatment. Once sufficient nematode egg counts were detected, the animals were treated. This day was called day 0. On 6 farms the mean EPG at day 0 was above 100, the other farms were included upon request of the farmers. The animals were treated by subcutaneous injection of 0.2 µg IVM (Merial) per kg body weight. The body weight was estimated by measurement of girth tape (chest circumference). Individual rectal faecal samples were collected from each animal prior to treatment.

A modified McMaster technique (Wetzel 1931 and Schmidt 1971) was used to obtain the faecal egg count, measured as eggs per gram fresh faeces (EPG). The animals with the highest EPG counts were included in the trial. For the FECRT about 10 - 15 calves per farm were tested after treatment. On day 14 and day 21 after treatment individual rectal faecal re-samples were taken and the EPG was determined. The reduction was calculated for this group.

Results

The results of the FECRT using IVM at day 0 of FSG calves in the year 2006 are shown in table 1.

Tab. 1: FECRT data (the data were calculated by the program „Bootstreat“, from Jacques Cabaret as part of the EU-Project PARASOL, in preparation)

Farm	No. of calves on farm	No. of test-calves	EPG of test-calves			Faecal Egg Count Reduction in % (lcl) in test-calves	
No.	n	No.	day 0			day 14	day 21
			arith. mean	min	max		
1	34	11	185	100	533	96 (91-100)	95 (88-98)
2	34	15	950	600	2000	90 (83-98)	84 (72- 95)
3	30	10	137	67	180	97 (90- 100)	94 (88-100)
5	39	10	40	0	100	87 (68- 99)	81 (66-94)
6	25	10	193	100	500	98 (96-100)	94 (88-100)
7	33	10	146	100	266	91 (82-98)	93 (83-99)
8	35	10	58	33	100	69 (34-82)	35 (-18-66)
9	24	16	107	67	150	100	96 (89-100)

Further statistic analysis will be published in association with the data analysis of the EU- Project PARASOL.

On day 14 post treatment at three farms the reductions were only 90% or less. On 4 farms the reduction on day 14 was below 95%. This is a sign of reduced efficacy of IVM on these farms.

Discussion

According to the guidelines of the World Association for the Advancement of Veterinary Parasitology (Coles et al. 1992) AR is present, if FECRT results are < 95% and the 95% confidence level is < 90%.The present data suspect the onset of IVM-resistant gastro-intestinal nematodes in Northern Germany. The results confirm with the notice that the importance of AR has increased dramatically in nematodes (Coles et al. 2006). Since no new drug classes can be expected to be commercialized in due course, it is important to maintain the efficacy of the current anthelmintics.

To postpone the development and spread of resistance some options are pointed out (Coles et al. 2001, Koopmann et al. 2007). A possible approach could be Targeted selective treatment (TST) strategies . TST means that only a part of the animal group is treated with anthelmintics, contrary to the current manner to treat the whole group. Through TST the use of anthelmintics can be reduced and selection pressure on susceptible endoparasite isolates decreases.

Conclusions

The results of this survey indicate that resistance against macrocyclic lactone type drugs in cattle may occur more often in the northern hemisphere than currently expected. Further surveys involving larger sets of farms and compounds from different anthelmintic drug classes are urgently needed.

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Effects of red clover and maize silages on the carriage of gut pathogens in steers

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Key words: Red clover silage, maize silage, pathogens, cattle, faecal shedding

Abstract

An experiment investigated the effects of increasing proportions of red clover (RC) (Trifolium pratense) silage relative to maize (M) (Zea mays) silage in the diet of steers on the pathogenic microflora of gut digesta and faecal samples. The experiment consisted of 3 periods of 21 d. Eight Hereford x Friesian steers were used, with 4 maintained on a 90 % maize: 10 % red clover (90M:10RC) silage diet throughout and 4 receiving 90M:10RC silage in period 1 then 50M:50RC, 10M:90RC in periods 2-3, respectively. Populations of Listeria monocytogenes and E. coli were enumerated at time points in each period. L. monocytogenes data showed disparity between periods. In the latter part of period 2, L. monocytogenes populations were higher in the rumen, duodenum and faeces of steers offered 50M:50RC but in period 3, L. monocytogenes populations were lower in the faeces of steers fed the higher level of red clover silage ($P < 0.05$). Despite negligible E. coli levels in the diets, populations of E. coli, including E. coli 0157, were detected in the steers throughout the trial. Diet effects on E. coli levels were not apparent at any of the three sites examined. Further research is needed to elucidate the effects of red clover and dietary pathogen load on gut and faecal pathogen populations.

Introduction

In agricultural systems, the use of manure and slurry may result in the contamination of land and water courses with pathogens, such as *Escherichia coli* and *Listeria*. These pathogens may then be transferred from contaminated forage and water to livestock, animal products and, thus, to humans. *Listeria monocytogenes* is the agent of listeriosis, a serious infection caused by eating contaminated food. This pathogen is a main contaminant of forage which can multiply during ensiling; therefore, silage feeding is a common route of infection for farm animals. Listeriosis is being recognized as an important public health problem as, in humans, the overt form has a mortality of greater than 25%. While infected animals rarely directly cause human infections, animal-derived food products (e.g., raw milk) and raw foods of plant origin, contaminated by manure from infected animals, represent links between human and ruminant infections (Nightingale *et al*., 2004). Research has found that up to 50% of faecal samples collected from ruminants with no clinical symptoms of listeriosis may contain *L. monocytogenes* (Ho *et al*., 2007).

Ruminants may be described as reservoirs of verocytotoxin producing *E. coli*, food-borne pathogens implicated in several outbreaks of disease in humans (US FDA, 1998). The commonest *E. coli* responsible for human disease in Europe is *E. coli*

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0157. Similar to *L. monocytogenes* infections, studies have shown that ruminants can harbour *E. coli* without any overt clinical signs (Kudva *et al*., 1996). In humans, infections can result from the consumption of contaminated beef and milk products, drinking and bathing water. In most instances, the source of contamination was faecal material (Phillips, 1999).

Studies have shown that dietary factors can influence pathogen shedding, with some evidence that red clover can reduce pathogen growth, possibily due to the action of secondary plant metabolites such as formononetin (Duncan *et al*., 2000). The aim of the current study was to determine the effects of increasing the proportion of red clover silage offered in the diet of steers when compared with maize silage on the subsequent shedding of *L. monocytogenes* and *E. coli* pathogens.

Materials and methods

Eight Hereford x Friesian steers (600 kg approx. weight) prepared with rumen and duodenal cannulae were offered a mix of a red clover (*Trifolium pratense*) silage (RC) and a maize (*Zea mays*) silage (M). The experiment was a continuous design consisting of 3 periods of 21 days. Four animals received 90M:10RC silage in period 1 then 50M:50RC and 10M:90RC in periods 2 and 3, respectively. The remaining four steers were maintained on the 90M:10RC diet throughout. Due to the simple nature of the diets, silages were switched with immediate effect at the end of each period, with no gradual changeover. Steers were housed individually and received their food in two equal feeds at 09.00 and 16.00. Refusals were removed before early morning feed and daily dry matter (DM) intakes were recorded. Samples of diets offered were accumulated weekly. Samples of rumen and duodenal digesta and faeces were collected prior to the morning feed on day 0, 1, 2, 4, 8, 16 and 21. All samples were incubated on agar plates following a series of dilutions to 10^{-3} in Ringers solution (Oxoid Ltd., Basingstoke, UK) and enumerated for *L. monocytogenes* using Listeria Isolation Medium (LAB M Limited, Bury, UK) and *E. coli* and *E. coli* O157 using Sorbitol McConkey with B.C.I.G. Agar (Oxoid Ltd., Basingstoke, UK). Data for one steer on the 90M:10RC treatment were excluded on account of antibiotic treatment in periods 2 and 3. Within period mean counts on days 16 and 21 were compared between the two groups of steers by one-way analysis of variance using levels in the preceding period as a covariate where appropriate.

Results

All diets showed *L. monocytogenes* counts in excess of 6.2×10^4 colony forming units (CFU) /g DM. *L. monocytogenes* counts for 90M:10RC, 50M:50RC silages were similar and 10M:90RC counts tended to be lower by a factor of 10. Taking DM intake into account, this resulted in steers offered 10M:90RC silage having a lower *L. monocytogenes* challenge compared with steers offered a 90M:10RC silage diet in period 3. *L. monocytogenes* populations in the rumen and faeces are presented in Figure 1. Trends in *L. monocytogenes* levels in the duodenum were broadly similar to those in faeces although less pronounced. Results showed disparity between periods. *L. monocytogenes* populations were higher in the rumen, duodenum and faeces of steers fed the higher proportion of red clover compared with maize silage in Period 2 ($P < 0.05$). In Period 3, *L. monocytogenes* populations were lower in the duodenum and faeces ($P < 0.05$) of steers fed the highest level of red clover. However, faecal shedding remained in excess of 10^5 CFU/g DM.

Silage contamination with *E. coli* pathogens was negligible. Only the 10M:90RC diet contained any *E. coli*, with counts of 2 and 4 CFU/g DM in the final two weeks of the experiment. *E. coli* 0157 was not detected in any of the treatment silages. Populations of *E. coli* pathogens, including *E. coli* 0157, were detected in the rumen, duodenum and faeces of steers within this experiment. However, data of *E. coli* populations were highly variable and no significant effects of diet were apparent.

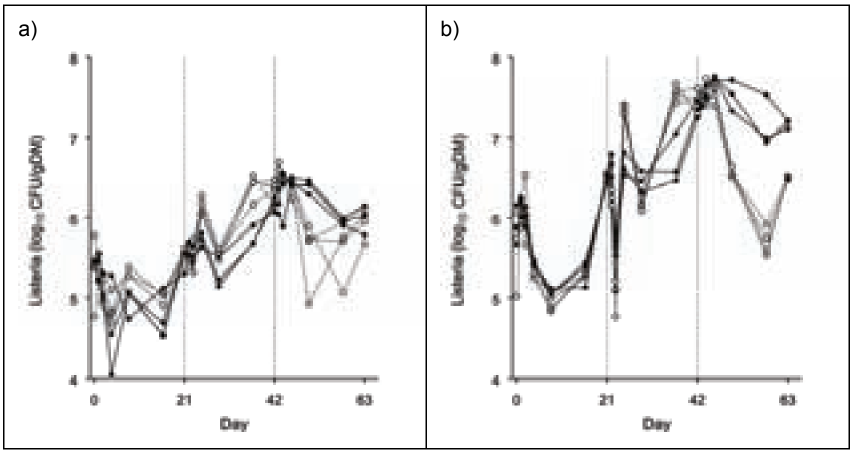

Figure 1: Populations of *Listeria* in a) rumen digesta and b) faeces from steers fed increasing proportions of red clover silage (denoted by open circles with broken lines) compared with steers receiving 90%maize:10% red clover silage. Vertical broken lines denote transitions between periods.

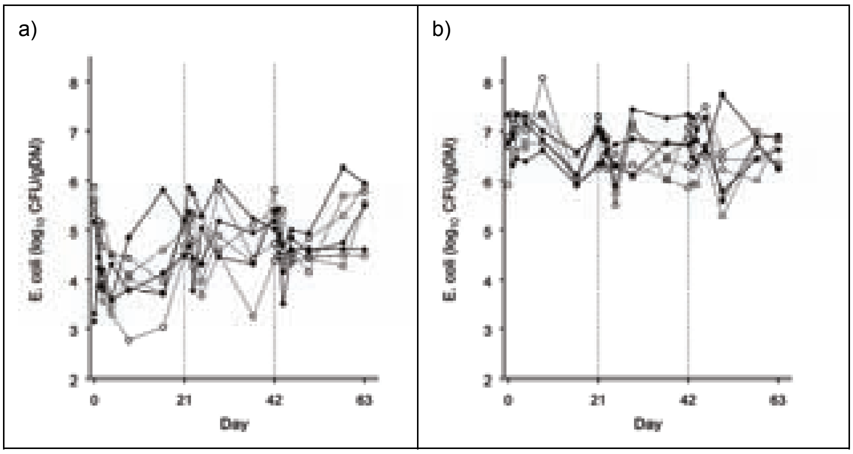

Figure 2: Populations of *E. coli* in a) rumen digesta and b) faeces in steers fed increasing proportions of red clover silage (denoted by open circles with broken lines) compared with steers receiving 90%maize:10% red clover silage.

Discussion

The results are in agreement with other studies showing that there are high levels of variation in the day-to-day shedding of *L. monocytogenes* and *E. coli* within the same herd (Ho *et al*., 2007). It appears that with respect to *L. monocytogenes*, the dietary pathogen load also had an impact on the shedding of this pathogen, as the low populations in the 10M:90RC silage resulted in fewer *L. monocytogenes* in the faeces on steers offered this diet. Overall, the transient nature of these infections may help to explain the disparity found in the results between different periods for the *L. monocytogenes* populations and the high variability observed for the *E. coli* populations with regards to the effects of diet on pathogen population numbers.

Conclusions

There are no clear indications from the findings in this study as to the dietary effects of red clover silage on the shedding of *L. monocytogenes* and *E. coli* from ruminant animals. Further studies are needed to determine the effects of red clover on *L. monocytogenes* and *E. coli* contamination during the ensiling process and to determine the dose-response effect of dietary pathogen load on pathogen shedding when different proportions of red clover are consumed.

Acknowledgments

The authors would like to thank Martin Leyland and Naomi Ellis at IGER Trawscoed for the care of the animals throughout these experiments. This work was carried out with funding from the EU framework VI QLIF project and the Department for Environment, Food and Rural Affairs, UK.

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Experiences of Veterinarians Using Acupuncture on Farm Animals

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Key words: Acupuncture, farm animals, veterinarians, Germany

Abstract

The aim of this study was to collect information about experiences of veterinarians with acupuncture. 27 German veterinarians who regularly used acupuncture on farm animals were interviewed. Most vets had received special training in acupuncture. This treatment method was most often used on horses, followed by cattle (mainly dairy cows). It was especially applied against common diseases which could easily be cured. Treatment costs were higher for horses than for cattle. There has been an increased demand for acupuncture mainly for horses.

Introduction

Acupuncture is a part of Traditional Chinese Medicine (TCM) which looks back at a 5,000 year old history. It is used to stimulate and strengthen the body's own healing mechanisms as well as to remove blockages or imbalances in the natural energy flow. This is done by sticking needles into so-called 'acupuncture points' along the body´s meridians.

In the Western world veterinarians started using acupuncture in the 1970s. They transmitted the concept of energy flow in meridians of human acupuncture to animals. This concept has never existed in the Traditional Chinese Veterinary Medicine.

With regard to organic agriculture, acupuncture could be an interesting issue. The IFOAM Basic Standards state that surgeons should use natural medicines and treatments, including homeopathy, Ayurvedic medicine and acupuncture whenever appropriate (no. 5.7). However, EU-regulations concerning organic agriculture do not mention acupuncture in particular. Hörning et al. (2004) and Rahmann et al. (2004) found that relatively few organic farmers in Germany make use of natural medicines. Leon et al. (2006) asked 358 organic farmers in this country if they used alternative treatments and medicine on their farm animals. More than 70% said they used homeopathy (mainly against mastitis) and about 40% used phytotherapy. Approx. 50% of farmers used homeopathy against 60% - 100% of all diseases. Phytotherapy was used by 60% of farmers against a maximum of only 20% of diseases. Information about acupuncture was not provided. The aim of this study was to collect information regarding experiences with using acupuncture on farm animals.

Materials and methods

Addresses of veterinarians were chosen from a list published by the *Gesellschaft für Ganzheitliche Tiermedizin* (Society for Holistic Veterinary Medicine). 80 of the 194 vets listed carried an additional title called 'veterinary acupuncture' (special training).

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A total of 27 veterinarians who had treated farm animals with acupuncture needles were interviewed. More vets could either not be contacted (n = 71), they were not interested in participating (6) or used acupuncture only on pets (90). Telephone interviews were carried out in May and June 2007 (by Benjamin Brandt, BA thesis).

Results and discussion

The interviewed veterinarians lived in 8 of the 16 federal German states. In Germany vets can enrol for a variety of courses in acupuncture. 77.8% of veterinarians had completed special training classes in veterinary acupuncture offered by the *Akademie für tierärztliche Fortbildung (ATF*). Another 11.1% of them had studied acupuncture at the International Veterinary Acupuncture Society (IVAS). Max. 1 to 2 vets had chosen other educational institutions of lesser importance for their training. The training had lasted between 1 to 6 years. The veterinarians had on average 11.3 years of experience with using acupuncture (range 3 years – 30 years, s = 6.54) (fig. 1).

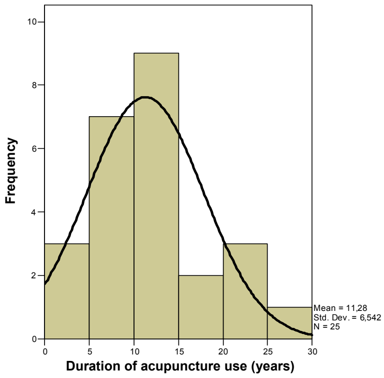

Figure 1: Experience with acupuncture (years)

88.9% of the veterinarians used acupuncture on horses, 70.4% on cattle, 22.2% on pigs, 18.5% on sheep and 3.7% on poultry. Acupuncture was mainly used on animals with a high individual economic value, e.g. dairy cows. 70.4% of vets treated horses most often, followed by cattle at 18.5% (3.7% of vets: half cattle and half horses). Eight veterinarians stated that they mainly used acupuncture on conventional farms. Only one vet used this treatment more often on organic farms. Six other veterinarians said that about 25% of the farms to which they were called for acupuncture treatments (1% – 75%) were organic ones. 12 veterinarians could not answer the question. Obviously, most veterinarians did not specialize in the veterinary care for organic farms. This could be explained by the fact that most organic farmers seek the help of regional veterinarians who have no experience with natural medicine. However, another reason could also be that organic farmers themselves were not familiar with acupuncture treatment and therefore were not asking for this special method, either.

Vets were asked about diseases which they frequently treated with acupuncture (tab. 1). Acupuncture was used against many common health disorders, depending on the species.

Vets were asked about the success of acupuncture treatments with regard to different diseases. They either gave purely qualitative answers ("good", "very good", etc.) or considered the therapeutic success by means of percentage of treatments. The second number in table 1 includes statements for 'good', 'very good' or treatment success of 50% or better (most estimates were at least 80%). Veterinarians most often used acupuncture against those diseases which responded well to this treatment method and showed high rates of recovery. Some vets successfully combined acupuncture treatments with other alternative methods such as homeopathy and phytotherapy. Vets were asked about average treatment costs. Rates for German vets stipulate € 12.78 per acupuncture treatment. However, costs quoted by the vets differed between species. Most treatment costs for horses averaged € 70 – € 90 and for cattle € 25 – € 50. For pigs and sheep there were only 1 – 2 statements (fig. 2).

Tab. 1: Number of diseases frequently treated with acupuncture (1st number) and its therapeutic success (2nd number)

	Horses	Cattle	Pigs	Sheep	Poultry
Lameness	17 / 16	1 / 1			
Locomotor disorders	10 / 10				
Laminitis	4 / 4				
Back problems (Azoturia etc.)	11 / 10				
Reproductive disorders		6 / 2		2 / 1	
Obstetrics		14 / 13	4 / 2	4 / 3	
Prolapse of the uterus		5 / 4			
Mastitis		6 / 5		3 / 3	
Respiratory disorders	7 / 6				
Coughing / chronic coughing	14 / 11				
Pneumonia	6 / 5				
Colic	6 / 5				
Skin diseases	6 / 5				
Metabolic disorders	5 / 3	7 / 7			
Inappetence		2 / 2		2 / 2	
Displacement abomasum		1 / 1		0 / 1	
Back muscle necrosis			1 / 1		
Allergies	5 / 5				
Infectious diseases					1 / 1

59.3% of vets have observed an increase in the demand for acupuncture treatments during the last two years. The percentage was higher for vets who only treated horses with acupuncture needles. This could perhaps be related to a growing interest in leisure riding.

Conclusions

Acupuncture treatments on farm animals are not very common in Germany. With regard to horses acupuncture is most often used on riding horses, as far as cattle is concerned it is most often used on dairy cows.

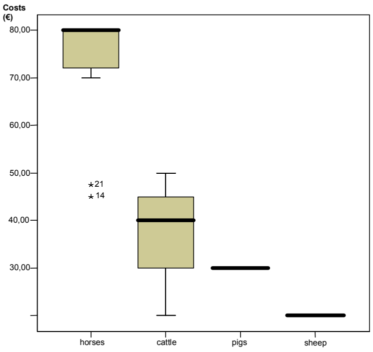

Figure 2: Costs for acupuncture application (€ per treatment)

One reason for this could be high treatment costs. Acupuncture is used against many common health disorders. Not surprisingly, vets most often used acupuncture against diseases which responded well to this treatment and exhibited high recovery rates. Information about diseases with lower recovery rates are not available. Because only those vets who frequently perform acupuncture treatments were included in this study it cannot be concluded that acupuncture in general works well. Further research is needed in order to compare acupuncture to other therapeutic methods.

Acknowledgments

We are grateful to and would like to thank all veterinarians who were willing to participate in this study.

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Growth performance of broilers fed with different strains of probiotics

Tarun, M.[1]

Key words: Broilers, probiotics

Abstract

Generally, this study aimed to determine the effects of different strains of probiotics on the growth performance of broilers. Specifically, to determine the effects of feeding different strains of probiotics on the growth performance of broiler and utilizing broiler chicks, An all mash ration with 21% CP was formulated. Completely Randomized Design (CRD) was used and Least Significant Differences (LSD) when comparing treatments; T_1-Control (0 Probiotics), T_2- 2 kg Lactobacillus sp./MT of feeds, T_3- 2 kg Bacillus sp./MT of feeds, and T_4-2 kg Pediococcus sp./MT of feeds. Statistical analysis revealed highly significant differences among treatments on the final body weight of broilers given diets with different strains of probiotics. Based from the result of the study, the inclusion of 2 kg Lactobacillus sp./MT of feeds in the diet of broilers had improved the growth of the experimental birds in terms of body weight, gain in weight, feed conversion and its economic returns due to the lactic acid content of Lactobacillus sp. The result obtained from this study suggest that inclusion of 2 kg of Lactobacillus sp. per metric tons of feeds can safely be used in the diet of broilers to produce an organically grown chicken for table meat as it produced the highest gain in weight, feed conversion and return above feed cost.

Introduction

Previous studies revealed significant performance of animals when probiotics was given instead of antibiotics. Probiotics is a live or dead non-pathogenic bacteria which could be used as feed additives to the diet of animals. These are bacteria that can compete with other bacteria to enhance and stabilize beneficial intestinal flora.Although, recently a study on the utilization of probiotics in Kabir chicken was undertaken, a follow-up study has yet to be conducted in order to validate the results made using the recommended levels. This study attempts to find out the effects of different strains of probiotics on the growth performance of broilers in terms of body weight, body weight gain, feed consumption, feed efficiency, mortality, dressing percentage and the economy of using probiotics, hence this study.

Materials and methods

Procurement of Stock. One hundred twenty straight-run day old Broiler chicks were purchased from a reputable dealer at Cauayan City, Isabela. The chicks were inspected for any deformities and health problems such as lameness, crooked legs and beaks, pasty vents and unhealed navels.

Formulation of Experimental Diets. All mash rations containing 21% Crude Protein was formulated for the study. The experimental diets were formulated using the

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following ingredients: ground yellow corn, soybean meal, fish meal, molasses, limestone, copra meal, salt, vitamin/ mineral premix and strains of probiotics. The composition, calculated nutrient contents, nutrient analysis of the different experimental diets are shown in Table 1 and 2.

Tab. 1: Composition and Calculated Nutrient Contents of Broiler Diet Containing Different Strains of Probiotics (kg.).

INGREDIENTS	T_1 (Control)	T_2(*Lactobacillus sp*)	T_3 (*Bacillus sp.*)	T_4 (*Pediococcus sp.*)
Yellow corn (ground)	53.65	47.49	47.49	47.49
Soybean Meal	48.46	24.56	24.56	24.56
Rice Bran D_1	10.00	10.00	10.00	10.00
Copra Meal	8.00	8.00	8.00	8.00
Fish Meal	6.00	6.00	6.00	6.00
Molasses	2.00	2.00	2.00	2.00
Lactobacillus sp.	-	0.20	0.20	0.20
Bacillus sp.	-	-	-	-
Pediococcus sp	-	-	-	-
Limestone	1.00	1.0	1.0	1.0
Salt	0.25	0.25	0.25	0.25
Vit./Min. Premix	0.50	0.50	0.50	0.50
TOTAL	**100**	**100**	**100**	**100**
Calculated Nutrients				
Crude Protein (%)	21.00	21.00	21.00	21.00
Metabolizable Energy (Kcal/kg.)	2,793.00	2.801.00	2.801.00	2.801.00
Calcium (%)	1.01	1.02	1.02	1.02
Phosphprus (%)	0.35	0.34	0.34	0.34

Tab. 2: Nutrient Analysis of Broiler Diet Containing Different Strains of Probiotics*

Nutrient	T_1	T_2	T_3	T_4
Crude Protein (%)	17.72	18.57	18.80	19.11
Calcium (%)	1.25	1.05	0.96	1.09
Phosphorus (%)	0.67	0.75	0.65	0.67

*Based from the analysis conducted at the Animal Nutrition Analytical Services Laboratory, UPLB, College of Agriculture, College, Laguna.

Experimental Design, Treatments and Distribution of Birds. The Completely Randomized Design (CRD) was used in the study. The chicks were randomly distributed to the different treatments and replicated thrice with ten (10) birds per treatment. For comparison of treatment means, Least Significant Differences (LSD) was used. There were four (4) treatments used as follows: T_1 - Control (0 Probiotics), T_2 - 2 kg Lactobacillus sp./ MT of feeds, T_3 - 2 kg Bacillus sp. / MT of feeds, T_4 - 2 kg Pediococus sp./MT of feeds.

Management/Experimental Procedures

Brooding. Identical care and management was provided to all birds in the different treatments throughout the duration of the study.

Feeding. The birds in the different treatments were fed with their corresponding rations throughout the duration of the study. Ad libitum feeding was practiced. Clean fresh water was provided as drinking water to the birds throughout the study.

Data Collection. The following data were collected during the experimental period.

Body weigh, feed consumption, feed conversion ratio, dressed weight, mortality and livability, other observations and economic analysis.

Results and discussion

Result of the study was summarized as follows

1. The initial weights of the birds before the feeding trial were all the same.

2. Birds fed with *Lactobacillus sp*. consistently obtained the highest final weight, gain in weight, feed conversion ratio and return above feed cost compared to other treatments and birds fed without probiotics.

3. The inclusion of the different strains of probiotics greatly enhanced the feed conversion ratio of the birds as compared to birds fed without probiotics.

4. Probiotics did not affect any significant differences on the dressing percentages and liver weight of the experimental birds.

Tab. 3: Average Initial, Weekly and Final Body weight of Broilers Fed Diets Containing Different Strains of Probiotics (g)

TREATMENTS	Average Initial and Weekly Weight (g)					
	Initial	1^{st}	2^{nd}	3^{rd}	4^{th}	Final
T_1 (O Probiotics)	54.25	190.00 b	433.33 c	808.33 c	1083.33 b	1300.00 c
T_2 (Lactobacillus sp}	59.66	223.33 ab	566.67 a	916.67 a	1358.33 a	1625.00 a
T_3 (Bacillus sp	59.25	211.33 ab	523.33 ab	883.33 ab	1300.00 a	1516.67 b
T_4 (Pediococcus sp.)	58.98	240.00 a	503.33 b	865.00 b	1233.33 ab	1358.33 c
C.V. (%)	5.5	10.5	5.3	2.2	7.0	3.5
LSD (%)						
.05	6.02	42.72	50.99	35.54	164.75	96.09
.01			74.17	51.70	239.67	139.78
	ns	ns	**	**	*	**

Tab. 4: Average gain in body weight (g), feed consumption (g) and fFeed conversion (%) of broilers fed with diets containing different strains of probiotics (g)

TREATMENTS	Feed Consumption	Gain in Body Weight	Feed Conversion	Dressing Percentage		Liver Wt
				W/ Giblet	W/o Giblet	
T_1 (O Probiotics)	3052.00	1245.75^c	2.45^b	75.86	70.09	55.33
T_2 (Lactobacillus sp}	3073.33	1565.64^a	1.96^a	74.89	61.04	55.00
T_3 (Bacillus sp	3062.67	1457.42^b	2.10^a	78.96	65.90	54.00
T_4 (Pediococcus sp.)	3039.00	1299.35^c	2.34^b	87.74	69.89	55.33
C.V. (%)	0.8	3.6	3.8	10.4	9.7	1.5
LSD (%)						
.05	43.54	93.80	0.16			
.01	63.34	136.45	0.23			
	ns	**	**	ns	ns	ns

Conclusions

Based from the result of the study, the inclusion of 2 kg *Lactobacillus sp.* /MT of feeds in the diet of broilers had improved the growth of the experimental birds in terms of body weight, gain in weight, feed conversion and its economic returns which might be due to the lactic acid content of Lactobacillus. The result obtained from this study suggest that inclusion of 2 kg of *Lactobacillus sp*. per metric tons of feeds can safely be used in the diet of broilers to produce an organically grown chicken for table meat as it produced the highest gain in weight, feed conversion and return above feed cost.

Acknowledgment

This research paper was in collaboration with the BIOTECH, UP Los Banos, Laguna through the assistance of Dr. Chay Bihn Pham and Staff, a supplier of the cultured microorganisms used in the study

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Welfare and production of organic sows and piglets

Prolonged suckling period in organic piglet production – Effects on some performance and health aspects

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Key words: Organic piglet production, prolonged suckling period, weaning age, performance, health aspects

Abstract

The organic piglet suckling period typically takes about 6 weeks due to the minimum requirement of the EEC Regulation 2092/91 of 40 days. But piglets weaned in such a period are often characterized by inferior performance and health status. It is the aim of the present study to examine whether a prolonged suckling period of 63 days results in better performance and health status of the piglets. Therefore 36 sows were divided into 2 groups of 18 sows each as a control group with 42 days suckling period and a test group with 63 days suckling period. The rearing period for both the control group and the test group ended on day 77 p.n., which was also the end of the piglets´ data collection period. Three farrowing cycles with 108 litters were recorded. The extended suckling period resulted in an improved growth rate and in a reduced number of medically treated piglets and did not negatively affect the body condition and teats of the sows. Hence a prolongation of the suckling period compared to the minimum requirement of the EEC Regulation 2092/91 seems to be advisable.

Introduction

In many cases organic piglet production is characterized by inferior animal health status and level of performance. Whereas the number of piglets born alive is satisfactory, the number of reared piglets is definitely too low (Löser, 2007). It is postulated that one of the reasons for this could be the piglets´ weaning date. The organic piglet suckling period typically takes about 6 weeks due to the 40 days minimum requirement of the EEC Regulation 2092/91. But at this point of time piglets are in a fragile physiological status, partly as a result of their limited feed intake capacity and their simultaneously high nutrient requirements (Zollitsch, 2007). Hence piglets are ill-equipped to cope with the burden in the context of weaning. It is the aim of the study to examine whether a prolonged suckling period of 63 days results in piglets with an improved immune status (see Ahrens et al. 2008 in the present volume) as well as an enhanced status of health and performance.

Materials and methods

The trial was performed from midyear 2005 to midyear 2007 at the experimental organic farm of the Institute of Organic Farming of the Federal Agricultural Research Centre (since 2008: Johann Heinrich von Thunen-Institute, vTI) in Trenthorst,

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Germany, in accordance with the Regulation 2092/91/EEC and IFOAM Basic Guidelines. A total of 44 sows of the genotype "Schaumann" (crossbreed of German Landrace, German Large White, and Duroc) were kept: 36 sows were used for the investigation and 8 sows were kept in reserve in a parallel farrowing rhythm in order to replace sow losses. The 36 sows were divided into 2 groups of each 18 sows: control group with 42 days suckling period and test group with 63 days suckling period. In-pig sows were kept outdoors on grass clover. Farrowing and suckling period were indoors. Fourteen days after single grouped farrowing the sows were grouped in threes with their respective litters and were group housed till day 42 or 63 p.p., respectively. At the weaning date the sows came outdoors again. Insemination started with the first oestrus after weaning. At the end of pregnancy the sows were randomly reintegrated in the experimental design. The weaned piglets remained in their familiar surroundings for 4 days. Then they were housed in separate indoor rearing pens in the composition of the previous sucking pig groups. The rearing period for both the control group and the test group ended on day 77 p.n. (after birth) which is the end of the piglets´ data collection period too. The trial included 3 farrowing cycles.

Data collection of sow and piglet performances included biological production traits. Health status was mainly characterized by the documentation of significant diseases (incl. post mortem examination and repeated parasitological faeces examinations), number of treatments, amount of drug use and number of losses. The present paper only deals with a limited amount of the corresponding criteria, which can be seen in the following chapter "results".

The data base rested upon a total of 3 farrowing cycles with 108 litters of 36 sows. Statistical analyses were performed with the GLM and MIXED procedure in SAS (SAS Inst. Inc., version 9.1) using a linear model with the fixed effects of suckling period, dam parity, sex of the piglets, and the interaction of suckling period and dam parity.

Results

A selection of the most important biological production traits of sows and progeny are presented in the Table 1. There were no teat problems recorded for the sows, either in the control group or in the group of 63 days suckling period.

Table 2 outlines the amount of treated piglets in the first 14 days after weaning without a specification of the related diagnoses. The dominating clinical picture during the whole trial was related to piglets´ diarrhoea with a total of 470 treated piglets. In both suckling groups about 65% of the cases occurred in the first 10 days after birth. Most of the findings were surveyed in the first of the three farrowing cycles assumedly due to the well known fact of an inferior immune status of gilts. Medical intervention (antibiotic and/or homoeopathic) took place when the piglets´ faeces were thin mushy (stadium between thick mushy and liquid). Further clinical pictures were mainly related to stunting of piglets and in a few cases related to dermatitis. Respiratory diseases did not occur and all animals (sows and piglets) were free of gastro-intestinal parasites.

Total piglet losses were 232 animals: 125 piglets i.e. 17.8 % came from the 42 days suckling period group and 107 piglets i.e. 14.8 % originated from the 63 days suckling period group. In both suckling groups about 95 % of the losses occurred during the suckling period and 82.5 % during the first 10 days respectively. A total of 23 piglets were lost due to diarrhoea. The differences between the two systems were statistically insignificant. Three sows were lost due to rupture of liver, urinary tract infection with

Clostridium septicum, and rupture of uterine vein, respectively. The losses occurred outdoors during pregnancy and were not related to the experimental conditions.

Tab. 1: Some biological production traits of sows and piglets (LSQ-Means)

	Suckling period 42 days	63 days	Significance
Litters, n	54	54	
Piglets per litter born alive, n	13.1	12.8	n.s.
Live weight per piglet born alive, kg	1.5	1.5	n.s.
Litter weight of piglets born alive, kg	19.8	19.5	n.s.
Stillborn piglets per litter, n	1.4	1.5	n.s.
Total piglets per litter, n	14.0	14.1	n.s.
Weaned piglets per litter, n	10.8	11.2	n.s.
Live weight of piglets at weaning, kg	12.1	20.8	* * *
Daily weight gain of sucking piglets, g	251	323	* * *
Sucking piglet losses per litter, n	2.3	1.7	n.s.
Live weight of lost sucking piglets, kg	1.9	2.0	n.s.
Reared piglets per litter, n	10.7	11.1	n.s.
Live weight of reared piglets[1], kg	26.7	28.9	* * *
Daily weight gain of rearing piglets, g	420	506	* * *
Rearing piglet losses per litter, n	0.09	0.05	n.s.
Live weight of piglets on day 42, kg	12.1	12.0	n.s.
Daily live weight gain of piglets from birth till day 42, g	251	249	n.s.
Live weight of piglets on day 63, kg	19.4	21.7	* * *
Daily live weight gain of piglets from day 42 till day 63, g	332	475	* * *
from birth till day 63, g	277	323	* * *
Live weight of reared piglets on day 77 (= end of trial), kg	26.8	28.8	* * *
Daily live weight gain of piglets from day 63 till day 77, g	541	506	* *
from day 42 till day 77, g	420	490	* * *
from birth till day 77, g	327	360	* * *
Body weight loss per sow during suckling period, kg	16.1	6.2	* *

** Significant for P<0.01, *** Significant for P<0.001, [1] corresponds with day 77 (end of trial)

Tab. 2: Distribution of piglet treatments for the first 14 days after weaning

	Suckling period 42 days	63 days	Significance
Total piglets[1], n	559	592	
Treated piglets, %	37.0	5.4	* * *

[1] All piglets alive at weaning day, *** Significant for P<0.001

Discussion

The data of Table 1 show that the production performance of the herd is high (Löser, 2007). It is consistent with the experimental design that there are no differences recorded between the two systems till day 42 after birth. Table 1 clearly shows the improved growth rates of the later weaned piglets. This corresponds with analogous findings in conventional piglet production systems (Main et al., 2004). The prolonged suckling period did not result in noteworthy body weight losses of the sows (Table 1) but enabled them to restock. Thus the piglets' improved performance seems to be an effect not so much of the supply of mother's milk but the maternal protection of the piglets and the longer period they spend in familiar relationships. Hence older piglets cope better with the stress of weaning (Mason et al., 2003). The opinion of the unimportance of mother's milk supply towards the end of the 63 days suckling period is supported by the observation of considerable feed intakes of the elder sucking pigs.

The necessity for treatment of animals is an effect of the individual local situation. In the present investigation the number of treatments after weaning was considerably lower in the long-suckling group compared to the short-suckling group (Table 2). These findings are in accordance with the assumption of reducing disease susceptibility by enhancing weaning age (Blecha et al., 1983; Main et al., 2004).

The level of piglet losses is tolerable compared to organic production (Löser, 2007). More than 85 % of the losses happened in the first week after birth which is compatible with the mean live weights of the lost piglets (Table 1). The main reasons were crushing and hypothermia of weak piglets, which is connected with the high number of piglets born per sow (Table 1). Therefore losses are not strictly related to the suckling regime.

Conclusions

The data of the present investigation show that a suckling period of 63 days was unproblematic for the sows and resulted in improved growth rates and reduced medical treatments of the piglets, whereas the piglet loss rate remained unaffected. It is reasoned that a prolongation of the suckling period compared to the minimum requirement of the EEC Regulation 2092/91 seems to be recommendable.

Acknowledgments

The trial was subsidised by the Bundesprogramm Ökologischer Landbau, Project No. 03oe378

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Group suckling in organic sow units

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Key words: organic pig production, lactating sows, group housing, animal health

Abstract

Group suckling - a combined system of single and group housing of lactating sows - appears a suitable system for organic pig production. The aim of the study was to describe the status quo of group suckling in organic farms. 31 organic sow units in Germany, Austria and Switzerland were investigated. Stockmen were interviewed, stables were inspected and animals were examined during three visits on each farm enterprise, respectively. The majority of farms kept three sows with piglets in one group suckling unit. 76 % of the group suckling sows (n=192) were in a good nutritional condition, 18 % were considered thin and 8 % of sows were too fat. Relatively few sows showed skin lesions caused by poor housing conditions. Only 18 of 203 sows behaved anxiously or aggressively. On average 9.1 piglets per sow and litter were weaned. Amongst the investigated farms, none was optimally managed. However, no plausible correlations between biological performance, animal health, human-animal relationship on the one hand and farm-specific production conditions (housing, management, feeding, watering) on the other hand were determined. It can therefore be deduced that the "success" or "failure" of the study farms can be attributed to the interaction of different factors rather than to individual production factors.

Introduction

The housing and management of lactating sows is one of the most challenging issues in organic pig production. Alternative to permanent single housing in farrowing pens, lactating sows and their litters can also be kept in groups. The literature and the experience of some farmers indicate that group housing of lactating sows is an interesting system for organic farming from an animal welfare and an economic point of view. The housing allows the natural social behaviour of the sows: Lactating sows kept in a natural environment rejoin the primary maternal group after separation for farrowing and the first days of the piglet's life; Piglets of several litters are reared together (Stolba & Woodgush, 1989). In commercial pork production this system reduces stress for piglets at weaning because there is no need for mixing (Bünger et al., 2004). Reduced investment costs for the stable and a more functional pen design

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are further advantages of group housing of lactating sows compared to single housing. Some studies describe negative effects of the group suckling system. Weight at weaning and daily weight gain can be reduced. Too many sows in one suckling group (Brodmann & Wechsler, 1995), a lack of milk or an interruption of lactation of group housed sows (Weber, 2000) can cause excessive cross-suckling with an increase of weight difference between piglets. Based on the literature (i.e. Baumgartner et al, 2002) we expected a big diversity of group suckling systems in organic farms and a lack of hard production data. The aim of our study was to describe the status quo of group housing systems in German-speaking countries and to identify the success factors of this system on a farm level.

Materials and methods

Data collection took place in 31 organic farms with group housing system in Germany (n=10), Austria (n=10) and Switzerland (n=11). Each farm was visited two times at weaning and one time at grouping the sows and piglets. The farmers were interviewed about management, housing, feeding and animal health. The housing conditions of the piglet production were inspected and recorded. At weaning the piglets were weighed and evaluated for skin lesions, injuries of legs and signs of diarrhoea. The sows were checked for body condition score (BCS), skin lesions and lameness. The human-animal relationship was evaluated within using a handling test with the stock person and an approach test with the investigator. Productivity data were collected on notes of the stockman. The data were analysed with descriptive statistics, analysis of correlation and ANOVA using the programmes Excel und SPSS 11.0. Finally an overall evaluation of the group suckling system of each farm was calculated. For this purpose target values based on the literature and the experiences of experts were defined in the areas of housing, management, feeding, animal health, human-animal relationship and productivity. Each farm was rated in these categories. If a farm achieved the target value, it was rated as “good”, if not it was “bad” or in between “mid”. In addition, success criteria for group suckling systems were defined: health of sows and piglets, homogeneity in piglet’s weight at weaning, normal behaviour of the sows at handling, productivity data.

Results

The group suckling systems found in the farms investigated were extremely inhomogeneous. The results did not differ as much between countries as they did between farms within one country. The mean size of the sow herds was 35 (11 – 90).

Housing: Group suckling was practised in 25 farms in modified buildings. Six stables were recently built for group suckling purposes. The size of the lying area per sow ranged from 1.6 m^2 to 6.7 m^2. Most farmers (19) kept three sows in one group suckling unit. The average weaning age was 47.8 days (n=1194 litters). The most obvious insufficiency in housing was found in the design of the piglet nest: lack of space (< 0.1 m^2 per piglet), deficient heat supply and inadequate protection from draft were found. Furthermore the water supply was insufficient frequently.

Management: Concerning management most farmers seek a low age difference between litters of one suckling group. In 83.5 % of all grouped litters (n=405 groups) the age difference was less than eight days. For the stockperson it seems to be difficult to manage the planned group size, only six out of 29 farmers had the planned number of animals in more than 75 % of the suckling groups.

Animal health: The main health problem in the farms was post-weaning diarrhoea (21 out of 31 farms). The majority of the group suckling sows (n=192) was in a good nutritional condition, 18 % were considered thin and 8 % of sows were too fat. Only few sows (61 out of 206 sows) in few farms (7 out of 30 farms) showed severe skin lesions. The prevalence of skin lesions in the head-neck-side region correlated significantly (p=0.01) with the group size in the suckling group. Sows and piglets showed an approach more often than retreat, flight or aggression in the approach test with a strange person. In the handling test the behaviour of the stockperson was considered positive or neutral in 18 out of 24 farms. Only 18 out of 203 group suckling sows behaved anxiously or aggressively during BCS.

Productivity data: Piglet losses from birth to grouping for group suckling were 15.6 % on average (5.9 – 25.0 %). The loss rate in the group suckling period was 3.9 % (0.6 – 9.3 %). On average 9.1 piglets per sow and litter were weaned (5.8 – 11.5).

Final evaluation of farms: The overall evaluation of each farm by an expert panel showed, that the piglet nest is the most critical housing factor and feeding of sows and piglets has to be improved in most of the farms. A minority of the farms can be considered as good in housing, feeding and management (Table 1).

Tab. 1: Summarised results of farms with group suckling (n=31) in different factors of production evaluated by an expert panel

Factor	Good	Mid	Bad
Pen design	9	17	5
Piglet nest	4	8	19
Outdoor run	6	18	7
Feeding	4	10	17
Management	8	11	8

Looking at productivity, only one farm with group suckling can be rated as successful. All farms had problems in animal health in a greater or lesser extend. In the other animal based welfare parameters a minority of farms showed bad results (Table 2).

Tab. 2: Summarised results of farms with group suckling (n=31) in different success criteria evaluated by an expert panel

Success criteria	Good	Mid	Bad	Missing
Productivity	1	13	13	4
Animal Health	-	14	16	1
Skin lesions, BCS, behaviour	6	20	4	1
Human animal relationship	6	13	5	7

The overall evaluation of each individual farm revealed, that none of the farms provided optimal conditions to the pigs in the areas of housing, feeding and management. Consequently, none of the farms can be considered successful both in productivity, animal health and human-animal relationship. However, no plausible correlations between success criteria on the one hand and farm-specific production conditions on the other hand could be found.

Discussion

The situation found in the organic farms with group housing of lactating sows and litters participating in this study was inhomogeneous and did in this respect, not differ from other studies on organic sow units (Baumgartner et al., 2002). Our results indicate that a group size of three to four sows are optimal for group suckling which is also described in other studies (Brodmann & Wechsler, 1995). Keeping the difference in age of the litters within a suckling group as low as possible is an important management factor. Even organic pig producers with group suckling systems still underestimate the importance of an optimal piglet nest for animal health and productivity. The problem of weaning diarrhoea, which is evident in conventional and organic pig production too, can not be solved with a group suckling system unless general deficiencies in feeding, hygiene, housing and management are eliminated.The marginal prevalence of skin lesions of the sows in this study indicates that aggressive behaviour of group housed lactating sows is low because this system allows the natural social behaviour. The group suckling system seems to facilitate a good human-animal relationship too. Productivity data do not differ between the group housed sows investigated in this study and single housed organic sows described in the literature (Loeser, 2004). The critical phase for the piglets is the time in the farrowing pen in the first weeks. None of the 31 investigated farms was optimally managed. Plausible correlations between farm-specific production conditions and the criteria of success such as productivity could not be determined. The relatively small number of farms investigated in combination with great variability in the production conditions of the farms did not allow a general statement about a successful group housing system. It can therefore be deduced that the “success” or “failure” of the study farms can be attributed to the interaction of different factors rather than to individual production factors.

Conclusions

Group housing of lactating sows is an alternative system to single housing for organic pig producing farms. Group suckling has advantages in both animal welfare and economic respects. To ensure success the basic requirements of pig production in the areas of housing, feeding, management and veterinary treatment must be adhered to. Experimental based further research is needed.

Acknowledgments

This project was sponsored by the Federal Organic Farming Scene, Germany.

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Development of a mobile organic piggery for outdoor pork production – function, productivity, animal behaviour and environmental risk assessments

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Key words: Outdoor, fattening pigs, foraging, feed conversion, plant nutrient balance

Abstract

Pens in outdoor pig systems in general become permanent during the grazing period. The excretion behaviour of the pigs creates plant nutrient hotspots within pens. In this study we developed a mobile organic piggery (MOP) without electric fencing that can be moved to a new grazing area each day. The aims were to distribute plant nutrients evenly, provide the pigs with continuous access to fresh herbage, and improve productivity and the working environment. Initially, 25 fattening piglets were installed in the MOP on a clover/grass ley. Nitrogen, P and K flows to and from the MOP were monitored during 87 days. The purchased feed included 80% of the energy norm for pigs in indoor systems and the pigs were automatically fed. The MOP was moved 65 times. Behavioural studies including excretion behaviour were conducted during a two-week period. Net nutrient accumulation was 88 kg N, 31 kg P and 10 kg K ha^{-1} for the total grazing area (4212 m^2). Average liveweight gain was 675 g day^{-1}. Average feed conversion rate was 2.7 kg feed kg^{-1} liveweight gain. The pigs grazed, on average, almost half the day. With the MOP system it was possible to use a lower quality concentrate feed in terms of energy and protein supply in combination with regular access to fresh herbage. The MOP system also allowed a more even distribution of animal manure within the total grazing area, compared with permanent pens. Avoiding harmful point loads of nutrients decrease the risk of nutrient losses.

Introduction

More economical and environmentally-friendly outdoor systems for organic fattening pig production are urgently required. The organic outdoor systems currently used in Sweden have to give pigs access to grazing during the summer. In reality, pens with electric fencing become permanent during the grazing period, which makes it more difficult to harvest surplus grass and to sow a winter crop on rooted areas. Feed are transported across the grazing area regularly, increasing the risk of soil compaction (Andresen, 2000). Although each pen may have a balanced overall pig density (corresponding to an application of 22 kg P ha^{-1} year^{-1} in Sweden), pig defecation and urination behaviour can create unacceptable point loads of nitrogen (Salomon et al., 2007a).

Homogeneous distribution of manure is expected to be a key factor in optimising plant nutrient availability in crop production, while also decreasing the risk of plant nutrient

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losses. Movement of the pen to provide continuous access to new grazing also stimulates forage intake by pigs, which can decrease the need for purchased feed (Andresen, 2000). However, equipments and fences currently available for outdoor production are not sufficiently user-friendly to allow regular moving. Screening of the working environment on six organic pig farms showed that manual feeding and watering increased the risk of accidents and created an unacceptable ergonomic load, compared with semi-automatic feeding (Geng & Torén, 2005).

The aim of this study was to develop and evaluate a mobile organic piggery (MOP) without electric fencing that can be moved to a new grazing area each day. Specific objectives were to create an outdoor system that: 1) Gives an acceptable distribution of nutrients; 2) provides continuous access to fresh herbage; 3) increases the possibilities of establishing a subsequent crop; 4) reduces working time and work load; 5) improves pig liveweight production.

Materials and methods

The two MOP prototypes developed were evaluated during two grazing periods on a commercial organic pig farm that had its own sows and bred its own piglets. This pig farm is situated in southern Sweden (56°02'N 13°42'E), with a mean annual temperature of 7.4° C and a mean total precipitation of 773 mm (local meteorological station). The soil at the site is a sandy loam.

The construction of the MOP2 year 2 (hut and pen) was designed to house 30 fattening pigs and to allow smooth repositioning by tractor under field conditions. The rectangular pen (9 x 6 m^2) is made of 10 guardrails of steel tubing. Each guardrail rests on steel runners to allow smooth forward movement. The corners of the pen are flexible to prevent breakages during turning. The rear end of the pen is stabilised with a road-drain. The hut (9 x 3 m^2) has no floor but three walls and a roof. The fourth wall is partly open to allow access for the pigs. The hut has three wheels, adjustable in the vertical direction. During transportation on roads the pen can be dismantled and the drawbar can be moved to the gable of the hut. Within the MOP, the pigs have access to purchased feed, drinking water and a bath-tub (3 m^2) linked to the back gable of the hut.

In the second year MOP2 was constructed and evaluated. Based on former experiences, the pen design from MOP1 year 1 was used without modifications (Salomon et al., 2007a). However, the hut was modified to include a 9-m long feed container for storage of one week's feed requirements. Along the bottom of the feed container run upper and lower augers with steel casings. The lower auger has an outlet for feed every 0.6 m, corresponding to alternate feeding stations, and is run by a 12 V battery supported by a solar cell. A time relay controls how much, when and how often the pigs are fed. Below the feed container is a 9 m long feeding trough where up to 30 pigs have space to feed at the same time.

The experimental period was 87 days. In May, 25 fattening pigs with an average liveweight of 36.8 kg were installed in MOP2 on a first year clover/grass ley. Nitrogen, P and K flows to and from MOP2 were monitored (Eq. 1). Behavioural studies including excretion behaviour were conducted every day over a two-week period.

MOP2 balance = [Purchased feeds + Piglets] – [Pigs + Ley harvest] (Eq. 1)

The planned frequency of moving MOP2 was based on a maximum N application of 170 kg ha^{-1} according to the EU Nitrate Directive. The concentrate feed contained 80% of the energy norm for pigs in indoor systems and the crude protein content was 15.9 % of DM (dry matter). Lysine was 6.1 g kg^{-1} DM and methionine 2.3 g kg^{-1} DM in the concentrate. This corresponded to 72.5% of the norm for lysine and 89.1% for methionine. The amounts fed per week were based on farm documentation. The pigs were automatically fed at 6.00 a.m, 11.00 a.m, 4.05 p.m and 8.00 p.m.

The pigs were weighed individually at the start of the trial and three times before slaughter. The average liveweight at slaughter was 110 kg pig^{-1}. Nitrogen, P and K contents in pig carcases were taken from the literature. One cut of silage was taken in June on half the total grazing area. Analysis of the clover/grass ley showed a plant nutrient content of 12 g crude protein, 3.7 g P and 31.5 g K kg^{-1} DM.

General behavioural studies on 5 pigs were conducted for 4 h in the morning and 4 h in the afternoon. Grazing, rooting, passive and other activities conducted in the hut and at the front and back of the pen were recorded on these occasions. Continuous recordings were made for defecation and urination.

Results

Tab. 1: Plant nutrient balance for the total grazing area (4212 m^2) traversed by 25 fattening pigs during 87 days

Flow	N	P	K
Pigs, kg in	+24	+5	+2
Feeds, kg in	+86	+23	+19
Pigs, kg out	-66	-13	-5
Harvested silage, kg out	-7	-2	-12
Balance, kg per hectare	+88	+31	+10
Balance, kg per fattening pig	+1.5	+0.5	+0.2

The largest inflow of N, P and K was from purchased feed, while the largest outflow of N and P was from pigs and of K from harvested silage. The balance resulted in a net accumulation of N, P and K on the total grazing area (Table 1).

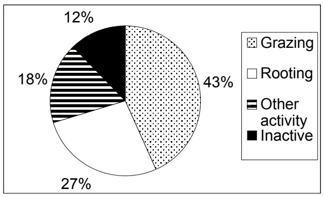

Figure 1: Foraging behaviour, expressed as average % day^{-1}.

The average liveweight gain was 675 g day^{-1} which corresponded to 33.6 MJ (metabolisable energy) kg^{-1} liveweight gain. Feed conversion rate was on average 2.7 kg feed kg^{-1} liveweight gain. There was no remarks on defective pig health from the abattoir. On average, the pigs grazed almost half the day (Figure 1). Defecation and urination behavioural studies showed that the pigs excreted without exception outside the hut, preferably at the back of the pen.

Discussion

The net accumulation of 88 kg N ha^{-1} and 31 kg P ha^{-1} was environmentally acceptable and lower than with MOP1, for which the corresponding values were 155 kg N ha^{-1} and 48 kg P ha^{-1}. One important reason for this was that MOP2 was moved more frequently (65 times) than MOP1 (36 times) (Salomon et al., 2007b). Frequent moving distributes nutrients in faeces and urine more evenly compared with stationary pens (Salomon et al., 2007a). On average, each pig received 3.7 kg N with purchased feed, which was lower than with MOP1 (4.6 kg N pig^{-1}). The reason was that with MOP1, the feed consumption was too high due to spillage and manual feeding in feeding troughs once a day, which made it difficult to adapt feed intake to pig liveweight. The feed conversion rate was on average 2.7 kg concentrate feed kg^{-1} liveweight gain, which was lower than in MOP1 (3.0 kg concentrate feed kg^{-1} liveweight gain) and rather low for organic pig production in general (Andresen, 2000). The forage intake thus influenced the growth rate positively, although in this experiment we did not measure actual forage intake. It has been reported that when pigs are frequently given access to new grazing areas, they spend more time grazing than in permanent pens (Andresen, 2000). Growth rate in this experiment was lower than in conventional production, which can be explained by the low crude protein content and rather low quality of the concentrate protein in terms of lysine and methionine content. In terms of feed conversion, the results were comparable to Swedish indoor pig production.

Conclusions

With the MOP2 system it was possible to use a lower quality of feed in terms of energy and protein supply in combination with regular access to fresh herbage. The MOP system also allowed a more even distribution of animal manure within the total grazing area, compared with permanent pens. Avoiding harmful point loads of nutrients decrease the risk of nutrient losses.

Acknowledgments

This study was financed by the Swedish Board of Agriculture.

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Effect of additional heating, floor length, straw quantity and piglet nest accessibility on piglet losses in organic farrowing pens

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Key words: farrowing, piglet mortality, organic, pig, pen design

Abstract

Newborn piglets on organic pig farms have a lower chance to survive their first week than conventional piglets. Poorer climatic conditions, a loose housed mother, large litters with low birth weights are some of the causes. In a series of experiments the effect of housing and climate measures were investigated. Additional floor heating around farrowing to increase vitality did not reduce piglet mortality. Enlargement of the solid floor to facilitate maternal behaviour also didn't show a lower mortality. In the third experiment the amount of straw didn't give a lower mortality, but longer flaps in the opening of the piglet nest tended to reduce mortality.

Introduction

Newborn piglets in organic farrowing pens have a lower survival rate than in conventional farrowing pens. This difference is mainly caused by housing the sow loose and by climatic effects of the outdoor temperature combined with relatively large litters. This results in a higher risk on crushing as a secondary cause of death in weakened piglets (Weary et al., 1998; Edwards, 2002). These housing and climate conditions were the main topics in three projects on reduction of piglet mortality. According to EU- regulations lactating organic sows should have at least 7.5 m² indoor area with straw, a 2.5 m² outdoor run and a weaning age of 40 days. The aim of this project was to increase piglet survival in order to improve animal welfare as well as the profitability of organic pig farms.

Three subprojects were conducted to reach the aims of the project:

1. Additional floor heating around farrowing
2. Solid floor size
3. Straw quantity and accessibility of piglet nest

Materials and methods

1. Additional floor heating around farrowing

Beside the continuous floor heating of the piglet nest the solid lying area where the sow gave birth to the piglets was heated from 12 hrs before farrowing until 24-30 hrs after farrowing. Heating means pumping water of 35 ˚C through the floor resulting in a surface temperature of 30 ˚C. The floor was covered with a thin layer of straw. The hypothesis was that this would result in dryer, warmer and more vital piglets with a lower risk on crushing. Every three weeks two rooms with each six pens were

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allocated to the treatments “Warm” and “Cold”. We used 83 litters per treatment. The layout of the pen is drawn in figure 1. Lying behaviour of sow and piglets was observed during the first five days post partum and post mortem section of the piglets was carried out to check the stomach content and the status of the lungs (live or dead born). Performance data and fraction dead piglets were analysed using GLM (Genstat) with litter size and birthweight as covariables in the model beside the main effects.

2. Solid floor size

To give sows the opportunity to perform a higher quality of maternal behaviour the surface of the 2.0 m wide solid floor was elongated from 2.25 m (Small) to 3.00 m (Large). This resulted in “Large” in a decreased slatted floor size from 1.50 m to 0.75 m deep (see fig.1). In both treatments 42 litters were born. Lying position of sows and piglets, dunging pattern and performance were recorded.

3. Straw quantity and accessibility of piglet nest

In this 2x2 factorial design we used 112 litters. Half of the pens was strawed with a thin layer and half with a thick layer of straw just before birth. The second factor was the accessibility of the piglet nest (grey area in fig. 1): long transparent flaps (ending 8 cm above the floor) and short flaps (ending 30 cm above the floor). Lying position of sows and piglets, sow posture changes and performance were recorded.

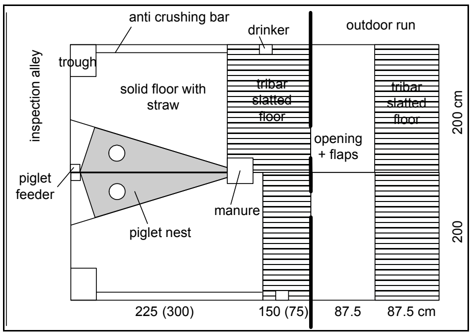

Figure 1: Layout of two farrowing pens with different solid floor sizes in the indoor area; the outdoor area is on the right in the drawing.

Results

1. Additional floor heating around farrowing

The extra heat during farrowing did not result in a lower piglet mortality. The performance of the sows in the two treatments was not statistically different. Table 1 shows the results. On average 12.63 liveborn piglets in “Cold” resulted in 10.12 weaned piglets and for “Warm” 12.36 liveborn piglets resulting in 9.94 weaned piglets. This leads to a mortality of respectively 20.0 and 19.4% (NS).

Tab. 1: Performance of sows farrowing on a heated and non-heated floor.

	Cold	Warm	Sign.
Liveborn (number)	12.63	12.36	ns
Stillborn (number)	1.19	1.18	ns
Birthweight (kg)	1.51	1.50	ns
Weaned (number)	10.12	9.94	ns
Mortality (% of liveborn)	20.0	19.4	ns
Weight loss sow (kg)	32	37	ns

* significant for P<0.05 ; ns = not significant

Behavioural observations showed no difference in use of the solid floor by the sow; all farrowings took place on the solid floor. Crushing was the cause of death in 43% and 45% of the total mortality in Cold and Warm. On the first day after birth 58.0% (Cold) and 50.5% (Warm) of the piglets were in the piglet nest (P<0.05), outside the "danger zone". The dead piglets in "Warm" had more often milk in their stomach than in "Cold" (62% and 42% resp.), indicating more vital pigs in "Warm" .

2. Solid floor size

The larger solid floor did not result in a higher survival of the newborn piglets. The difference in birth weight was not reflected in the weaning weight (Table 2). The lying behaviour of the sow did not differ, but the large floor was dirtier than the small floor. However the majority of the excretion behaviour was performed in the outdoor area.

Tab. 2: Performance of sows farrowing on a large and small floor.

	Large floor	Small floor	Sign.
Liveborn (number)	12,4	12,6	ns
Stillborn (number)	1,2	0,9	ns
Birthweight (kg)	1.64	1.51	*
Weaning weight piglets (kg)	12.2	12.1	ns
N weaned	9.3	10.0	ns
Mortality (%)	25	21	ns

* significant for P<0.05 ; ns = not significant

Tab. 3: Performance of sows with 2 straw quantities and 2 lengths of nest flaps

	Low Straw	High Straw	Sign.	Long Flaps	Short Flaps	Sign.
Liveborn (number)	13.3	14.5	*	13.7	14.1	ns
Dead born (number)	0.9	1.2	ns	1.0	1.1	ns
Birthweight (kg)	1.67	1.63	ns	16.90	16.05	ns
Weaning weight (kg)	12.45	12.07	ns	12.39	12.14	ns
Weaned (number)	10.43	11.02	ns	11.02	10.43	ns
Mortality (% of liveborn)	22.2	24.2	ns	19.7	26.7	# (P=0.06)

* significant for P<0.05 ; # tendency P<0.10; ns = not significant

3. Straw quantity and accessibility of piglet nest

The longer flaps of the piglet nest resulted in a tendency for a lower mortality, but the extra straw was not successful in reducing mortality (Table 3). This matches the thick straw bedding not resulting in fewer postural changes compared to the thin layer. We also did not find any difference in lying preference of the piglets.

Discussion

The results do not show a very strong effect of the different housing and climate measures on the survival of the newborn piglets. Unfortunately some of the housing measures seem to bring positive and negative aspects. Heating the floor around the sows is favoured by the sow (Phillips et al., 2000), but attracts the young piglets to this potentially dangerous area. Long flaps in the entrance of the piglet nest keep the heat inside but reduce the accessibility. Straw bedding insulates the newborn piglets but also hampers them when escaping from a rolling sow, which is a risk factor for crushing according to Damm et al. (2004) . However heating around parturition is crucial in keeping the piglets vital (Herpin et al., 2002). These results led us to the conclusion that there is more to gain in maternal behaviour, nutrition (milk production) and management (human animal relationship). In the next years the focus will be more on these topics.

Conclusions

From the described experiments it can be concluded that:

- Floor heating in the lying area of the sow during one day after parturition did not increase piglet survival;
- Enlargement of the solid floor to facilitate maternal behaviour did not increase piglet survival;
- Increasing the amount of straw did not give a lower piglet mortality;
- Longer flaps in the opening of the piglet nest increased piglet survival.

Acknowledgments

This project was part of the research programme "Organic Animal Husbandry" and was financed by the Dutch Ministry of Agriculture, Nature and Food quality.

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Towards loose housing in Swedish organic dairy production

Swensson, C.[1]

Key words: milk production, dairy cow houses, tethered cows, loose housing

Abstract

For hundreds years there has been a tradition with tethered dairy cows in Sweden. The last decades the old fashioned way to hold cows have been questioned and the number of dairy cows in loose housing has been increasing. Last year (2004) 19 percent in total of all farms with milk production in Sweden had their cows in loose housing. Because of EU-legislation concerning all organic production no farms are allowed to build tie stalls any more and after 2010 all organic dairy cows are supposed to live in loose-housing systems.

The aim of the thesis was mainly to find out the number of farms with tethered organic dairy cows. Furthermore the purpose was to study if there are any regional differences regarding the building system for organic dairy herds. There are important differences between buildings made for conventional dairy cows and organic ones. Some examples from organic rules are that calf and cow are allowed to go together during the whole colostrums period and the area per animal in some cases is bigger. That often makes organic buildings for dairy cows more expensive to build than conventional ones.

In the end of 2004 60 percent of the organically kept dairy cows, which is equivalent to 40 percent of the farms in Sweden, were already in loose-housing systems depending on that decision. There are big regional differences.

Introduction

For hundreds years there has been a tradition with tethered dairy cows in Sweden. Historical investigations concerning cow houses in Sweden during the 18th century find only examples of cow houses with tethered cows independently of herd size (Israelsson, 2005). When organic dairy farming started in Sweden approximately 25 years ago, the tradition with tethered dairy cows continued. Referring to the organic principles of agriculture (IFOAM), tethered dairy cows should be forbidden. The "Principle of fairness" insists, "that animals should be provided with the conditions and opportunities of life that accord with their physiology, natural behaviour and well-being". Also the EU –legislation on organic animal production highlights that "the housing conditions for livestock must meet the livestock's biological and ethological needs". According to an overview regarding the situation in Europe for organic animal production, only 5 countries of 17 investigated had no tied stalls (Vaarst et al., 2006). Hence, there is a conflict between the traditional housing systems for dairy cows and the organic principles. Furthermore, this conflict is most common in mountain areas, for instance the Alps, and areas not suitable for large-scale farming or large dairy herds. Examples of the latter are the northern part of Sweden.

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Due to the EU-legislation concerning all organic production no farms are allowed to build tie stalls any more and after 2010 all organic dairy cows are supposed to live in loose-housing systems (EEC, 1991). There are important differences between buildings made for conventional dairy cows and organic ones. Some examples of organic rules are that calf and cow are allowed to be together during the whole colostrums period and the area per animal in most cases is larger. The investment for an organic dairy cow stall compared to a conventional dairy cow stall is therefore often bigger.

Hence, there is a conflict between the Swedish traditional system of dairy cow housing and the rules for organic dairy production.

The aim of this presentation is mainly to find out the number of farms with tethered organic dairy cows in Swedish organic dairy production. Furthermore the purpose is to study if there are any regional differences in Sweden.

Materials and methods

The investigation was carried out during 2005 and data were collected concerning 2004. Information sources to the investigation were the dairy plants, the controllers of KRAV (private labelling organisation) and the dairy farmers themselves. All dairy plants in Sweden, which are selling organic milk, claim that the dairy farms are affiliated to KRAV.

Information from controllers of KRAV gave statements regarding type of housing from 76% of the 440 organic dairy herds in Sweden with 21 641 dairy cows (year 2005). The missing information was collected by interviewing the dairy farmers by telephone. One percent of the dairy farmer was unable to contact despite they were contacted by telephone at least 5 times.

Results

In the end of 2004 60 percent of the organically kept dairy cows, which is equivalent to 40 percent of the farms in Sweden, were already in loose-housing systems. There are large regional differences both regarding housing system and where the organic dairy cows herds are situated (Table 1).

Some of the tethered dairy herds were rather large (Fig. 1), although the herd size is larger in loose housing systems (Fig. 2).

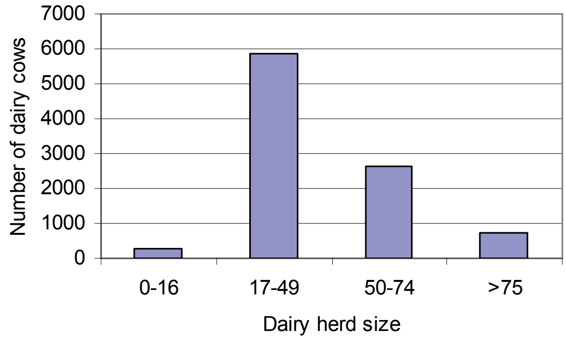

Figure 1: Number of tethered dairy cows in different herd sizes

Tab. 1: Regional differences regarding dairy herds and housing system in Swedish organic dairy production

	% of dairy herds of all Swedish organic dairy herds	% of dairy cows of all Swedish organic dairy cows	% loose housing system of all dairy herds in the region
Southern Sweden	58	61	40
Middle Sweden	23	24	37
Northern Sweden	19	15	38

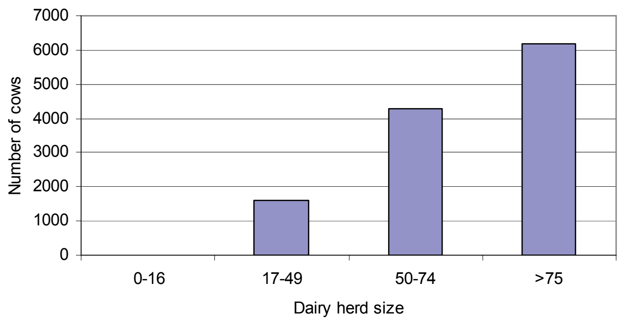

Figure 2: Number of dairy cows in loose housing system in different herd sizes

Discussion

The new EU-regulation- EG 834/2007 – which is implemented from 1st January 2009 has not yet any detailed regulations concerning how to deal with tethered cows or tethered animals in general. Considering animal welfare and the individual need of animals the overall goal must be loose housing for organic dairy cows. However, there are several dilemmas with this standpoint. Firstly, the organic rules according to EU made an exception for tethered dairy cows in small dairy herds. However, the definition of small dairy herds has never been decided on EU-level. Instead, it was decided that the definition of small herd should be decided on national level. According to Swedish authorities, a small organic dairy herd in Sweden has 45 dairy cows, slightly below the average dairy herd size in Sweden. Referring to figure 1, roughly 3 000 dairy cows are in tethered dairy barns with more than 45 dairy cows. This means that 15 % of the total organic dairy production is produced from organic dairy cows in dairy barns which are going to be forbidden in the year 2011. Today the market of organic dairy products is increasing and in some regions in Sweden it is difficult to recruit new organic dairy producers. Secondly, some of the organic milk is produced in areas with small opportunities to increase herd size due to lack of land, especially in Northern Sweden. In these areas, there is a need of cattle on pasture to keep the landscape open. Organic tethered dairy herds in these areas have difficulties to make heavy investments in loose housing which means that these dairy farms quit dairy production and hence, society looses the open landscape in the long run. The mountain regions in Europe, for example, France and Austria, have the same problems.

Another point of view is that most organic dairy farmers emphasise natural behaviour among animals and supports animal welfare (Lund et al.2002). Still, in several European countries there are a lot of tethered dairy cows. It seems that tradition in animal husbandry means more than animal welfare. To survive, organic dairy production has to be market driven and probably is consumer's view of organic dairy production a loose housing system. In other words, there is a need to develop loose housing systems for small-scale organic dairy production.

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Excreting behaviour of pigs from organic housing systems in relation to ammonia emission

Ivanova-Peneva, S.G.[1], Aarnink, A.J.A.[2] & Verstegen, M.W.A.[2]

Key words: pigs, organic housing, excreting behaviour, ammonia emission

Abstract

The objective of this study was to establish a pattern of excreting behaviour of pigs in relation to ammonia emission and to predict the ammonia emission rates from clean and fouled with excretions areas.

The study involved 3 organic pig farms in which the housing systems included straw pens inside and a paved yard outside.Two pens with fattening pigs were chosen on each farm and measurements of excreting behaviour and ammonia emission were made at two stages in the fattening period, at approximately 45 and 80 kg of body weight. Behaviour was observed with video cameras at two consecutive days for 24 hours. From video recordings urinations and defecations, including the corresponding times, were noted. Diagrams of the excretion activity pattern during the day for every weight class and every farm were made. From the figures of the frequency of urinations during the day it was clear, that in all the tree farms there were two excretion peaks – one in the morning and one in the afternoon-evening hours. Clean areas inside emitted 1.9 g ammonia.day^{-1}m^{-2} and clean areas ouside – 2.7 gday^{-1}m^{-2}. Inside polluted areas had a higher emission than the polluted areas on the outside yard – 13.3 gday^{-1}m^{-2} vs 11.4 gday^{-1}m^{-2}, resp.

Introduction

One of the most important objectives of organic farming is to consider the physiological and behavioural needs of the animals, according to Regulation No 1804/1999. In this regulation the use of straw is based on the statement that pig's welfare can be improved in straw-based systems compared to conventional, intensive systems. In the same time this can contribute to increasing of ammonia emission in organic production systems. Increased area per pig and the availability of outside yards in this type of housing could also become a significant source of ammonia volatilization.

Excreting behaviour of pigs is in close relation to ammonia emission rates. It is important to know not only the rates of ammonia emission, but also variation with time during the day and the emissions from clean and fouled with excretions areas. Both variations and degree of fouling of pen floor could be monitored by observations of the excreting behaviour of pigs. The objective of this study was to establish a pattern of excreting behaviour in relation to ammonia emission and to predict the ammonia emission rates from clean and fouled with excretions areas.

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Materials and methods

The study involved 3 organic pig farms in which the housing systems had straw pens inside and a paved yard outside.Two pens with fattening crossbred pigs (Large White x Dutch Landrace) were chosen on each farm and measurements of excreting behaviour and ammonia emission were made at two stages in the fattening period, at approximately 45 and 80 kg of body weight. The number of the pigs in pen in every farm was different, depending on the size of the pens.

Behavioural observations were made by video cameras. For this purpose, two or four cameras were installed for each pen (inside and outside the building). The cameras covered 90% of the area on farm 1 and 100% on farms 2 and 3. Time-lapse video recorders on tapes recorded the signal from the cameras. The recording was done on two consecutive days simultaneously for fatteners of 45 and 80 kg on each farm. The data on the excreting behaviour (number of urinations and defecations and whether they occurred (inside or outside) obtained from the video recording were analysed. Diagrams of the excretion activity pattern during the day (24 hours) for every category and every farm were made.

Ammonia emission was measured using a ventilated chamber both inside the building and on the outside paved yard. The total surface areas of polluted and clean areas were determined. The ammonia measurements were carried out at 9, 10 and 8 locations in each of the two periods in every pen on farm 1, 2 and 3, respectively, at similar number of fouled and clean locations, as it is shown at Fig. 1.

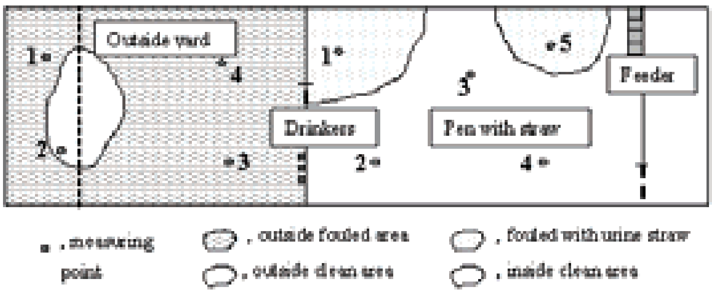

Figure 1: Measuring points and fouled areas in pens of 45-kg fatteners on farm 1.

Results

Urination activity is closely related to the rate of ammonia emission, that's why the urination frequency during the day is shown on the figures 1-3. On farm 2 and 3 only a few urinations inside occurred therefore only urination activity of outside yard in 45 and 80-kg pigs were presented. From the figures of the urination activity during the day it is clear that at each farm there are two peaks – one in the morning and one in the afternoon-evening hours. Difference exists between 80-kg pigs at farm 3 and the other two farms as well as between 80 kg pigs and 45-kg pigs at the same farm, with two picks in the morning hours close to each other and not very clear pick in the afternoon hours. In farm 1 and 2 afternoon activity in urinations is higher than in the morning. The peak in the afternoon has a longer duration – from 14 to 19 h at farm 1 and from 16 to 20 h at farm 2. This pattern of excretion frequency is the same as it was observed by Aarnink (1997).

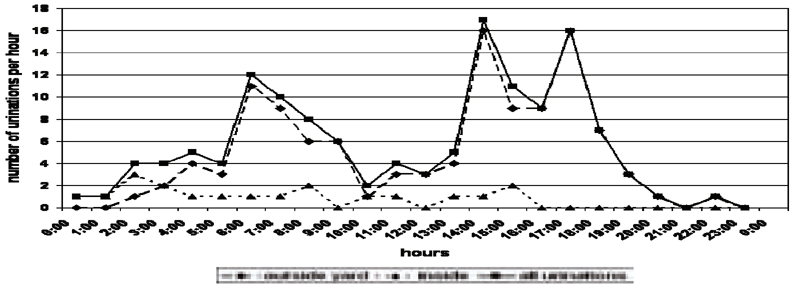

Figure 2: Urination activity of 45-kg fatteners at farm 1.

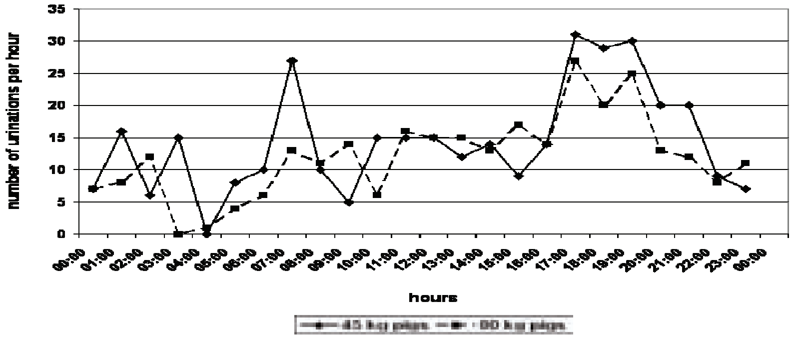

Figure 3: Urination activity of 45-kg and 80-kg fatteners at farm 2.

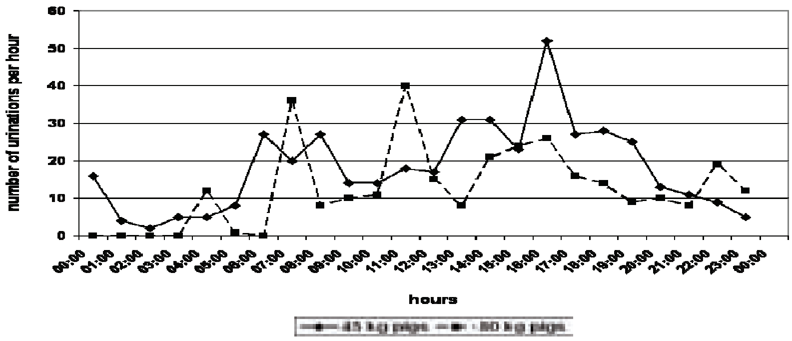

Figure 4: Urination activity of 45-kg and 80-kg fatteners at farm 3.

Tab. 1: Predicted means of NH_3 emissions ($gday^{-1}m^{-2}$) for interaction between location and degree of fouling in fattening pigs at three organic farms.

Location	Clean	Fouled	S.E.D
Inside	1.9	13.3	Location - 3.1
Outside	2.7	11.4	Fouled – 3.1

In table 1 the effect of fouled and clean areas for all three farms on ammonia emission is summarized. A fouled area inside caused higher emission per m^2 than a fouled area outside. These results correspond to the results of von Wachenfelt and Jeppsson (20060 from outside yards of organically raised pigs (9-12 $gday^{-1}m^{-2}$).

Discussion

Ammonia emission from pig buildings is influenced very much from the pattern of excreting behaviour. When given the choice, the natural behaviour of pigs is to separate the lying and dunging places (Aarnink et al., 1996, van Putten, 2000). In our study, the pigs had a preference to urinate and defecate on the outside yard and to keep the lying area inside clean. Thus the polluted area outside was larger than that inside. Because ammonia emission is positively related to the fouled area (Aarnink et al., 1996), this also could explain the effect of clean and fouled areas inside/outside. In our study fouled areas inside emitted more ammonia than that outside, because of a building up of dung and urine in the straw. This could contribute to the longer emission of ammonia. Fouled straw inside the building, used in organic pig production compulsory to improve animal welfare, could also increase this effect because of a larger emitting area than paved outside yard.

As it was discovered before (Aarnink, 1997) the peaks in emission coincide with the peaks of urinating frequency. Since number of excretions is closely related to the ammonia emission, this could provide information for their variation during the day. So in our study the peaks in ammonia emission could be predicted from urinating behaviour once in the morning and second in the afternoon hours.

Conclusion

There were two excretion peaks – one in the morning and one in the afternoon-evening hours. Clean areas inside the building emitted 1.9 $gday^{-1}m^{-2}$ ammonia and clean areas on the ouside yard – 2.7 $gday^{-1}m^{-2}$. Inside polluted areas had a higher emission - 13.3 $gday^{-1}m^{-2}$ than the polluted areas on the outside yard – 11.4 $gday^{-1}m^{-2}$.

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Profitability of Sow husbandry in organic farming– Performance and construction costs for group housing of lactating sows

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Key words: sows, group housing, profitability, performance, construction costs of sow housing

Abstract

The group housing of lactating sows represents an economically interesting and also animal welfare alternative to the otherwise usual individual housing in this phase. Aim of this study is to fill existing information gaps and create more planning security.

The performance efficiency of the housing system is determined on the basis of biological parameters, based on empirical data of a co-operation project. The influence of the housing system on the construction costs for housing sows is examined by construction models, which are defined on the basis of empirical data and by an expert interview.

Better performance data are reached by the group housing system analysed here compared to other studies. The results show that the housing system is both suitable and efficient on farm level.

The group housing of lactating sows causes a reduction of construction costs. This difference is especially noticeable when modifying existing buildings. The saving potential is 993 € per housing place.

Introduction

The group housing of lactating sows represents an economically interesting and also animal welfare alternative to the otherwise usual individual housing in this phase. It probably has the potential to optimise the profitability of sow husbandry in organic farming (FiBL 2007). However, these group housing systems are as yet not common (Kühberger & Jais 2006) and there is a lack of economic data. Due to this a comparison with other forms of housing is impossible.

The most important target is to analyse whether the group housing of lactating sows is a possibility to potentially increase the profitability of sow husbandry. This study makes a contribution to fill existing information gaps and create more planning security for farm managers. The economic effect of the housing system is primarily recognisable on the performance, the housing construction costs and working time requirement. Therefore the performance with group housing is measured using biological parameters. Furthermore, the potential for cost reduction within the range of sty construction is analysed. The correlation with working time requirement is not part of this research paper.

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Materials and methods

In this study the term group housing means the combination of individual and group housing over time, because all farms in this research practise it in this way. The empirical data on performance and construction of sow styes are available in a co-operation project (FiBL 2007). The database for this study covers 30 farms, 10 in Germany, 9 in Austria and 11 in Switzerland. For the investigation of the biological parameters, the farmers made written notes for an average of 9 months. 1214 litters were available for evaluation. The empirical data on housing structure was available in the form of sketches and photo documentations.

The biological parameters of "piglet losses", "weaned piglets/ litter" and "reared piglets/ litter" are the interfaces, on which the economic effects of the housing system is recognisable. Firstly, parameters are calculated on the level of each individual farm and afterwards an integrated evaluation is carried out. The parameters in the calculation conform to the arithmetic mean or the weighted mean. Additionally to the means of all farms the parameters are also evaluated for the 25% best, the average ones and the 25% worst. The classification of success is based on the number of weaned piglets per litter. Since this parameter has a normal distribution according to the Shapiro Wilk test, the evaluation conforms to the formation of quartiles. Afterwards the results are to be compared with those of other studies. This procedure makes it possible to determine the performance ability of farms with group housing even if the real influence of the housing system cannot thereby be proven.

The influence of the housing system on the sty construction costs is examined by modelling. Doing so, uniform conditions and realisation can be simulated, that again makes it possible to compare different options of construction concerning the costs. According to the target to determine the financial saving potential of group housing, the investigation focus is concentrated on the housing for farrowing and lactating sows. The empirical data of the group pens on the farms in the research are the basis for further modelling. Additionally to the construction models, the necessary farm models are defined: population of 72 sows, 36 housing places in the housing for farrowing and lactating sows. An additional expert interview supports the accuracy of the achieved results. A scenario for new construction and for modification of buildings (building shell already exists) is depicted. The calculation of construction costs (structure of the costs) is according to DIN 276. The kind of cost calculation is according to DIN 276 cost estimation and cost accounting. In this study only cost groups 300 (construction), 400 (technical facilities) and 500 (outside facilities) are calculated. Other cost groups remain unconsidered, since they are not relevant to answer the given question.

Results

Performance (Tab. 1):

- The parameters of piglets born alive, weaned and reared piglets per litter are significantly different between the farms in research.
- Better farms have less loss of piglets even if the differences were not significant.
- The performances in group housing are better throughout than those of the farms in the comparative studies (partly even comparing the average of this study with the best of these in other studies).

- Based on the assumption of additional 0.5 piglets per litter (ca. 1 piglet per sow and year) and a price of 80 € per piglet, means that there is an extra income of 80 € per sow and year.

Tab. 1: Sow husbandry - Performance parameters *(comparison)*

Parameter \ Farms	number of farms in research	all farms [mean]	25% worst farms [mean]	25% best farms [mean]
live born piglets/ litter [mean]	30	11,01[a]	9,94[b]	12,02[c]
mortality in the farrowing pen [% of live born piglets]	27	15,06	15,75	13,48
mortality in the grouping pen [% of live born piglets]	27	3,35	4,01	2,94
total suckling piglet mortality [% of live born piglets]	28	18,62 *(21*)*	19,76	16,43 *(16,7*)*
weaned piglets/ litter [mean]	30	9,00[a] (8,1*)	7,96[b] *(7,2*)*	10,05[c] ***(8,5*)***
rearing loss (after weaning) [% of live born piglets]	16	1,90 *(5,5*)*	1,46	2,91
reared piglets/ litter [mean]	16	8,59[a] *(7,5*)*	7,63[b]	10,11[c] ***(8,15*)***
total piglet mortality [% of live born piglets]	16	all farms [mean]: 21,2 (2002/03: 26,6 %**; 2004/05: 23,6 %**)		

Different letters per row indicate significant differences at $p<0.05$ (Tukey HSD).
* Source: Löser & Deerberg 2004 (17 organic piglet producers-no differentiation between housing systems)
** Source: Löser 2006 (2002/2003: 17 organic piglet producer; 2004/2005: 20 organic piglet producers-no differentiation between housing systems)

Construction costs (Tab. 2):

Tab. 2: Comparison of construction costs in sow husbandry

	farm model 1		farm model 2 (farrowing house with 36 housing places)
	farrowing house (12 housing places)	sty with grouping pens (24 housing places)	
capital expenditure for modification of buildings	33.662 €	31.582 €	100.986 € (2.805 €/ housing place)
	65.244 € (1.812 €/ housing place)		
capital expenditure for new construction	82.721 €	110.952 €	218.471 € (6.069 €/ housing place)
	193.673 € (5.380 €/ housing place)		

farm model 1: group housing (population of 72 sows)
farm model 2: individual housing (population of 72 sows)

- Group housing reduces construction costs by 993 € per housing place when existing buildings can be modified.
- Group housing reduces construction costs by 689 € per housing place when new construction of buildings is necessary.
- The annuity of 993 € (11 years useful economic life, 5 % interest rate) is 120 € per year, equivalent to 1.5 piglets.
- Group housing reduces costs since there are not so many expensive farrowing pens necessary.

Discussion

Performance:

The comparison with the parameters measured by Löser and Deerberg shows that on farms with group housing, examined for this study, better results are reached. It could be concluded that group housing of lactating sows leads to an increase in performance. Nevertheless the causality is not yet finally proven. Appropriate results from comparative housing experiments, are at present not adequately existent.

Construction costs:

The calculation in this study is done for a farm model, so that the costs in a real planning situation have to be examined. In this calculation complete new sty equipment is assumed as well as all services from construction firms. In practice the situation is often different, so that the construction costs may be lower. The cost difference for newly built styes is lower because 2 houses in farm model 1 are assumed.

Conclusions

The results show that the housing system is suitable and efficient on farm level. With group housing of lactating sows the construction costs could be reduced considerably. According to the present level of knowledge the profitability of sow husbandry in organic farming can be optimised by the analysed group housing system.

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Relationships between sow and piglet traits in organic production outdoors and indoors

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Key words: organic production, piglet mortality, piglet growth, weight loss, backfat loss

Abstract

The aim of this study was to describe sow and piglet traits and the relationship between them in animals bred for conventional production kept in organic outdoor and indoor environments. *40 sows were studied during a seven week lactation. In parity one and three the sows farrowed outdoors (April to September) in huts and were moved to family grazing paddocks two weeks post partum (pp). In parity two and four the sows farrowed indoors (October to March) in individual pens and were moved to family pens with deep straw bedding two weeks pp.* High backfat and weight loss during lactation was related to low piglet mortality and the relationship was stronger outdoors than indoors. Large litters had lower piglet growth than small litters and the relationship was stronger indoors than outdoors. Sows with larger litters were thinner and lighter at weaning than sows with smaller litters and the relationships were stronger outdoors than indoors. Our interpretation is that the outdoor environment stimulates sows to mobilise their energy reserves and produce milk, to a larger extent than the indoor environment does.

Introduction

The animals used in organic piglet production today are in most cases animals bred for high production in conventional environments. There is a range of housing and management systems in organic piglet production, determined by herd conditions and country regulations for organic production. Traits have different importance in different environments. Production level differs between breeds in outdoor environments (McGlone and Hicks, 2000). Sow and piglet traits differ in production level between outdoor and indoor environments (Wülbers-Mindermann et al., 2002).

To select suitable animals and develop good management procedures for different organic environments, it is important to know how the animal material used performs in the different environments. The aim of this study is to describe sow and piglet traits and the relationship between them in animals bred for conventional production kept in organic outdoor and indoor environments.

Material and methods

Forty Yorkshire x Swedish Landrace sows and their first four litters were studied at a research station, on the 60th latitude. The research station was not certified as organic but rules of the Swedish organic certification organisation KRAV were followed, with three exceptions; the sows were dewormed, the feed was not organically grown and

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the indoor housing did not have outdoor access. The sires of the litters were Hampshire boars. The sows were born and raised outdoors. Sows farrowing during winter and spring were kept indoors and sows farrowing summer and autumn were kept outdoors during pregnancy. In parity one and three the sows farrowed in huts (3.9 m2) in individual grazing paddocks (2500 m2). Two weeks post partum (pp) four sows and their piglets were moved to grazing paddocks (14000 m2) with one hut (13.0 m2) and one sun shed (11.0 m2). In parity two and four the sows farrowed indoors in conventional Swedish farrowing pens without crates (8.2 m2). Two weeks pp, four sows and their litters were moved to pens (55m2 – 114m2) with deep straw bedding in an uninsolated building. The sows were individually fed during pregnancy, in the farrowing paddocks and in the farrowing pens. In the family paddocks and the family pens the sows were fed ad lib from an automatic feeder, to which piglets had access. The feed followed a typical Swedish organic feed composition, with 12.2 MJ ME, 154.3 g crude protein, 122.6 g digestible protein and 7.5 g lysine per kg feed. The sows were weighed and measured for backfat (ultrasound) five days before expected farrowing as well as at two and seven weeks of lactation. The piglets were individually weighed at day four, two weeks and seven weeks pp. Piglet mortality was registered continuously from farrowing until weaning. During the first parity two sows were excluded the second week pp, one was treated for disease and the other was culled. Three sows were culled after weaning their first litter. During the second parity one sow was culled the second week and another during the fourth week pp. Two sows were culled after weaning their second litter and seven sows after their third litter.

The statistical analyses were performed with the SAS package, version 9.1 (SAS institute, 2007). PROC GLM was used to estimate residual correlations. Number of live born piglets (15 classes), farrowing season (4 classes) and parity (4 classes) were included in the model. There was no significant interaction between season and parity. Number of live born piglets was excluded from the model when calculating correlations with litter size. For piglet weight day 4 and at weaning, age at weighing (days, 4 and 16 classes, respectively) were included in the model. For sow weight at farrowing and sow weight loss from farrowing to weaning, days from weighing to farrowing (mean 6 days std. 1.9) was included in the model (12 classes). Sow weight five days before expected farrowing was pre-corrected for estimated litter, placenta and amniotic fluid weight to better reflect the sow weight directly after farrowing.

Results

Least square means for production traits in different parities are given in Table 1. The negative correlation between litter size and piglet growth was stronger indoors than outdoors (Table 2). Sows with larger litters were lighter and thinner at weaning than sows with smaller litters and the relationships were stronger outdoor than indoor. Sows that lost much weight during lactation and were light and thin at weaning had lower mortality in their litters compared to fat and heavy sows, both indoor and outdoor. (Table 2). Piglet growth was not significantly correlated to sow weight or backfat loss. Outdoor litters with high mean piglet weight four days pp had lower mortality than litters with low piglet weight (Table 2). Large indoor litters had higher mortality than small litters (indoor r=0.30*, outdoor r=-0.10ns).

Tab. 1: LS-means[1] for production traits in parity 1 to 4

	DF	Parity 1 Outdoor N=37-40	Parity 2 Indoor N=33-36	Parity 3 Outdoor N=31	Parity 4 Indoor N=25
Litter size at d4	125	8.8^{a}	11.6^{b}	10.5^{b}	12.8^{b}
% total mortality until weaning	107	30.1	23.3	31.2	20.5
Piglet mean weight at d4 (kg)	104	1.9^{a}	2.4^{b}	2.4^{b}	2.3^{b}
Piglet growth, d4 - weaning (g/day)	86	283^{a}	393^{b}	348^{b}	409^{b}
Sow weight at weaning (kg)	104	196^{a}	228^{b}	264^{c}	273^{c}
Sow weight change (kg)	91	-22^{ab}	-19^{a}	-32^{a}	-8^{b}
Sow backfat thickness at weaning (mm)	104	13.0	12.6	15.2	15.9
Sow backfat change (mm)	103	-6.9^{a}	-4.2^{ab}	-3.4^{bc}	-1.5^{c}

[1]The values marked with different superscripts on the same row differ from each other (p<0.05). The effect of parity and weighing days were included in the model.

Tab. 2: Residual correlations between litter size, piglet mortality and piglet and sow traits

	Number of piglets d4		% piglets dead until weaning of live born	
	Outdoor Parity 1 and 3	Indoor Parity 2 and 4	Outdoor Parity 1 and 3	Indoor Parity 2 and 4
Piglet mean weight at d4	-0.53^{***}	-0.72^{***}	-0.41^{**}	$-0.30^{\dagger}$
Piglet growth, d4 - weaning	-0.45^{***}	-0.72^{***}	0.39^{*}	0.04
Sow weight at weaning	-0.35^{**}	-0.03	0.44^{**}	0.43^{*}
Sow weight change	-0.12	$-0.28^{\dagger}$	0.44^{**}	0.38^{*}
Sow backfat thickness at weaning	-0.47^{***}	-0.40^{**}	0.39^{**}	0.53^{***}
Sow backfat change	-0.20	-0.16	0.42^{**}	0.00

*** = p<0.001, ** = 0.001<p<0.01, * = 0.01<p<0.05, † = 0.05<p <0.1.

Discussion and conclusions

During lactation, the sow has to handle the parent-offspring conflict; she has to prioritize between her own, her present litter's and her future litters' needs (Manning and Stamp-Dawkins, 1998). During the first parity the sow is not yet fully grown and need to prioritize energy also to her own growth (Noblet et al., 1998). In accordance to this we found that in first parity litter size, piglet mean weight, piglet growth and sow weight at weaning were significantly lower, and sow weight loss was significantly higher than in later parities (Table 1). Wülbers-Mindermann et al. (2002) found that sows with large litters lost more weight and fat during lactation than sows with small litters and that the relationship was stronger outdoor than indoor. In the present study we found no significant correlation between litter size and sow weight or backfat loss. Yet, we found that sows with large litters were lighter and thinner at weaning and the relationship was stronger outdoor than indoor. The outdoor environment seems to stimulate sows to mobilize energy reserves to produce milk to a larger extent than the indoor environment does and this seems to be important also for piglet survival. In our study, sows losing little weight and backfat during lactation had higher piglet mortality in their litters, both indoor and outdoor. Outdoor this relationship was also found for backfat change. These findings are in accordance to Grandinson et al. (2005). In order to have energy for the next parity, it is important that the sow has the ability to store and rebuild fat and weight (Whittemore, 1996). In this study, backfat loss during lactation decreased and backfat thickness at weaning increased with parity number (Table 1).

Our interpretation of the estimated correlations from different environments is that an outdoor environment stimulates sows to mobilize their energy reserves and produce milk in favour of piglet growth, to a larger extent than the indoor environment does. It is important for organic pig producers to take these differences between environments into consideration in order to develop good sow management procedures for different organic environments.

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Effects of silage or probiotics on performance and gut microbial composition of organic growing-finishing pigs

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Key words: organic, growing-finishing pigs, nutrition, performance, microbiota

Abstract

*This paper will deal with the effects of the oral application of a probiotic preparation (Bifidobacterium animalis) and of the provision of forage (maize and grass silage) to growing-finishing pigs on the composition of the intestinal microbial population and faecal microflora as an important determining factor for pork safety. 76 pigs were reared in 4 different dietary treatments. Clinical health and immune status plus faeces samples and samples of the gut content from the duodenum, ileum, caecum and colon were collected from each animal. Since the second round of the feeding experiment was only finished in March, the datasets are still incomplete because analyses are ongoing, but preliminary results are already available. Microbial analysis showed that CFU (per g DM of faeces) of bifidobacteria ranged from 2.6*10^8 (maize silage treatment) to 8.7*10^8 (probiotic treatment). CFU counts of E.coli showed a significantly lower amount for the control treatment (4.4*10^5) compared with the grass silage- group (3.0*10^6). Blood analysis did not show significant differences between treatments. Both the high level of animal performance (ADG between 902 and 929 g/d) and the negative clinical findings confirm the good health status of the animals. Statistical analysis with the complete data set will soon show whether the trends from these preliminary results will be confirmed for the overall experiment.*

Introduction

Organic pork is placed as a premium product on the meat market. Besides the eating quality, the nutrient content and other product quality traits, organic production also has to guarantee a high level of food safety. Meat contaminated with pathogens will potentially threaten public health (Leclerc et al., 2002). Pathogens may be introduced into the pig production chain at several levels, reaching from the feed mill to the pork distributors. Therefore, control measures must be applied on different levels if meat safety is to be guaranteed (Lo Fo Wong et al., 2002). On the herd level, the occurrence of pathogens in the intestines of growing-finishing pigs can be seen as one potential starting point for further problems in the food chain. To avoid spreading of potential pathogens via this path, organic production systems focus on improved housing conditions, high quality components in nutrition and animal health and

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welfare. The concept of eubiosis seems to be a promising strategy for organic livestock; this includes the maintenance of a stable microbial population in the intestines which puts substantial competitive pressure on pathogens. Regulation 2092/91 (Council of the European Union, 1999) oblige organic farmers to provide forage as a routine management measure for monogastric livestock. This practice should lead to beneficial effects on animal health and welfare by maintaining homeostatic conditions in the intestines. The occurrence of enteric pathogens may be reduced due to the formation of organic acids and the growth of competing eubacteria which utilize a variety of fibre components (non-starch carbohydrates, oligosaccharides, cellulose etc. (Zentek, 1997; Brunsgaard, 1998; Stege et al., 2001)). Basically, a stable eubacterial microflora exerts fundamental stimuli on the formation of antibodies (Gebbers & Laissue, 1984; Alverdy et al., 1985).

Therefore in this study the effects of providing growing-finishing organic pigs with either grass silage, maize silage or a probiotic preparation were tested on performance, carcass quality and gut microbial composition.

Animals, materials and methods

The experiments were conducted at the experimental barn of the Institute of Organic Farming and Farm Animal Biodiversity (HBLFA Raumberg-Gumpenstein) from August 2006 until March 2007. 76 pigs were assigned to 4 different dietary treatments in two experimental rounds: control diet (ct), ct+grass silage, ct+maize silage, ct+probiotics. All groups were feed restricted from 90 kg BW onwards to the end of the experiment with a maximum daily feed provision of 2.7 kg of compound feed.

Each group (4 - 5 animals) was offered two to three kilograms of silage every morning. In case the total amount of silage was consumed by one group, the amount offered was increased. Before giving the fresh silage, the leftovers from the day before was weighed back in order to record the estimated amount that disappeared. Additionally, the n-alkane method (Mayes et al., 1986) was used three times per trial to estimate the forage intake. The probiotic group received a probiotic preparation (*Bifidobacterium animalis* subsp. *lactis* Ra 18, developed at the University of Bologna) fed daily together with the compound feed. Every pig in the probiotic group was planned to receive about 200 millions of bifidobacteria per day.

Results and discussion

Since the datasets are still incomplete due to ongoing analyses, preliminary results are presented herein. In table 1 the faecal microbial composition is given for the experimental treatments.

Tab. 1: Microbial composition of faeces (CFU/ g DM)

treatment	n	*Clostridium* sp.	*Bifidobacteria* sp.	*E. coli*
		$p = 0.030$	$p < 0.001$	$p = 0.059$
control	19	$1.19*10^8$ [ab]	$5.95*10^8$ [a]	$3.74*10^5$ [ab]
probiotics	19	$1.09*10^8$ [ab]	$9.04*10^8$ [c]	$1.70*10^5$ [a]
maize silage	19	$8.10*10^7$ [a]	$3.49*10^8$ [b]	$7.48*10^5$ [b]
grass silage	19	$1.57*10^8$ [b]	$5.03*10^8$ [ab]	$6.43*10^5$ [ab]

The only significant differences concerning the microbial composition so far detected are shown in table 1. In general the number of Colony forming Units (CFU) per g faeces was high, indicating a well established microbial community in the gastro intestinal tract. Some of the differences between treatments were significant but in microbiological terms too small to conclude a relevant effect. Realtime-PCR showed only 4 positive results in different groups and over the two experimental rounds. In the first round three samples at the slaughterhouse showed the presence of *Lawsonia intracellularis* (2 pigs from the grass silage treatment and 1 from the probiotic treatment) and in the second round one of the faeces samples contained *Lawsonia intracellularis* (grass silage treatment). Blood analysis did not show significant differences between treatments.

Both the high performance level (see table 2) and the negative clinical findings confirm the good health status of the animals.

Tab. 2: Animal performance

treatment	n	daily weight gain	carcass	lean meat	pH
		p = 0.634	p = 0.215	p = 0.093	p = 0.003
control	19	902 g/d	79.01 %	58.52 %	6.41[ab]
probiotics	19	929 g/d	79.39 %	57.84 %	6.39[ab]
maize silage	19	916 g/d	79.09 %	59.64 %	6.26[b]
grass silage	19	903 g/d	79.61 %	58.74 %	6.48[a]

Preliminary results for forage intake using the n-Alkane method (Mayes et al., 1986) from the first sampling period (1st experimental round) showed that all animals consumed certain amounts of forage. The control and probiotic group consumed only straw (from the straw bedding) and the grass and maize silage group a mixture of straw and silage. The relation of straw and silage is unknown but intake of grass and maize silage was observed for both silage groups.

Obtaining reliable results from daily weighing of the trough feeder was sometimes difficult. All of the animals showed distinct explorative behaviour using silage as substrate; due to its structure and other factors, maize silage was obviously more attractive for pigs than grass silage. Obvious losses had to be replenished without adding too much straw or other organic material from the area around the trough feeder. After the n-Alkane analysis is completed, the results will help to correctly interpret the results derived by weighing and to estimate the overall forage intake (table 3).

Tab. 3: Estimated forage intake using the n-Alkane method (Mayes et al., 1986) and weight difference

treatment	n-Alkane method (**g as fed** /d & pen)	weighing trough feeder (**g as fed** /d & pen)
control	299	
probiotics	234	
maize silage	1503	450
grass silage	588	465

However, the stimulating effect of fibre components on the gut microbiota should be granted even if the lactic acid bacteria do not survive the stomach passage. Additional effects can be expected from the formation of organic acids which help create a hostile environment for enteric pathogens in the gut (Zentek, 1997; Brunsgaard, 1998; Stege et al., 2001). From the data available so far it can be concluded that supplementing organic growing-finishing pigs with maize silage, grasssilage or a probiotic preparation consisting of a certain strain of *Bifidobacteria* sp. does not significantly affect performance and carcass traits. Effects on the microbial composition of faeces may be too small to be of practical relevance and need to be confirmed by analysis of digesta samples from different positions of the intestinal tract.

Acknowledgments

The authors gratefully acknowledge funding from the European Community financial participation under the Sixth Framework Programme for Research, Technological Development and Demonstration Activities, for the Integrated Project QUALITYLOWINPUTFOOD, FP6-FOOD-CT-2003- 506358. The views expressed are those of the authors, not of the commission.

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Prolonged suckling period in organic piglet production – effects on selected immunological parameters

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Key words: Organic piglet production, prolonged suckling period, weaning age, immune system

Abstract

During weaning, piglets are under strain from the loss of their dam, the change in feed, and a new microbiological environment. How much this strain influences the piglets depends mostly on their immune system. Piglets from organic production are weaned later (at least 40 days) than piglets from conventional rearing, but the performance and health status of organic piglets are often not satisfying. Therefore, it was the aim to investigate whether a prolonged suckling period of 63 days results in better immune status of piglets than with weaning at day 42. To answer that question we vaccinated piglets at different times with a "known" (by vaccination of dam) and an "unknown" antigen and analysed the plasma for immunoglobulin G (IgG) concentration and the antigen-specific IgG antibodies by ELISA. Two farrowing cycles of 36 sows were recorded. Time of vaccination did not influence IgG concentration. In contrast, early weaned piglets showed a higher IgG concentration on day 49 than late weaned piglets. During the first farrowing cycle a significant immune response against both antigens was present in piglets vaccinated on day 42. Such a response was not found in piglets vaccinated on day 63 and in piglets of the second farrowing cycle. In conclusion, the results did not show an improved immune status of piglets undergoing a suckling period of 63 days.

Introduction

Organic piglet production is often characterized by poorer performance compared with conventional reared piglets. Whereas the number of piglets born alive is the same, the number of reared piglets is definitely too low (Löser, 2007). Weaning challenges piglets in many different ways. How much the different strains influence the health status of the piglets depends mostly on the immune system. Passive immunity, firstl established by immunoglobulin transfer by colostral milk from the sow to the piglets, decreases in the piglet as long as the production of endogenous immunoglobulin is at

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the beginning. This leads to an "immunological gap" between day 20 and day 40 (Lang, 2004). Even if piglets from organic production have a longer suckling period (at least 40 days, minimum requirement of the EEC Regulation 2092/91) than piglets from conventional rearing, the "immunological gap" still seems to be present in those piglets, leading to the described consequences in performance and health status. Therefore, it was the aim of the present study to investigate whether a prolonged suckling period of 63 days results in better immune status of the piglets compared to weaning at day 42. The immune response to a "known" and "unknown" antigen was tested.

Materials and methods

The trial was performed from spring 2006 to mid 2007 at the experimental organic farm of the Institute of Organic Farming of the Federal Agricultural Research Centre in Trenthorst, Germany, in accordance with Regulation 2092/91/EEC and the IFOAM Basic Guidelines. A total of 44 sows of the genotype "Schaumann" (crossbreed of German Landrace, German Large White, and Duroc) were kept: 36 sows were used for the investigation and 8 sows were kept in reserve in a parallel farrowing rhythm in order to replace sow losses.

The 36 sows were divided into 4 groups with the following treatment of the piglets: (I) early weaning and vaccination (day 42); (II) early weaning (day 42) and late vaccination (day 63); (III) late weaning (day 63) and early vaccination (day 42); (IV) late weaning and vaccination (day 63). Fourteen days after single grouped farrowing, three sows were grouped together with their respective litters and were group housed until weaning. At the weaning date the sows were removed. The weaned piglets remained in their familiar surroundings for 4 days. Then they were housed in separate indoor rearing pens in the composition of the previous suckling pig groups. Piglets were vaccinated with two antigens: avian immunoglobulin Y (IgY), which should be "unknown" for the piglets; and the "known" ovalbumin (OVA). For that antigen, maternal antibodies should exist because of a vaccination of the sows before farrowing. Secondary vaccination (Booster) was done 21 days later.

Blood was sampled from eight piglets per litter on days 7, 42, 49, 63, 70, 84, and 91. Plasma was analysed for immunoglobulin G (IgG) concentration and for specific IgG antibodies against IgY and OVA by a sandwich ELISA (Erhard et al., 2001). Two farrowing cycles were recorded.

Because of a significant influence of the sows on the IgG concentration of piglets on day 7, we pooled the values of the piglets for each litter. Thereafter, two-way analysis of variance with the factors "time of weaning" and "time of vaccination" was used for the statistical comparison of groups in IgG concentration, including both farrowing cycles. Specific IgG anti-OVA and IgG anti-IgY titer were compared between early and late weaned piglets separately for each farrowing cycle by Student's t-test and Mann-Whitney's rank sum test, respectively.

Results

Despite a higher level in the course of IgG concentration over time of late vaccinated piglets in contrast to early vaccinated piglets, vaccination itself did not seem to have any influence on the IgG concentration (Fig. 1).

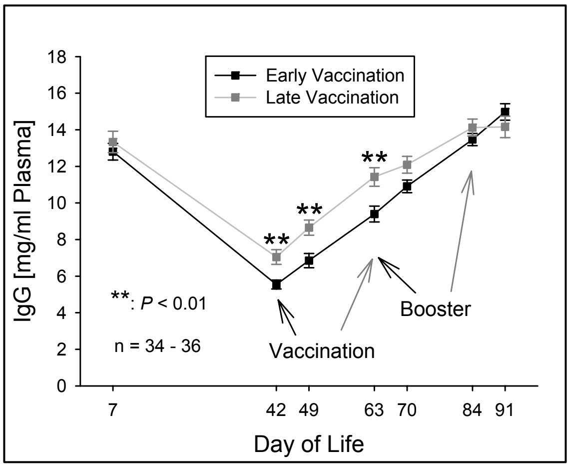

Figure 1: IgG levels of piglets early and late vaccinated, independent of the time of weaning. Mean ± SEM of litter means from 34 - 36 litters and eight piglets per litter.

However, early weaned piglets showed a higher IgG concentration on day 49 than late weaned piglets (Fig. 2).

During the first farrowing cycle a significant immune response against OVA and IgY was present in piglets vaccinated on day 42, independent of the time of weaning. Such a response was not found in piglets vaccinated on day 63 and in piglets of the second farrowing cycle (data not shown).

Discussion

The course in IgG levels over time of all treatment groups is congruent with data from conventionally reared piglets weaned after 21 days (Lang, 2004). The differences in the IgG values between early and late vaccinated piglets might be caused by the study design, where the allotment of sows and litters to the different treatments was oriented to the more important factor “time of weaning”. Interestingly, early weaned piglets showed a significantly higher IgG concentration on day 49. It is known that weaning increases the production of inflammatory cytokines (Pie et al., 2004), but it is postulated that weaning stress decreases the immune response (Blecha et al., 1983). Additionally, such an IgG “response” was not present in piglets after weaning at day 63.

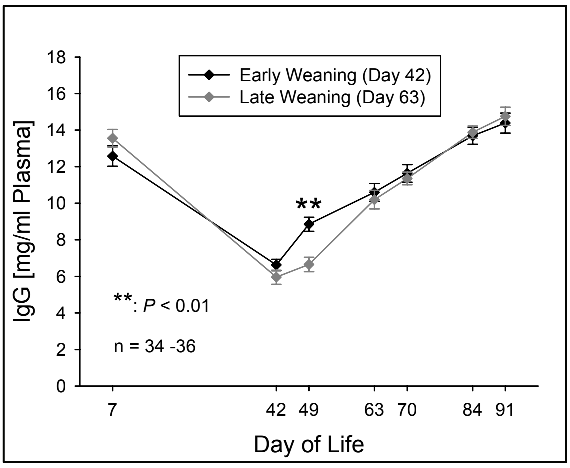

Figure 2: IgG levels of piglets early and late weaned, independent of the time of vaccination. Mean ± SEM of litter means from 34 - 36 litters and eight piglets per litter.

Conclusions

The results of the present study did not show an improved immune status of piglets undergoing a suckling period of 63 days. However, because good performance and health status of these late weaned piglets was found by Bussemas and Weissmann (2008, in this volume), a prolonged suckling period compared to the minimum requirement of the EEC Regulation 2092/91 seems to be recommendable.

Acknowledgments

This work was supported by the Bundesprogramm Ökologischer Landbau, Project No. 03oe378.

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Antimicrobial effect of dietary nitrate in weaning piglets challenged or not with Salmonella enterica serovar typhimurium

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Key words: nitrates, intestinal microbiota, weaning piglets, Salmonella.

Abstract

The maintenance of a beneficial bacteria balance in the gut is important to increase the animal's resistance to diseases. Nitrite may kill gut pathogens representing a non-immune defence mechanism. Nitrite can be derived from dietary nitrate that is reduced under the acidic conditions of the oral cavity.

An in vivo study was designed in order to establish the antimicrobial effects of dietary nitrate on the gut microbiota and on the health of 96 weaning piglets. The pigs were fed a diet containing high levels of nitrate (15 mg/kg feed and 150 mg/kg feed) and then challenged with Salmonella enterica serovar typhimurium. Changes of the intestinal microbiota composition were assessed by analysing the stomach and jejunum contents from all the pigs.

Results showed that nitrate only affected the population levels of Lactic Acid Bacteria (LAB) in both segments. Pigs challenged with Salmonella showed a reduction in the levels of E. coli and clostridia in the jejunum suggesting a mechanism of competition for niches or for active sites. The time from challenge significantly decreased the number of LAB in stomach and jejunum. It also decreased the population density of clostridia in the stomach. The supplementation of feedstuff with high dietary nitrate intake contemporarily to the challenge with Salmonella did not affect the degree of ulceration in the pigs.

Introduction

To combat pathogens is of primary importance in livestock production. This due to the economically damaging problems linked with infections caused by pathogens in newborn animals (Jacobson et al., 2003).

It has recently been shown that compounds such as nitrates, become powerful antimicrobial agents to acid conditions (e.g. stomach). They increase the resistance to

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pathogens, whereas acid alone would only have a bacteriostatic effect (Dykhuizen R. et al., 1996).

When dietary nitrates are swallowed they are rapidly absorbed mostly from the upper small intestine and lesser from the stomach in the blood stream (McKnight G.M. et al., 1997). Nitrates are then concentrated into the salivary glands (Spiegelhalder B. et al., 1976). Approximately 25% of dietary nitrate is re-circulated by this process named “enterosalivary circulation”. Nitrites are then formed from nitrates in the oral cavity by nitrate reductase expressed by microorganisms in the mouth and then re-secreted into the upper intestinal tract (McKnight G.M. et al., 1999; Dykhuizen R. et al., 1996).

Nitrates can have antimicrobial effects not only towards intestinal pathogens as *Salmonella*, *Yersinia* and *E. coli* strains, but also against *Helicobacter pilori* (Benjamin N. et al., 1994), a bacterium that could be responsible for ulcers in the mucous of the stomach. These ulcers represent a problem from the commercial point of view of the livestock production, due to the reduction of the feed conversion power and of the animal growth (Preziosi R. et al. 2000).

Furthermore the recirculation of nitrates by the organism into the “enterosalivary circulation” would also suggest a beneficial function of nitrates for the animals (McKnight G.M. et al., 1999).

The aims of this study were to assess the impact of increasing doses of dietary nitrate on ulceration levels in pigs and to quantify the effect of supplementing the diet of pigs with nitrates on the population density of normal stomach and upper intestine microflora.

Materials and methods

The experiment was carried out to test the effect of two different doses of nitrate supplied by potassium salt, on normal stomach and upper intestine microbiota and ulceration levels in the stomach of pigs challenged or not with *Salmonella enterica* serovar *typhimurium*. The pigs were challenged with 1.5 ml broth orally supplied containing $1x10^9$ CFU *Salmonella enterica* serovar *typhimurium.* Control pigs received a placebo (only broth). Half of the pigs were sacrificed on day+7 (+ 2 after being challenged), and the other half on day+25 (+20 after being challenged).

A total of 96 pigs (Landrace x Large White), weaned at 21 days, were randomly assigned to one of the following treatments: 1. base diet (16 pigs); 2. base diet + 15 mg/kg nitrates (16 pigs); 3. base diet + 150 mg/kg nitrates (16 pigs); 4. base diet + Salmonella (16 pigs); 5. base diet + 15 mg/kg nitrates + Salmonella (16 pigs); 6. base diet + 150 mg/kg nitrates + Salmonella (16 pigs).

The stomach was removed for quantification of the ulcerae. The gastric content was measured for pH after sacrifice.

Using plate counts, five microbial groups were enumerated in the stomach and in the jejunum contents: LAB, *Bifidobacterium* spp., *E. coli*, *Clostridium* spp, and Yeasts. The quantitative detection of *Bifidobacterium* spp. was also performed by a direct semi-quantitative genus PCR. The pathogen *Salmonella enterica* serovar *typhimurium* was qualitatively detected in faecal samples, mesenteric lymph nodes and in jejunum contents.

The data were analysed by analysis of variance (GLM of SAS) of three factorial models, A) data in vivo before challenge: diet and block (batch); B) data post challenge: model A + challenge (yes/not) and the interaction; C) data obtained at different days of sacrifice: model B + day of sacrifice (2 or 20 days from the challenge) and the interaction. Orthogonal pre-planned comparisons were tested for the effect of the diet: control vs. nitrate additions; between nitrate additions.

Results

The effects of the diet, the challenge and the time from challenge on average values of cultivable microbial groups in stomach and jejunum contents are shown in table1.

There were no interactions between the different factors.

In both segments, the population density of clostridia, bifidobacteria, yeasts and *E. coli* were not affected by the diet. However the concentration of *E. coli* in the stomach was sufficient to be recoverable by plate counts in 62.5% of the pigs in the control group, whereas in the groups of pigs receiving nitrates the frequency of pigs positive for the *E. coli* presence was lower (ranging from 31-37%). With higher intake of nitrate (150mg/kg), a significant decrease in the levels of LAB was observed in jejunum contents (P<0.05).

The time from challenge had an important effect of decreasing the counts of LAB in both segments and the counts of clostridia in the stomach (P<0.01).

In challenged pigs, *E. coli* significantly decreased in jejunum, whereas we only noted a trend of decreasing clostridia counts in the same segment.

Table 1. Effect of the diet, challenge and time from challenge on average values of bacteria in the stomach and in the jejunum contents of pigs fed high nitrate concentration.

	Diet				Challenge Salmonella			Days post challenge		
Stomach	**C**	**Ni15**	**Ni150**	**SEM**	**no**	**yes**	**SEM**	**2**	**20**	**SEM**
E. coli [a]	2.90	3.21	3.44	0.34	3.04	3.32	0.28	2.96	3.40	0.29
LAB	5.99	6.09	6.19	0.34	6.19	5.99	0.28	6.97	5.20	0.28 [b]
Yeasts	5.29	5.31	5.45	0.24	5.40	5.30	0.20	5.57	5.13	0.20
Clostridia	5.61	5.54	5.96	0.31	5.84	5.56	0.25	6.39	5.02	0.25 [b]
Bifidobacterium spp.	6.41	6.18	6.38	0.12	6.38	6.26	0.10	6.53	6.11	0.09
Jejunum										
E. coli [a]	5.82	5.90	6.01	0.32	6.32	5.50	0.26 [c]	5.96	5.86	0.26
LAB	6.55	7.17	6.51	0.21 [e]	6.93	6.56	0.17	7.14	6.35	0.17 [b]
Yeasts	5.79	5.87	5.82	0.22	5.82	5.83	0.18	5.78	5.88	0.18
Clostridia	7.05	7.13	7.17	0.20	7.31	6.92	0.17 [d]	7.16	7.07	0.16
Bifidobacterium spp.	6.82	7.07	6.46	0.19	6.65	6.91	0.16	6.86	6.70	0.16

[a] Only 32 pigs had detectable values: 10 for C, 12 for Ni15; 10 for Ni150; 20 for unchallenged, 12 for challenged pigs.

[b] Days Post challenge, P < 0.01.

[c] Challenge, P < 0.05. [d] Challenge, P = 0.10.

[e] Ni15 Vs Ni150, P < 0.05.

Interactions between different factors were never statistically significant (P > 0.05).

Discussion

The dietary addition of nitrate and the presence of *Salmonella* did not affect the degree of ulceration in the stomach. The appearance of the gastric mucosa was indicative of a healthy condition of pigs. The supplementation of the diet with nitrates did not affect the population density of the bacteria in both segments, with the only exception of cultivable LAB in the jejunum contents that significantly decreased ($P<0.05$). The reduction of LAB content with time, and therefore with age, could be linked to the suspension of milk supplementation after weaning that reduces the intake of substrates favourable for LAB growth.*Salmonella enterica* serovar *typhimurium* was found in almost all challenged pigs. In jejunum contents of challenged piglets there was a significant reduction of *E. coli* concentration ($P<0.05$) and a trend of reduction in clostridia levels. This could be probably due to a niche exclusion mechanism and/or to a competition for active sites. Nitrates did not seem to confer resistance against the *Salmonella* colonisation, even though some unchallenged pigs also resulted positive for the *Salmonella* presence in the lymph nodes and in jejunum contents.

Acknowledgments

The authors gratefully acknowledge funding from the European Community financial participation under the Sixth Framework Programme for Research, Technological Development and Demonstration Activities, for the Integrated Project QUALITYLOWINPUTFOOD, FP6-FOOD-CT-2003- 506358.

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Organic ruminant feeding

How can the organic dairy farmer be self-sufficient with vitamins and minerals?

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Key words: Dairy, Decision support model, Mineral, Vitamin,

Abstract

The aim of the present paper is to present a prototype of a decision support model simulating the feed and vitamin supply during a year on a farm self-sufficient with feed. The model takes into account that the content of vitamin and minerals depends on choice of crops, conservation method, season, plant development at harvest, quality of the silage production, and duration of storage together with traditional optimizing of the feeding scheme.

Introduction

Self-sufficiency and recirculation of nutrients within the farm are central elements of the organic principles and if supplements such as vitamins and micro minerals are necessary they should come from natural sources, if possible (IFOAM, 2002). Organic dairy herds are fed 100% organically grown feed, but most supplements of minerals and vitamins are based on inorganic and synthetic products imported to the farm. Our hypothesis is that self-sufficiency with vitamins and minerals could be obtained at farm level through optimization of the choice of forage crops, management and combination of feedstuffs.

Materials and methods

The decision support model is a static, deterministic model that calculates the consequences of choosing different strategies for feed production. Inputs are type of crops grown, including the use of herbs; conservation methods; season, stage of plant development at harvest, quality of the silage production and duration of storage. Output is the total supply of vitamins and mineral from the feed production on the farms, as well as actual supply for the different animal groups during the season. The model is therefore also a way to plan the use of the produced feed strategically during the season taking into account the loss of vitamins during storage. In the model, focus is primarily on the supplementation of zinc (Zn), copper (Cu) and selenium (Se) and vitamin A and E.

Results and discussion

The highest concentrations of pro-vitamin A (in the form of beta-carotene) and vitamin E (alfa-tocopherol) are found in grass, legumes and other green plants, while seeds, whole crop and corn silage only contain small amounts of vitamins. Some herbs have especially high levels of one or more minerals. A high concentrations of Zn, Cu, Se has been found in chicory and plantain (Sanderson et al., 2003) and sainfoin had a

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high Cu and Zn concentration (Kidambi et al., 1990). One means of ensuring adequate mineral nutrition of the diet is to increase the floristic diversity of the sward. The model includes the crops traditionally grown on organic dairy farms: barley, oats, wheat, maize, peas, blue lupines, perennial ryegrass, white and red clover, and lucerne. Furthermore some new crops and herbs are included: timothy, chicory, plantain, caraway, bird's-foot trefoil, sainfoin, chervil and salad burnet.

Grazing cattle normally have their requirements for fat-soluble vitamins met, whereas the content of fat-soluble vitamins may decrease to very low amounts when conserved herbage is used instead of pasture. The content of vitamin E in the ensiled crop is 59% lower for grasses and clover, when compared to the fresh crop and the content of vitamin A is reduced by 75% (Jensen, 2003) by ensiling. Hay making causes an up to 90% reduction in the content of A and E vitamin when compared with fresh grass (Jensen, 2003). The vitamin loss is lower if grasses and clover are dried for pellet production, compared with fresh crops there is a loss of vitamin E of 67% and of A vitamin of 25% (Jensen, 2003). In the model, grasses and legumes can be grazed, ensiled, harvested as hay or produced as pellets.

For grass-clover grazed it was found that the concentration of both Zn and Cu were increased during the season (Jensen et al., 2000). Also for chicory the contents of Cu and Zn were increased during the growing season (Jung et al., 1996). The model includes the effect of season by including month in which the crop is harvested.

The highest concentrations of pro-vitamin A and vitamin E are found in the green leaves, while stem and more mature crops only contain small amounts (Jensen, 2003). For lucerne and timothy, content of vitamin E fell by 20-65% depending on whether the crop was harvested at the grass-stage or at the full flowering stage (Kivimäe & Carpena, 1973). Flye & Strudsholm (1994) found that variation in plant development (digestibility) could explain 25 to 85% of the variation in content of vitamin E in whole crop silage. In the model plant development is defined as early, middle or late. It is assumed that the level of vitamin E is 33% higher than the average value for plants harvested at early development and 33% lower than average for plants harvested at late deveolpment.

In the model the quality of the silage production is defined by pH and ammonia.

The vitamins will undergo continuous degradation during storage, whereas the minerals will normally not be lost. The loss of E-vitamin in ensiled feed seems to be greater for whole crop than for grass silage, probably due to the higher risk of creating heat (Knudsen et al., 2001). According to Knudsen et al. (2001) 20% of vitamin E in the ensiled grass, clover and lucerne will be lost after six months of storage, for maize and whole crop silage the loss of vitamin E is expected to be 30-40% after six months. Number of months in storage is included in the model.

Strategies for feed production

In table 1 is presented different strategies for organic milk production based entirely on home-grown feed. Farm no 1 represent the present Danish organic milk production with a feeding level of 6415 kg dry matter per cow per year and a milk production of 8161 kg ECM per cow per year. 60% of the land on farm no 1 is grown with grass-clover for pasture and silage and 40% are grown with cereals for maturity and whole crop. On farm no 2 same strategy is used but the digestibility of the silage is lower, resulting in a lower level of feed intake and milk production per cow. On farm 3 maize silage make up 25% of the silage during winter-feeding and all silage during summer feeding. On farm 4 cereals is replaced by grass pellets.

In Table 2 is shown the level of vitamins (E and A in the form of beta-carotene) and minerals (Zn, Cu and Se) in summer and winter-feeding for the high yielding cows. Growing silage with low digestibility reduced total E vitamin production by 21%, and the level of vitamin E in the winter feeing ration for high yielding cows could not reach the recommended level for vitamin E. Replacing cereals by grass pellets increased total production of beta-carotene by 11%. All feeding rations were above the recommended level of beta-carotene.

During summer feeding, all strategies almost reached recommended level for Zn (95 to 98% of requirement). During the winter feeding the Zn requirement was only fulfilled by 83 to 85%, except for the grass pellet strategy that reached 96% of the requirement. Regarding supply of Cu, only 56-67% of the requirement is reached by the strategies, except for the grass pellet strategy that reach 82% of the requirement. Regarding supply of Se, only 38 to 49% of the requirement was reached by the strategies.

One way to increase the supply of Cu is to add chicory and plantain to the grass-clover fields as these crops both have a high content of Cu. If chicory and plantain each make up 10% of dry matter yield in all grass-clover fields in strategy 1, the total production of Cu from the 200 ha on the farm will increase by 30%. Thereby, it becomes possible to reach 95% of the recommended level for Cu. However, as crop yield (kg DM/ha) from chicory is assumed to be 75% of that of grass-clover, and crop yield from plantain is assumed to be 36% of that of grass-clover, the total crop production from the 200 ha will be 6.6% lower than that in strategy 1. Thereby, there will be feed for seven milk producing units (cows with heifers) less than in strategy 1 and income from milk will decrease by 6.1%. As expenses not are reduced proportionally, the financial result of the farm is decreased by 23% when Cu has to be supplied as home-grown feed.

Tab. 1: Feed ration per cow per year

Kg DM per cow per year	1 Basic	2 Low dig.	3 Maize	4 Grass pellets
Cereals	1628	1628	1382	826
Grass pellets	0	0	332	761
Grass-clover fresh	1518	1518	1518	1518
Grass-clover, silage high dig.	3269	0	1757	2472
Grass-clover, silage low dig.	0	3140	0	0
Maize silage	0	0	1341	0
Whole crop silage	0	0	0	903
Kg DM/cow/year	6415	6286	6330	6480
Milk production				
kg ECM/cow/year	8161	7505	8017	7781
kg ECM/ha/year	4990	4771	5273	5049

Conclusion

This model is supposed to be an effective way of combining existing knowledge with knowledge generated in other parts of this project and makes it applicable to organic farmers and advisers. This preliminary model will be developed in interaction with visits to the study farms, where the aims are to evaluate the present practice and to demonstrate relevant alternatives for mineral and vitamin supply.

Tab. 2: Content in rations for high yielding cows during summer and winter

Winter feed ration	1	2	3	4
E-vitamin, mg/cow/day	1248	622	1066	1290
Beta-carotene, mg/cow/day	743	685	745	775
Zn, mg/cow/day (% of requirement)	829 (84)	775 (83)	822 (85)	943 (96)
Cu, mg/cow/day	132 (67)	122 (65)	124 (64)	160 (82)
Se, mg/cow/day	0.79 (40)	0.75 (40)	0.74 (38)	0.77 (39)
Summer feed ration				
E-vitamin, mg/cow/day	1726	1772	1558	1518
Beta-carotene, mg/cow/day	1974	2007	1986	1837
Zn, mg/cow/day (% of requirement)	879 (95)	904 (95)	904 (96)	923 (98)
Cu, mg/cow/day	112 (61)	116 (61)	107 (57)	105 (56)
Se, mg/cow/day	0.91 (49)	0.93 (49)	0.88 (47)	0.89 (47)

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Production of grain legume crops alternative to soya bean and their use in organic dairy production

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Key words: high protein pea, field bean, lupin, dairy cattle

Abstract

This work evaluates the possibility to substitute external soya bean, a high risk GMO alimentary source, with other legumes produced on farm, such as sweet lupin, protein pea and field bean, as alternative protein source in the formulation of diet in organic dairy cattle nutrition. In 2005/2007 periods both the field and feeding trials were carried out in an organic dairy farm in Tuscany. The performances of grain legumes crops were evaluated in terms of grain yield and quality of grains. The alimentary experiment was carried out on dairy cattle fed with two diets: A with extruded soya bean and B with bitter lupin + field bean + high protein pea. In the field trial the Italian sweet lupin varieties (Multitalia) were the most interesting for CP production and pea the best for yield. The feeding trial provided that the protein content was higher for the A diet (with soya bean) while fat, somatic cells and urea content did not differ.

Introduction

Grain legumes crops represent a great resource in organic agriculture both to satisfy the nutritional content of organic livestock feeding and to maintain soil fertility. The commercial availability of organic grain legume is decreasing, the costs are high and the GMO contamination risk is particularly high for soya bean, used to achieve the high protein values required by the animals. So, the cultivation of grain legumes such as sweet lupin (*Lupinus albus*), field bean (*Vicia faba var. minor*), high protein pea (*Pisum sativum*) on farm could solve the problem and improve the sustainability of the farm. In particular lupin appears more interesting and promising. It has a DM yield in grain of 1-4 t/ha with a crude protein (CP) and oil content of 30 - 35 % and 10%, respectively (on DM). On contrast soy bean, a high risk GMO supplement, has a DM yield in grain of 2784 kg/ha and 40 - 41% of CP (on DM). Although sweet lupin is widely used in Northern Europe and other large areas of the world, in Italy it is not anymore widely cultivated and only one registered variety (Multitalia) is available. In this work we evaluate the substitution of soya bean with lupin to dairy cattle diet in terms of milk production.

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Materials and methods

The performances of grain legumes crops (sweet lupin, field bean and high protein pea) were evaluated in an organic dairy farm of Tuscany in 2005-06 (Migliorini et al., 08) and 2006-07 in terms of grain yield, competitive ability against weeds and quality of grains. The feeding trial was carried out on 36 dairy cattle of the Italian Holstein breed from the same dairy farm in Tuscany, divided in two groups, and fed with diet A, containing soya bean and diet B, containing lupin, from June 2006 to March 2007. To avoid the influence of age, season and ration, each group of 18 animals was composed with the same number of primiparous (9) and pluriparous (9), 6 in the 1st 100 days of lactation, 6 the 2nd (100-200 days) and 6 in the last part (>200 days). The two diets (table 1) were conform to the Reg CE 2092/91 for concentrate/forage ratio and they satisfied the energetic and protein needs of 600 kg milking cows with 32,5 kg/day milk production at 4% of fat (INRA, 1988). Feeds were analysed in order to determine dry matter (DM), crude protein (CP), fat, crude fiber (CF), ash according with AOAC methodology (AOAC, 1990) and fibrous fraction (NDF, ADF, ADL) according with Van Soest et al. (1991). Unfortunately, we were limited by commercial reasons to the use of bitter lupin and the one produced in the farm was not yet available. In a previous trial, in order to investigate alkaloids and anti-nutritional factors contained in the bitter lupin (Singh et al., 1994; El-Adawy et al., 2001), we compared two different diets (with and without bitter lupin) to evaluate the apparent digestibility (Lorenzini et al., 2007). Moreover, in order to eliminate the bitter flavour of the lupin bean that cattle seemed not to like, it was necessary to crush and mix the lupin with field bean and protein pea, to make it more appealing to the animals.

Tab. 1: Characteristics of the two diets provided to two groups of milking cow.

Components	Dry matter kg		Crude protein kg		UFL	
	Diet A	Diet B	Diet A	Diet B	Diet A	Diet B
Alfalfa hay	1.7	1.7	0.2	0.2	1.1	1.1
May hay	0.9	0.9	0.1	0.1	0.5	0.5
Maize silage	7.2	7.2	0.6	0.6	6.1	6.1
Alfalfa silage	2.1	2.1	0.3	0.3	1.5	1.5
Corncob silage	3.4	3.4	0.3	0.3	3.1	3.1
Extruded soya bean	0.9	-	0.4	-	1.1	
Barley	2.7	2.7	0.3	0.3	3.1	3.1
Bitter lupin	-	0.8	-	0.3		0.9
Field bean + protein pea	2.2	2.9	0.6	0.8	2.3	2.9
Total	21.1	21.7	2.8	2.9	18.8	19.2
Notes	For. 72%/ Conc. 28%	For. 71%/ Conc. 29%	13.3% DM	13.4% DM	0.9 UFL/kg DM	0.9 UFL/kg DM

Analysis of variance (ANOVA) was applied to milk production using SAS statistical procedures considering as fixed factor diet regime (diet A and diet B) and lactation phase.

Results and Discussion

The quantity and quality parameters of grain legumes cultivated on farm in 2005-06 are shown in table 2. Considering only the crude protein content, sweet lupin var. Multitalia is the best variety producing 1.607 kg/ha of protein, almost double the field bean var. Vesuvio (CP 819 kg/ha), the less productive one. The protein pea crop varieties, although the CP content is not very high, are very interesting for the production of total CP, due to the good yields. The field bean produced the lower CP total quantity, due to lower yield, compared to others grain legumes. The varieties sown in spring (Pea Hardy and Lupin Luxe) didn't manage to mature properly before the warmth and, except for Lupin Multitalia, their yields were zero.

Tab. 2: Characteristics of the grain legumes produced in a Tuscan organic farm in 2006.

Species Variety	GY DM (t/ha)	DM%	CP % DM	FAT % DM	CF % DM	Ash % DM	NDF % DM	ADF % DM	ADL % DM	CP (kg/ha)
F. Vesuv.	3.16	93.65	25.93	0.88	13.77	3.82	30.37	19.86	5.01	819
F. Chiaro	3.49	93.93	27.66	0.76	9.37	3.83	34.58	14.12	2.87	965
P. Class.	5.36	93.75	21.14	1.25	5.16	3.09	30.39	9.73	0.50	1133
P. Hardy a	6.03	93.68	20.32	1.29	1.45	3.10	31.03	11.32	0.10	1225
P. Ideal	5.15	94.53	23.60	1.19	8.01	3.17	30.48	11.82	1.11	1215
P. Hardy s	0.00	93.33	22.41	1.08	10.34	3.62	32.73	18.51	2.03	0
L. Multi.	4.50	95.05	35.72	3.96	15.61	8.68	33.77	26.34	4.42	1607
L. Luxe	0.00	95.05	36.36	5.60	16.66	4.58	27.16	23.23	4.92	0

Tab. 3: Result of milk productions (diet A, with soya bean and B, with lupin)

DFR = 306		Treatment		Lact. per.	Treatment x Lactation period			
		Mean	Sig.	Sig.	0-100 days	100-200 days	>200 days	Sig.
Milk kg	Diet A	32.5	***	***	36.7	33.2	30.0	ns
	Diet B	27.8			30.0	28.5	24.6	
Fat %	Diet A	4.1	ns	ns	4.1	4.1	4.0	ns
	Diet B	4.1			4.3	3.9	4.2	
Protein%	Diet A	3.3	**	***	3.0	3.2	3.4	ns
	Diet B	3.1			2.9	3.1	3.4	
SCCx 10^3/ml	Diet A	361	ns	ns	503.0	437.6	251.9	ns
	Diet B	267.1			266.5	196.7	362.6	
Urea g/100 ml	Diet A	0.026	ns	ns	0.027	0.025	0.026	ns
	Diet B	0.026			0.027	0.026	0.028	

* significant for P<0.05 **significant for P<0.01 *** significant for P<0.01

The results of milk production of the two group fed with different diet are shown in table 3. Although the quantity and quality of milk of the B cow group, fed with bitter lupin, is good, is not the same of the A cow group, fed with soya bean. In particular the alimentary treatment and the lactation period (0-100 days, 100-200 days, >200 days) had a positive influence on the diet A for milk production (+4,7 kg/day) and protein content (+0,2%), while no influence on fat, somatic cells and urea content was observed. Although the interaction of the two parameters did not show significant differences, we reported the mean value in the table 3 to get an idea of the lactation curve of the two experimental groups. The bitter lupin has never influenced the urea contents in the milk, always at physiological levels in both the experimental groups. It means that it didn't negatively influence the protein metabolism.

Conclusions

Because the climate (often too dry, too hot and too cold) and soil characteristics (rocky soils), the Mediterranean area normally offers poor pastures and scarce possibilities to produce a sufficient amount of vegetal protein sources to feed dairy cattle (Boyazoglu and Morand, 2000). But, alternative of buying soya bean is feasible in many countries of this area, like in the Central Italy. In fact the production on farm level of field bean, protein pea and sweet lupine provide considerable contributions of nutrient for cattle. In particular, sweet lupine var. Multitalia produced the highest total protein content, while the other non-Italian varieties failed. Protein pea is very interesting for its higher grain yield while field beans may suffer under climatic condition resulting in lower yields. Anyway more research work is needed on the use of local varieties. The introduction of lupine as alternative to soy bean in the formulation of diet in organic dairy cattle nutrition is interesting also in case of bitter lupine. In fact, when mixed with field bean and protein pea, to make it more palatable, the quantity and quality productive levels are slightly lower in comparison with soy bean diet.

Acknowledgments

The work was partly funded by the interregional project EQUIZOOBIO. Special thanks are due to Coop. Emilio Sereni for hosting the experimental trial in its organic farms.

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A discussion of norms for S supply in organic farming based on content in forage and ruminant performance in Norway

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Key words: forage, dairy cattle, deficiency, grassland, sheep

Abstract

The content of sulphur (S) in grassland on 27 Norwegian organic farms with dairy or sheep production was investigated in 2001 and 2002. The forage content of S was below the norms (2 g S kg DM^{-1}) for both plants and animals in a large proportion of the samples. The average S content in forage at dairy farms was 1.4 g S kg DM^{-1} and at sheep farms 1.5 g. Even on grasslands with low plant S content (<1 g S kg DM^{-1}), S-fertilization did not increase yields and increased the plants' S content only very slightly. No indications of S deficiency were observed on the dairy farms. For one sheep farm with a forage S content of 1.1 ± 0.1g S kg DM^{-1}, brittle and short winter wool was reported.

Introduction

Fertilization and mineral supplementation in organic farming systems must be based on the guidelines for organic farming from IFOAM and the set of rules that regulate organic farming practices. The plant and animal requirements for S will depend on growth rate and yield. In organic farming systems, the rather low supply of nitrogen from the soil and diet is an important reason for the low production levels that often are targeted and obtained (e.g. Berry et al. 2002).

If there is a risk that animals are suffering because of too low a mineral supply, or if there is a risk that the production is severely limited, farmers may be allowed to add extra sulphur (S). However, supplementation with any single element may cause new disorders in plants or animals. For example, increased S content in the fodder ration for ruminants may induce secondary copper deficiency in a forage rich diet with a high content of molybdenum (Underwood & Suttle, 1999) and may reduce selenium uptake by both plants (Hopper & Parker, 1999) and ruminants (Ivancic & Weiss, 2001).

Because development of relevant norms demand a lot of resources, extension services often use recommendations developed for conventional agriculture. In case of S, a feed content of 2.0 g S kg DM^{-1} for dairy cattle is recommended in Norway (NRC standards, National Research Council, 2001), and the same herbage content for grasses and clover. Because of the high S-content in wool, NRC recommend a S content in feed ration of 1.8 to 2.6 g S kg DM^{-1} for young lambs and 1.4 to 1.8 g S kg DM^{-1} for mature ewes (Underwood & Suttle, 1999).

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The aim of this paper is to discuss the present recommendations for supply of S to forage plants, dairy cattle and sheep in relation to the S content recorded in forage from Norwegian organic dairy and sheep farms.

Materials and methods

A survey was carried out on organic sheep (13) and dairy (14) farms in Norway. Samples of standing forage crop were taken from each of three plots in three different grasslands on each of the farms in 2001 and 2002 (Govasmark et al. 2005). On most farms there were two harvests annually, except for on five mountain farms, where only one cut was taken. The botanical composition of the grasslands varied greatly among the farms. The median content of clover was 13 % and 28 % for the first and second harvest, respectively. The corresponding lower - upper quartiles were 5-23 % and 18-44 %. None of the farmers applied any kind of mineral fertilizer to their soils.

There were large variations in feed ration and milk yield among the 14 dairy farms. The fodder ration consisted of 7 to 24 % concentrates (mainly homegrown barley and oats), 20 to 40 % pasture, and the rest silage and hay. The milk yield varied from 3000 to 6300 kg per cow per year, with an average of 4600 kg. The majority of the herds had calving time distributed over a large part of the year. On the sheep farms the main forage in winter was hay. In summer the sheep grazed in mountain areas or other outlying fields. Only small amounts of concentrate before and after lambing were used. Seaweed meals as supplied on four dairy farms contained 2.5-3.5 % S. The rest of the farms did not supply any S beyond S occurring in herbage and cereals.

To investigate whether S fertilization increased S content, yield, and the protein content of the forage, trials were conducted in established grasslands on organic farms; three in 2002, seven in 2004, and five in 2005. In 2002, S was applied in spring as $MgSO_4$ at rates of 0, 30 and 60 kg S ha^{-1}, and in 2004 and 2005 S was applied in spring as $CaSO_4$, Na_2SO_4 and K_2SO_4 at rates of 0, 20 and 40 kg S ha^{-1}. In all years herbage samples were taken in mid-June and mid-August at the first and second harvests. Timothy (*Phleum pratense*) and red clover (*Trifolium pratense*) were collected separately on each plot for S and N analysis.

Results

In the farm survey, the forage S content varied from 0.8 to 3.1 g S kg DM^{-1}in the first cut and from 1.0 to 3.1 in the second. Weighted mean values for content of S in forage from dairy and sheep farms were respectively 1.4 and 1.5 g S kg DM^{-1}. All forage samples from dairy farms had less than 2.0 g S kg DM^{-1}at first cut, and 79% at second cut; 13% and 1% had less than 1.0 g S kg DM^{-1}at first cut and second cut, respectively. On the sheep farms, 91% of forage from first and 33% of forage from second cut had less than 2.0 g S kg DM^{-1}, and 54 and 9 % had less than 1.4 g S kg DM^{-1}. Only two of the total of 110 forage samples collected from sheep farms contained less than 1 g S kg DM^{-1}. The S content of oats and barley grown on some of the farms varied from 1.4 to 1.7 g S kg DM^{-1}.

In spite of low content of crude protein, the forage N/S ratio was high, and was higher than 12, the recommended value from NRC, in 62 and 70 % of all forage samples from first and second cut, respectively. Neither forage protein nor forage S content had a clear relationship to milk yields. The urea concentration in milk was generally low (3.6 mmol/l).

S fertilization did not increase either the yield or the protein content in the field trials, but had a small but significant effect on forage S content at most sites (Table 1).

Tab. 1: Yield (t ha^{-1} yr^{-1}) and content of sulphur (S) (g kg DM^{-1}) in red clover and timothy after application of 0 and 20 kg S ha^{-1} yr^{-1} as $CaSO_4$; mean of four fields with two harvests in 2004 and 2005 ± std dev.

	First cut			Second cut		
Kg S ha^{-1} yr^{-1}	0	20		0	20	
DM Yield[a]	5.6 ±1.6	5.6 ±1.3	n.s.	3.7 ±1.4	3.7 ±1.3	n.s.
S Timothy[b]	1.0 ±0.1	1.1 ±0.1	***	1.5 ±0.5	1.7 ±0.6	*
S Red clover[b]	1.4 ±0.2	1.5 ±0.2	***	1.2 ±0.2	1.3 ±0.2	n.s.

[a]n=16, [b]n=8,* significant for P<0.05, *** significant for P<0.001

Discussion

The S content in forage was much lower than recommended for cattle and sheep. Supplementation with concentrates based on barley and oats did not improve the S supply, as indicated by the low S content in grain produced on the farms in this investigation. Thus the S content in the whole fodder rations was low, as seaweed was supplied only on four farms. However, no indications of S deficiency were observed on the dairy farms.

If the supply of N relative to S was too high in the herds studied here, the content of urea in the milk would probably have been considerably higher than recorded, as observed by Qi (1992). Even though 54% of the main harvests (first cut) on the sheep farms contained less S than the lower limit of the recommendations from NRC, no symptoms of deficiency were observed, except on the farm with the lowest S and protein content in the forage. On this farm there were problems with brittle and short winter wool. Lack of symptoms of S-deficiency cannot be caused by the animals using stored S in periods with low S-supply, as sulphur is mainly spent in muscle and the mammary gland, and excess sulphur will be excreted (Underwood & Suttle, 1999). From these observations it may be suggested that the recommendations for S supply are higher than the requirement for dairy cattle and sheep with fodder rations given on these organic farms.

However, the symptoms of S deficiency in ruminants are not specific. S deficiency may result in reduced appetite and digestibility of forage, which is not easy to identify and which may be caused by other factors too (Underwood & Suttle, 1999). The recommendations are also ambiguous. In the British standards (ARC, 1980) the suggested minimum is from 1.0 to 1.5 g S kg DM^{-1}. The recommendations for S supply to sheep and cattle needs to be critically evaluated in view of the moderate to low intensity levels that are found in organic farming. However, the recommendations may also be too high for conventional agricultural systems.

The lack of response to S application observed in the field trials can be explained by factors other than S limiting plant growth on these farms. However, we are surprised that the yield responses were so low. At some sites the S content in red clover was less than half the level of 2 g S kg DM^{-1} that is often used as a marginal value for optimal plant growth. We observed similar results for potassium (K) (Øgaard and Hansen, in prep.). Even with low concentrations of K in grassland (< 15 g K kg DM^{-1} in most cases), K fertilization did not increase yields, either alone or in combination with additional S-supply. N-limited soil-plant-animal systems like those studied here will seldom respond to inputs of other nutrients, as stated by Liebig. The low N availability should be taken into account when extension services are evaluating the need for supplementation of S and other elements in organic farming systems.

Since increased N intensity of farming systems decreases their N efficiency (Bleken et. al, 2005) and increases the N surplus and nitrous oxide emissions (Olesen et. al., 2006), the effects of increased intensity level should be taken in to account in the further development of organic farming systems.

Conclusions

Except for the symptoms of S-deficiency in wool on one sheep farm, no clear symptoms of S deficiency were observed in the investigated sheep and cattle herds despite S content in roughage that is much lower than what is recommended by the extension service. S fertilization did not increase either the yield or the protein content in the field trials. In most trials, fertilization had a small but significant effect on S content in the herbage

Acknowledgments

The Norwegian Research Council is acknowledged for financing this study as part of the research program: “Mineral content in plants and mineral supply for ruminants in organic agriculture”. Espen Govasmark, Håvard Steinshamn, Turid Strøm, and Martha Ebbesvik are acknowledged for valuable discussions.

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Pisum sativum as alternative protein source in diets for buffalo cows in middle and late stage of lactation

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Key words: *Bubalus bubalis*, Alternative protein source, Peas, Milk production.

Abstract

A study was carried out at an organic buffalo farm in order to examine the effect of feeding peas (Pisum sativum L.) as an alternative protein source for buffalo cow diets during middle and late stage of lactation. Two concentrates were formulated to contain, as fed basis, either 350 g/kg of soybean cake (control concentrate, CC) or 450 g/kg of peas (experimental concentrate, ExpC) as the main protein sources. The two concentrates were almost isonitrogenous (on average, crude protein 240 g/kg DM). Twenty buffalo cows were blocked into two groups according to lactation number and previous milk yield and were assigned to one of two dietary treatments from 10° day in milk onwards: control group was offered in the milking parlour 3 kg of CC, while treatment group was offered the same quantity of ExpC. All cows were fed a total mixed ration containing 3 kg of CC. The experimental period was from 100° day in milk onwards. Daily milk yield was not affected by treatment, as well as, milk fat and protein percentages, somatic cell count, urea content, fatty acid composition and clotting properties. Results support the partial substitution of soybean meal with peas in diets for buffalo cows with no negative effects on milk yield and composition.

Introduction

In the Italian traditional areas of buffalo (*Bubalus bubalis*) breeding (Latina province, Sele Plain and Volturno Plain) there are about 2,000 farms, but only 3 are certified organic. One of the several reasons of this low number is the farmers' concern about the standards required in organic regulation, in particular for feed supply. In the organic farms the protein needs of lactating cows are often supplied by soybean (fed as heat-treated seed or cake) which is, however, agronomically suitable only in limited areas of Italy. By contrast, pea (*Pisum sativum*), besides being better adapted to Mediterranean growth conditions than soybean, has good nutritive value and can be used as protein source for ruminant diet (Khorasani et al., 2001; Froidmont and Bartiaux-Thill, 2004; Masoero et al., 2006, Vander Pol et al., 2008) even in organic livestock systems because have no risk of GMO contamination. The aim of this study was to evaluate the effect of partial replacement of soybean cake with extruded peas in lactating buffalo cow diets on milk production and quality during the second phase

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of lactation. The results concerning the first 100 days of lactation were published elsewhere (Di Francia et al., 2007).

Materials and methods

The study was carried out on an organic dairy buffalo farm located in the Sele Plain, Campania Region, Southern Italy, in which a commercial compound concentrate containing (as fed basis) 350 g/kg of soybean cake (control concentrate - CC) was used. An experimental concentrate was formulated to contain as the main protein sources 450 g/kg of extruded peas (experimental concentrate -ExpC). The two concentrates were almost isonitrogenous and were organically produced. Twenty multiparous buffalo cows (on average, 604±109 kg of body weight) were blocked by parity (on average, 2.9 ± 1.3 lactations) and milk yield from their previous lactation (on average, 2,116±508 kg) and assigned to one of two dietary treatments from 10° d of lactation onwards: control group was offered twice a day in the milking parlour 1.5 kg of CC, while treatment group was offered the same quantity of ExpC. All cows were fed a standard total mixed ration (TMR) containing 3 kg of CC. Individual milk samples were collected at 2-weeks interval from 100° day in milk onwards and were analysed for chemical composition (Milkoscan 605), urea (CL 10, Eurochem), somatic cell count (SCC; Fossomatic 250). Additional milk samples were taken at 25-day interval and analysed for fatty acid (FA) composition, by using gas chromatography, and clotting properties (Formagraph). The AOAC (1990) methods were used to determine chemical composition of feedstuffs. Mozzarella cheese yield was calculated according Altiero et al. (1989). Data on milk yield and quality underwent analysis of variance for repeated measures (SAS, 1990) with treatment (CC and ExpC) as a non-repeated factor and week of observation and week of observation x treatment as repeated factors. Single cows were the experimental unit.

Results

ExpC concentrate compared to the CC had similar chemical characteristics (g/kg DM): crude protein 245 vs. 239; NDF 244 vs. 242; ENL 7.8 vs. 7.4 MJ/kg DM). Only soluble protein (SP) content was slightly higher in ExpC (76 vs. 42), reflecting the differences between the two protein sources (115 vs. 60, for extruded peas and soybean cake, respectively). For all variables presented in Tables 1 and 2, the effect of week of observation was always significant, due to the modifications of milk composition as the lactation progressed, whereas no significant effect of the interaction week of observation x treatment was found. Daily milk yield was not affected by treatment, as well as, milk fat, lactose and protein percentages. Moreover, the level of milk urea in treated group was comparable to that of control group. Although an impressive difference in SSC was observed between the two dietary groups, it was not statistically significant. Milk pH was almost identical in the two treatments, as were the clotting properties and the mozzarella cheese yield (Table 1). No differences were observed between the groups for milk FA composition (Table 2).

Discussion

In dairy cows a number of studies have investigated the effects of the substitution of ration composition, level of peas inclusion and technological treatments. Although the two protein sources differed for SP content, no differences were found for milk yield and milk urea content between the dietary groups.

Tab. 1: Milk traits, cheese yield and clotting proprieties for the dietary groups

		Diets		SE
		CC[1]	ExpC[2]	
Milk yield	kg/d	6.4	5.9	0.17
Fat	%	9.5	9.9	0.40
Protein	"	4.7	4.5	0.073
Lactose	"	4.6	4.5	0.05
Somatic cell count		40,813	93,615	18,183
Milk Urea	ml/dl	45.0	40.6	1.20
pH		6.70	6.68	0.037
Mozzarella Cheese yield	(%)	27.2	28.0	0.53
Rennet clotting time	(min)	20.4	19.9	1.25
Curd firming time 20 mm	(min)	1.7	1.7	0.10
Curd firmness 30 min	(mm)	41.1	41.8	2.68

[1] CC control concentrate based on: maize grain, dehydrated whole maize plant, soybean cake (35%), faba bean (4%), dehydrated alfalfa meal, wheat bran, barley, maize gluten meal, sodium bicarbonate, calcium carbonate, dicalcium phosphate, sodium chloride. [2] ExpC Experimental concentrate based on: extruded peas (45%), maize grain, dehydrated whole maize plant, faba bean (4%), dehydrated alfalfa meal, wheat bran, barley, maize gluten meal, soybean cake, sodium bicarbonate, calcium carbonate, dicalcium phosphate, sodium chloride.

Tab. 2: Fatty acid composition (wt%) of milk for the dietary groups

	Diets		SE
	CC[1]	ExpC[2]	
Butyric	2.31	2.50	0.15
Caprinic	2.02	2.14	0.12
Capronic	1.30	1.32	0.056
Myristic	11.4	11.2	0.21
Palmitic	34.1	32.6	0.39
Stearic	10.8	12.1	0.21
Oleic	22.7	23.3	0.39
Linoleic	2.59	2.71	0.079
Linolenic	1.07	1.06	0.025
CLA	0.96	0.87	0.04
Total Short Chain FA	8.28	8.58	0.41
Total Medium Chain FA	53.3	51.2	0.59
Total Long Chain FA	38.5	40.2	0.60
Mono Unsaturated FA	25.6	25.7	0.36
Poly Unsaturated FA	3.66	3.78	0.09

soybean with peas (Froidmont and Bartiaux-Thill, 2004; Masoero et al., 2006; Vander Pol et al., 2008), with contradictory results perhaps due to the confounding effects of Probably, the protein solubility and the non structural carbohydrate degradability of the two diets were adequate to satisfy the requirements of buffalo cows and to reduce the loss of N from the rumen. As expected, clotting properties and mozzarella cheese yield were similar between the two dietary treatments, because milk protein and fat contents of the two groups were almost identical. Milk protein and fat percentages, in fact, are the essential factors that affect firming time, curd firmness and cheese yield (Altiero et al., 1989; Martin and Coulon, 1995). Although the fat percentages of two protein sources were very different (15 vs. 100 g/kg DM for peas and soybean cake, respectively) milk FA composition was not affected by dietary treatment, due to the fact that the level of the pea inclusion which was below the threshold to allow changes for FA.

Conclusions

Peas can partially substitute for soybean meal as the main protein source in diets of buffalo cows in late stage of lactation without adverse effects on production and quality. The lack of negative effects on milk yield makes peas an attractive GMO free protein feed in diet formulation for buffalo cows raised in organic farms.

Acknowledgments

Research funded by Regione Marche, Project EQUI.ZOO.BIO.

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Rearing improvement in organic Maremmana beef production: "in vivo" performance and carcass characteristics.

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Key words: Maremmana breed, Organic beef production, carcass characteristics

Abstract

"In vivo" performance and carcass characteristics of Maremmana young bulls and steers were evaluated during a three year extension service program based on the improvement of animal performance and the production of steers. Average slaughter ages were 568, 562 and 642 (P<0.01) days and the average slaughter weights were 494.2, 567.2 and 548.2 kgs (P<0.01) respectively for young bulls in the first and second trial year and steers in the third, with a dressing percentage of 52.3%, 53.6% and 54.82% (P<0.01) respectively. No significant differences were found in carcass conformation and fatness scores which were similar to those found by other authors in the same breed reared in similar conditions.

Introduction

The rearing system of Maremmana, one of the most important rustic breeds in Italy, is characterised by early spring calving season and the use of pasture only by suckling cattle from spring to fall, when calves are allocated on feedlot and fed by forage and concentrates until 16–20 months of age, when young bulls are slaughtered. For these reasons Maremmana could be considered the breed that better than others can contribute to the organic beef production in Italy. Nevertheless the lack of specific technical guidelines, more than those in 1804/99 EU Rule, requires specific extension services programs. Aim of the work was to modify feeding management and production system in an organic farm, in order to improve growth curves, slaughtering performance and to evaluate the possibility to rear steers, which are better suited on the organic farm due to their calm temperament, to the pasture, in a three years (2002-2005) extension service experimental project proposed by the Regional Agency for Development and Innovation in Agriculture (ARSIA) of the Tuscany Region.

Materials and methods

In the first and second year spring born calves (eight and six, respectively) were weaned at the begin of the autumn and allocated in feedlot until slaughtering. In the

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third year calves (seven) were castrated by means of Burdizzo emasculator immediately after weaning, allocated in feedlot and from spring to mid summer managed on pasture until fattening, when they were allocated in feedlot until slaughtering. Weaning weights were 164±25, 215±43 and 165±50 kg, for the first, the second and the third year, respectively, with great differences dues to the climate. Weaned calves were given oat hay and oat haylage *ad libitum* until the beginning of fattening period, when they were given *ad libitum* oat hay. During growing period (from weaning to 90 days before slaughter) and during fattening period (last 90 days before slaughter), concentrate was supplemented on the basis of 0,8 kg/100 kg live weight (LW) during the first year and 1 kg/100 kg LW (in order to improve the animal performance) during the second and third years, according to 1804/99 EU rule guidelines (40% of concentrates on annual total dry matter intake). Concentrate was composed by 75% of grounded barley and 25% of grounded field bean during the first two years and during the growing period of the third and by 80% barley and 20% of field bean during the fattening period of the third. Forage chemical characteristics are reported in table 1. From weaning to slaughtering young bulls and steers were weighted every two months to determine the average daily gain (ADG). The slaughter age was influenced by the meat demand by consumers, because of direct selling strategy used by the farm owner. At slaughter, conformation and fatness of carcasses were evaluated according to the SEUROP grid and converted to continuous variables in a 18 and 15 levels, respectively. To evaluate relationship between age ad Live Weight, regression analysis was performed using PROG REG of statistical package SAS (SAS, 1999). *"In vivo"* and at slaughter performance data were submitted to analysis of variance by PROC GLM of the same statistical package.

Tab. 1: Forage chemical characteristics (DM basis)

Parameter		Forages		
		Oat hay	Oat Haylage	Pasture
Dry Matter	%	88.2	40.2	25.8
Crude Protein	% DM	11.5	11.3	13.6
Ether Extract	"	1.8	2.8	2.6
NDF	"	54.8	53.3	53.4
ADF	"	35.6	34.2	33.8
ADL	"	3.4	3.6	2.2
Ash	"	7.0	8.9	9.5

Results

The rationalization of rearing system was based in: a) concentrate creep feeding during pre-weaning period; b) increase of concentrate administered during growing and fattening period and c) steers production using pasture. The relationship between age and weight follows a cubic trend (Fig. 1) (Table 2). All curves showed a self-accelerated growth until 370 days of age when growth decelerated until kg 500 LW similarly to those reported by Sargentini (1998) in the same breed. Young bulls reared in the second year showed the lower slaughtering age, the higher slaughtering weight and the higher ADG if compared with first year reared young bulls and steers. The last ones showed the higher slaughter age and the lower ADG (Table 3). Young bulls reared before optimization of rearing system showed the lower slaughtering weight even if slaughter age was similar respect young bulls reared in the second year.

Dressing yield was higher in steers than in young bulls (54.82% vs 53.6% and 52.3%: P<0.01) reared in the second and first year respectively. No significant statistical differences were found in carcass conformation score and fatness score whose values corresponded respectively to R in young bulls and R- in steers, and to 3- and 3 on the basis of SEUROP grids.

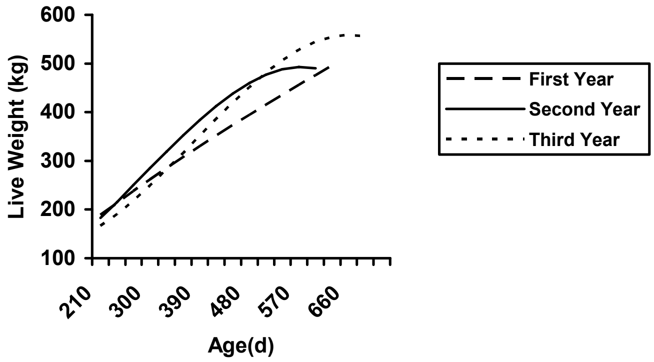

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Figure 1: Growth curves of young bulls and steers during the trial.

Tab. 2: Regression equations for growth parameters.

Years	Regression Equations	R^2	RSD
First	$Y=3.74 + 0.997x - 0.000427x^2 + 0.000000396x^3$	0.88	47.32
Second	$Y=88.71 - 0.271x + 0.005273x^2 - 0.00000786x^3$	0.70	75.32
Third	$Y=167.48 - 0.420x - 0.0035x^2 - 0.0000031x^3$	0.88	47.04

Tab. 3: LS Means for "*In Vivo*" and Slaughter Performance by year

		Years			RMSE
Parameters		First	Second	Third	
Slaughter age	D	568B	562B	642A	69.48
Slaughter weight	Kg	494B	567.2A	548A	38.54
Average Daily Gain	g/d	947b	982a	924b	92.53
Carcass weight	"	258.8B	320.8A	300.48A	24.17
Dressing yield	%	52.3B	53.6B	54.82A	2.44
Carcass conformation score		7.75	7.75	7.00	1.4
Carcass fatness score		7.50	6.50	6.60	1.6

A, B: P<0.01; a, b: P<0.05present study

Discussion

The slower growth rate observed in steers is mainly due to the different hormonal status. In intact male androgens promote muscular development throughout the increase in nitrogen retention. This anabolic property of androgens, especially testosterone, influences ADG of bulls to increase up to 19% than that of steers (Steen, 1995). In the present study ADG of bulls is 6% higher than that of steers, this difference, even if statistically significant, is quite slight and could be due to different environmental differences among years. Slaughtering ages, slaughtering weights and ADG (Table 3) were similar to those found by Sargentini et al. (1998) in the same breed and Berthiaume et al. (2006) in Angus cross steers fed by 40% barley and 60% grass silage on daily DM intake. Dressing yields were similar to those found by Marino et al. (2005) in Podolian young bulls organically reared. Carcass conformation and fatness scores were respectively similar and higher than those found by Sargentini et al. (2005) in the same breed organically reared.

Conclusions

If growth curves are considered as a method to evaluate the success of rearing systems, in the present study they are quite similar to those found by other authors. Steers performances on pasture during spring appear interesting, because obtained in typical Mediterranean harsh conditions. Carcass conformation and fattening could be considered interesting and confirms the good adaptation of Maremmana breed to this rearing system.

Acknowledgments

Research supported by Development and Research in Agriculture Agency of Tuscany (ARSIA).

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Indigenous sheep breeds in organic livestock production in karst areas of Croatia*†

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Key words: sheep, indigenous, karst, organic, Croatia

Abstract

Organic sheep breeding in Croatia is based on indigenous breeds, which are well adapted to their environment. This practice eliminates most of the problems usually encountered when imported foreign breeds have to be adjusted to the new conditions. Karst areas, encompassing about 50% of Croatian territory, are the natural habitat to eight of nine indigenous sheep breeds. These areas are nearly free from pollution, which makes them ideal for organic production. These facts were the foundations for the onset of the projects "Organic lamb production in Croatia" and "Standardisation of some health parameters of Croatian indigenous sheep breeds". Their goal is to promote and support the development of organic sheep production in Croatian karst areas. In the course of two years, we monitored housing conditions, feeding regime and general health status of animals from five organic flocks. We took blood and faeces samples to determine normal ranges of key physiological and biochemical parameters, since no such previous data existed. They will provide the basis for health monitoring as an aid to veterinarians and sheep breeders in organic production. The development of organic livestock production in the karst areas of Croatia is aimed at accelerating the economic growth of this underdeveloped region by providing a framework for creating a competitive product, while preserving the traditional way of life and protecting the environment.

Introduction

Croatian consumers started to show interest in organic products some 15 years ago. At that time organic production was not surveilled, nor was there a proper regulative system introduced. Finally in 2001, Ministry of Agriculture issued the relevant legislative acts, which were in accordance with the IFOAM Basic Standards 2000, and founded the Department for Organic Production. Since then, 446 farms have been registered for organic production on a total of 6.011 hectars, which represents only about 0.5% of agricultural land in Croatia.

For further development of organic production, especially sheep farming, almost ideal conditions are found in Croatian karst areas (Šimpraga et al. 2005). Karst represents a landscape shaped by the mildly acidic water acting on soluble bedrock such as limestone. When plans for farming in karst areas are made, the lack of surface water must be taken in account, since even when rainfall is adequate, the rainwater quickly flows away through the crevices into the ground, sometimes leaving the surface soil parched between rains. Nearly 50% of the Croatian territory can be classified as karst areas, most of which are situated in the Mediterranean region. Most of the land in these areas can be used only for grazing, which makes livestock production the most promising branch of agricultural production in this area (Boyazoglu, 2002). Sheep that

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have been reared there for centuries have adapted to the harsh environment exceptionally well, using the potential of the karst areas to the maximum and providing high-quality products such as meat, milk, leather and wool (Garibović et al., 2006). The number of sheep in karst areas in Croatia kept on 5.781 farms has reached 338.903 in 2006. These figures are still far from more than one million sheep reared in the 19th century in Dalmatia only, which at that time represented the highest *per capita* number of sheep in the whole Europe. Previous attempts to increase meat and milk production in karst areas were based on import of foreign breeds suitable for intensive production. All such attempts failed and showed that the specific conditions of karst areas support only the rearing of indigenous breeds which are exceptionally well adapted to their native environment (Mioč et al., 2006).

Taking into account the huge potential of organic breeding in pristine, unpolluted karst areas based on the nine well-adapted Croatian indigenous sheep breeds, we started with the research projects. Their main goal was to establish a network of organic sheep farms in order to stimulate and promote development of organic sheep breeding in Croatian karst areas.Regular checking of health status of the reared animals becomes almost indispensible because organic breeding excludes any kind of preventive treatment, especially anti parasitic. This makes parasite infestations a true challenge in organic sheep production (Rahmann and Seip, 2007). Blood profiling is therefore a well known method for health monitoring (Ingraham and Kappel, 1988). Since none of the parameters for indigenous sheep breeds have been standardized previously, normal physiological values of key haematological and biochemical parameters have been determined in this study.

Materials and methods

The research was conducted on 30 animals from organically reared flock of indigenous Lička pramenka sheep. As control group we used 30 animals from a heard of Merinolandschaf sheep reared under same conditions as Lička pramenka. Samples of blood and faeces were taken every 3 months in a course of two years. The parameters determined included erythrocyte count (RBC), leukocyte count (WBC), haemoglobin (Hb), hematocrit (Hct), red blood cell indices (MCV, MCH, MCHC), Calcium (Ca), Phosphorus (P), Magnesium (Mg), glucose, blood urea nitrogen (BUN), creatinine, aspartate aminotransferase (AST), gama-glutamil transferase (GGT), serum albumine and total protein concentrations.

Animals were monitored clinically through standard veterinary supervision, which included general health status and determination of haematological and biochemical profiles. Rearing conditions, especially housing and feeding, were supervised in order to comply with the rules of organic production.

Results

The results shown in Tables 1 and 2 provide a sub-range specific for organically bred Lička pramenka sheep. Differences between RBC, WBC and thrombocyte count, Hb concentration, MCV, MCH in Lička pramenka and Merinolandschaf sheep were statistically significant to the level of $p<0.01$.

Tab. 1: Haematological values (mean±SD) and range for organically bred Lička pramenka are given.

Parameter	*Value (±SD)*	*Range (min–max)*
Hemoglobin (g/l)	97,49±14,65	76–118
Hematocrit (%)	29±4	22.6–36.2
MCV (fl)	31,81±2,11	31.0–38.5
MCH (pg)	10,61±0,68	10.2–12.1
MCHC (g/l)	333,7±14,53	306–356
Erythrocytes (10^{12}/l)	9,23±1,44	6.72–10.34
Thrombocytes (10^{9}/l)	263,05±154,11	30–377
Leukocytes (10^{9}/l)	11,22±3,21	5.1–18.7

Tab. 2: Biochemical values (mean±SD and range) for organically bred Lička pramenka are given.

Parameter	*Value (±SD)*	*Range (min–max)*
Calcium (mmol/l)	2,59±0,31	2.50–3.11
Phosphorus (mmol/l)	1,74±0,62	0.60–6.01
Magnesium (mmol/l)	1,44±0,23	1.16–1.99
Glucose (mmol/l)	3,38±0,64	2.8–6.2
Urea (mmol/l)	6,05±1,72	3.4–8.4
Creatinine (µmol/l)	128,55±13,46	121–164
AST (U/l)	131,12±26,93	62–183
GGT (U/l)	41,3±15,49	23–44
Serum total protein (g/l)	76,85±6,74	72–120
Serum albumin (g/l)	37,9±5,77	30–49

Differences in Hct were significant to the level of $p<0.05$, while differences in lymphocyte, monocyte, basophyl and eosinophyl count and MCHC were not significant. Differences in biochemical values – P, BUN, creatinine level and AST activity were significant to the level of $p<0.01$; Ca, glucose and GGT to $p<0.05$. Mg, total protein and albumin levels were not significantly different.

Discussion

The use of haematological and biochemical parameters in health monitoring is already well established (Meintjes et al., 2002) but since these values depend on the specific sheep breed and rearing conditions, they have to be determined as a sub-range of the much broader range found in literature (Tibbo et al., 2005). This called for determination of relevant parameters characteristic for each breed under specific conditions of organic production. By combining haematological and biochemical parameters with the results of the coprological examination, we can gain insight into the impact of parasitic invasion on the general status of the animals raised, and also determine the degree of natural resistance and adaptation of indigenous breeds (Matanović et al., 2007). Since parasites are one of the most important limiting factors in organic production, their impact needs to be further investigated for the specific Croatian breeds. Natural resistance of indigenous breeds to parasites is a subsequent research area that is a logical and necessary extension of the present work.

Conclusions

Upon completion of the research, physiological parameters of indigenous Croatian sheep breeds will have been fully standardised, which will enable their use in health monitoring, especially in organic production. Production which is in compliance with the policies of European Union will ensure a recognizable high-quality organic product ready to be offered on the international market and also promote stricter regulation of sheep rearing thus facilitating the effective eradication of the black market for sheep and lamb products in Croatia. Organic breeding can guarantee increased profit from sheep production in karst areas, while keeping the benefit of traditional production and combining it with the modern approach to veterinary monitoring.

Acknowledgments

* This work was financially supported by the Croatian Ministry of Science, Education and Sport (projects TP-02/0053-02 and 053-1780469-2110).

† All research and other procedures undertaken within this project are in full compliance with Croatian legislative regulating treatment of experimental and other animals, and were reviewed and approved by the relevant Ethics committee.

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Quality of organically grown protein crops in Norway for livestock concentrates – limited N and S supplementation

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Key words: Camelina, Concentrates, Oilseed crops, Pea, Rape, Turnip rape

Abstract

The aim of organic farming husbandry is to be entirely based on an organically produced diet. Shortage of organically produced protein crops for production of concentrates supplying the European market and a contemporary ban on the use of fishmeal for ruminants in the EU have led to an increased need for organically produced feedstuffs for production of concentrates in Norwegian organic husbandry. Pea is the most commonly cultivated protein-rich crop in organic agriculture in Norway. For ruminants, peas have a low bypass protein content compared to common protein supplements, such as rape meal and soybean meal. Other high-protein crops with complementary properties are therefore needed to meet the demand in feed quality for ruminants, pigs and poultry. Oilseed crops, which are rich in both fat and protein, will become of considerable interest if problems related to their cultivation are solved. Currently, our experience with oilseed crops in organic agriculture is limited. a The four year research project "Organic protein feed and edible oil from oilseed crops" will serve to improve current knowledge and evaluate the feed quality of organically grown protein crops like rape, turnip rape and camelina. The project will provide knowledge about the rumen degradability of protein, starch and NDF (neutral detergent fibre) and intestine digestibility of protein and starch of organically grown, protein-rich crops necessary for the production of concentrates with an optimal feed quality.

Introduction

The content of crude protein is often low in the herbage from an organic ley (Olberg *et al*., 2005) resulting in insufficient protein content to meet the nutritional demands of for example high productive milking cows. Therefore, feedstuffs with additional protein are normally added to the ration. Husbandry in organic farming should be based entirely on an organically produced diet (Council for The European Union, 1999). An obstacle in the production of concentrates for use in organic farming is that extracted soybean meal, which is the main protein source in conventional concentrates, is not permitted in organic husbandry. This is caused by a general ban of the use of chemical extracts in fodder production (www.debio.no). Fish meal has been a vital constituent in concentrates and secured the need for high-quality proteins in organic husbandry. However, precautions to avoid contamination with prions from meat bone meal and high prices have made it important to look for alternatives. Currently, pea is the most commonly cultivated protein-rich crop in organic agriculture in Norway. For ruminants, peas have a low bypass protein content compared to common protein supplements,

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such as rape meal and soybean meal (Corbett, 1997). Other high-protein crops with complementary properties are therefore needed to meet the demand in feed quality for ruminants, pigs and poultry. Oilseed crops, which are rich in both fat and protein, will become of considerable interest if problems related to their cultivation can be solved.

The content of chemical constituents, such as protein, fat, NDF (neutral detergent fibre) and amino acids, varies among crops. In addition, nutritional quality parameters like fatty acid composition and rumen degradability of protein vary much among crops as well. High rumen degradability of protein results in a low AAT-value (amino acids absorbed in the small intestine) and a high PBV-value (Protein balance in the rumen) (Madsen *et al*., 1995). Turnip rape and rape are rich in unsaturated fatty acids, which restrict the content of oilseeds that can be used in the daily feed ration for ruminants. However, the content of oilseeds in the ration can be increased if fat is removed through squeezing or compression. In addition, expeller cakes produced in that way usually have an increased protein value for ruminants because the heat produced in the treatment reduces the rumen degradability of protein, increasing the AAT-value and reducing the PBV-value of the feed. Moreover, the oilseeds are rich in S-containing amino acids, complementing the amino acids found in peas. Unfortunately, the mentioned crops do also contain elements, which different animal species have different tolerances to (Wollenweber et al., 2002). Camelina or gold-of pleasure (*Camelina sativa* L. Crantz) is another oil-seed crop, which may have considerable interest for organic cropping in northern areas (Alen *et al*., 1999). It has a low nutrient requirement, no seed dormancy, less problems with insect damage than rape and turnip rape and the seed quality makes it suitable for both edible oil and animal feed (Vollmann *et al*., 1996).

Experiments with conventionally grown oilseed crops show great differences in protein and fat content according to the N fertilization rate (Rathke et al., 2004; Asare & Scarisbrick, 1995). Currently, our experience with oilseed crops in organic agriculture is limited, and we do not know to what extent limitations in the N supplement will influence the content of crude protein and fat. In addition, N and S application have increased the seed glucosinolate concentration (Asare & Scarisbrick, 1995). Different fertilization strategies may perhaps result in differences in the feed quality. Experiment with long-term cattle manure application to rape increased the total N content and decreased the oil content in the seed (Hao et al., 2004).

Our ongoing project “Organic protein feed and edible oil from oilseed crops” involves the whole production chain for protein feed and edible oils and will obtain knowledge for secure production of high-quality proteins for livestock feeds and edible oil for human consumption in Norwegian organic farming based on oilseed crops. One of the sub-goals in the project is to establish knowledge on the feed quality of organically grown protein crops. The project will provide knowledge about the rumen degradability of protein, starch and NDF and intestine digestibility of protein in organically grown, protein-rich crops in order to plan the production of concentrates for the Norwegian organic husbandry in the future. The project period is 2006 to 2010.

The project is led by the Norwegian Institute for Agricultural and Environmental Research in co-operation with the Norwegian University of Life Science, the Swedish University of Agricultural Sciences, the Norwegian Institute for Land Inventory, the Norwegian Meteorological Institute, Norwegian food research institute - Matforsk and the companies 'Felleskjøpet Fôrutvikling BA', 'TINE produsentrådgivning' and 'Norsk Matraps AB'. This presentation gives an overview of the project and gives some preliminary results from the first year.

Materials and methods

In the main project, fields with peas, spring sown green manure and barley will be established as pre-crops for turnip rape and camelina in spring 2006, 2007 and 2008 on the organic research area at Research Farm Apelsvoll and at Lanna Research Station, in spring 2007 and 2008. For winter rape and winter turnip rape, fields will be established with a spring sown green manure crop of white clover (Trifolium repens), ryegrass (Lolium spp.) and phacelia (Phacelia tanacetifolia), and barley as pre-crops in the same years. Split-plot experiments with four nitrogen levels (0, 40, 60 and 80 kg ha^{-1} in organic fertilizer) on main plots and turnip rape and camelina with and without S ($MgSO_4$) on sub-plots will be placed in each pre-crop field with three replications in 2007, 2008 and 2009 at Apelsvoll and at Lanna in 2008 and 2009. Split-plot experiments in winter rape and in winter turnip rape with autumn fertilization (0 and 40 kg N ha^{-1}, chicken manure pellets) on main plots and spring fertilization (0, 40, 60 and 80 kg N ha^{-1} as chicken manure pellets with and without S) on sub plots will be placed in each pre-crop field in 2006, 2007 and 2008 at Apelsvoll and in 2007 and 2008 at Lanna. Each experiment will have three replicates. At each experimental site, weather data such as air and soil temperature, precipitation and time of snow cover will be recorded. The soil mineral N content for each treatment will be determined in late autumn in the establishing year and after harvest.

Samples of rape, turnip rape, camelina and pea will be sampled from the respective fields and analysed chemically for ash, starch, protein, fibre, NDF (neutral detergent fibre), fat, sugar, the amino acids methionine, lysine, cysteine, tryptophan, threonine and arginine and the minerals Ca, P, Mg and S. Rumen degradability of protein and NDF and intestine digestibility of protein in rape, turnip rape, camelina and pea will be analysed using the nylon bag methods (Madsen *et al*., 1995). For pea, the rumen degradability and intestine digestibility of starch will also be analysed with nylon bags. Content of fat and protein, rumen degradability and intestine digestibility of protein will be determined in samples from both expeller cake and entire seed for camelina, rape and turnip rape. Glucosinolate concentration will be analyzed in camelina, rape and turnip rape, while tannin concentration will be analyzed in pea. Samples will be analysed according to the methods used by Nordic Feed Evaluation.

Discussion and results

In Autumn 2006, pea samples (varieties Faust, Integra and Pinochio) from six different farms were analysed chemically for ash, starch, protein, NDF (neutral detergent fibre), fat, fibre, Ca, P and Mg. The results from the analyses were comparable to results from conventional studies but new samples will be analysed in winter 2007 and 2008 until a full evaluation of the results can be performed. In the 2006, rumen degradability of starch, protein and NDF, and intestine digestibility of starch and protein were analysed for varieties of Faust and Pinochio with the nylon bag method (Madsen *et al*., 1995). The protein degradability in the two samples was lower than estimated in the Norwegian feed table for 2008 but was within normal variation. This was also the case for starch and NDF. The degradability of starch was lower in pea than in oat and barley, which is of special interest concerning high yielding dairy cows. The measurement of intestine digestibility of protein and starch showed unexpectedly high values for the indigestible portion of starch (39% of total) and protein (13% of total). This might be due to the analytical technique used, and will be further investigated. However, lower digestibility of starch than protein is in agreement with studies on conventional peas (Ljøkjel *et al*., 2003a, b).

We expect a pronounced variation in the quality of protein-rich crops dependent on the cultural measures, soil fertility and climatic conditions. The results from the different quality parameters will be evaluated in comparison to published results and former feeding trials with conventionally grown rape, turnip rape and pea. Quality-parameters of significance for the use of crops in the production of concentrate for ruminants and poultry will be prioritized.

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Use of grass and red clover silage mixtures for milk production and whole-body N partitioning by dairy cows

Moorby, J.M.[1], Ellis, N.M., Fisher, W.J., Davies, D.R. & Scollan, N.D.

Key words: dairy cows, grass silage, milk production, nitrogen partitioning, red clover.

Abstract

Twenty-four multiparous Holstein-Friesian dairy cows in mid lactation were used in a 4×4 Latin square changeover experiment with four 4-week periods to investigate the effect of altering the ratios of red clover (RC) and ryegrass silage (GS) in the forage component of their diet. Ratios (in the dry matter (DM)) were: R0, 0 RC:1 GS; R34, 0.34 RC:0.66 GS; R66, 0.66 RC:0.34 GS; R100, RC 1:0 GS. All cows received ad libitum access to their allocated forage with 4 kg of a standard concentrate per day. Results are presented in order of R0, R34, R66 and R100 respectively. Feed DM intakes (16.7, 17.8, 18.3, 19.0 kg d^{-1}, s.e.d. 0.24, P_{lin}<0.001) and milk yields (25.2, 26.1, 26.5, 26.1 kg d^{-1}, s.e.d. 0.47, P_{lin}<0.05, P_{quad}<0.05) increased as the proportion of RC in the forage increased. Nitrogen (N) intake and excretion of N in urine and faeces increased (P<0.01) with increasing proportion of RC in the diet, but milk N secretion as a proportion of diet N intake, decreased (P<0.01). It is concluded that the best balance of feed intakes, milk yields and efficiency of utilisation of dietary N was achieved when cows were offered a diet with RC silage as 0.66 of the forage.

Introduction

Red clover (RC; *Trifolium pratense*) requires no nitrogen (N) fertiliser for growth and is therefore highly suitable for use in organic farming systems. Red clover can be successfully ensiled as bales, and when fed to dairy cows RC silage has been shown to allow higher intakes, leading to higher yields of milk, than grass silage (Dewhurst *et al.*, 2003a; 2003b; Thomas *et al.*, 1985). However, the efficiency of utilisation of RC silage can be low, and for agronomic purposes may be best offered to cows as a mix with another forage such as grass silage. Ryegrass silage is a common forage that is widely used in the UK and other parts of Europe, and offers this potential.

The objectives of this experiment were to investigate the effect of mixing red clover and ryegrass silages at different ratios on feed intake, milk production and whole-body N partitioning in dairy cows.

Materials and methods

Twenty-four multiparous Holstein-Friesian dairy cows in mid lactation were used in a 4×4 Latin square changeover experiment. Following a covariate period with all cows offered a common diet, cows were allocated to one of six replicate Latin squares on the basis of milk yield recorded shortly before the start of the experiment. Four experimental diets were offered to the cows differing in the ratios (on a dry matter (DM) basis) of grass silage to RC silage: 1) diet RC0: 1 grass:0 RC; 2) diet RC34: 0.66 grass:0.34 RC; 3) diet RC66: 0.34 grass:0.66 RC, and 4) diet RC100: 0 grass:1

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RC. The grass silage was prepared from a first cut perennial ryegrass sward and stored as a large clamp under cover. The red clover silage was a mixture of first and second cut bales and used in a ratio of one bale first cut to one bale second cut.

In each of four 4-week periods, the first 21 days were used for adaptation to diets, and the remaining 7 days were used for measurements. All cows received *ad libitum* access to their allocated forage diets (to allow at least 0.1 of offered feed as refusals), and also received a constant allocation of 4 kg standard dairy concentrate per day. Feed intakes and milk yields were recorded for all cows throughout the experiment.

Feed samples were collected during the measurement week and composited to give one sample per experimental period. A subset of eight of the cows were used for digestibility and whole-body N partitioning measurements during the last 7 days of each experimental period. For these, separate collections of total outputs of faeces and urine were made from all cows during the measurement period. Dry matter, organic matter (OM), N, and neutral detergent fibre (NDF) were determined in feeds and faeces and used to calculate apparent whole-tract digestibilities of these components (intake in feed minus output in faeces divided by intake in feed). The N content of urine was also measured, which enabled the calculation of whole-body N balance (by difference of intakes and total outputs in milk, faeces and urine). Milk fat and protein was measured by commercial near-infrared milk analysis in 4 consecutive samples collected from all animals during the measurement week in each period.

Results

The concentrations of DM and water-soluble carbohydrates (WSC) decreased, and the concentrations of ammonia-N and fibre fractions increased, as the proportion of RC silage in the diet increased (Tab. 1). Diet CP concentration was similar for all forage mixtures.

Tab. 1: Mean composition of the silage mixtures offered to dairy cows during the experiment. Values in g kg^{-1} DM unless otherwise specified

	Silage mix				Concentrate
	R0	R34	R66	R100	
Dry matter, g kg^{-1}	374	359	338	322	869
Organic matter	894	893	893	894	927
Crude protein	206	205	196	194	210
Ammonia-N	2.00	2.32	2.72	3.06	-
Water-soluble carbohydrates	113	74	49	29	92
pH	3.98	4.17	4.41	4.66	-
Acid detergent fibre	290	317	335	373	143
Neutral detergent fibre	439	459	447	461	222
Ether extract	36	31	27	24	-
Acid detergent ether extract	-	-	-	-	56

Tab. 2: Effect of altering the forage ratio of grass and red clover silages on feed intakes, diet apparent whole-tract digestibilities, and milk yield and composition of dairy cows

	Diet				SED	Sig.[1]	
	R0	R34	R66	R100		L	Q
Total DM intake, kg d^{-1}	16.7	17.8	18.3	19.0	0.24	***	n.s.
Digestibility, g g^{-1} intake							
Dry matter	0.63	0.62	0.59	0.55	0.008	***	*
Organic matter	0.73	0.71	0.68	0.64	0.007	***	*
Nitrogen	0.67	0.69	0.67	0.66	0.010	n.s.	n.s.
Neutral detergent fibre	0.73	0.71	0.68	0.60	0.024	***	n.s.
Milk yield, kg d^{-1}	25.2	26.1	26.5	26.1	0.47	*	*
Fat conc., g kg^{-1}	38.0	36.7	35.6	35.5	0.99	**	n.s.
Protein conc., g kg^{-1}	30.8	30.7	30.6	29.3	0.39	***	*
Fat yield, g d^{-1}	955	947	935	923	27.2	n.s.	n.s.
Protein yield, g d^{-1}	770	798	810	763	17.1	n.s.	**

[1] Significance: L, linear effect, Q, quadratic effect. There were no significant cubic effects; n.s., not significant; +, P<0.1; *, P<0.05; **, P<0.01; ***, P<0.001

Tab. 3: Effect of altering the forage ratio of grass and red clover silages on N intakes, N outputs, and apparent partitioning of dietary N by dairy cows

	Diet				SED	Sig.[1]		
	R0	R34	R66	R100		L	Q	C
N intake, g N d^{-1}	529	577	552	611	14.0	***	n.s.	**
N output, g N d^{-1}								
Faeces	172	181	184	206	6.6	***	n.s.	n.s.
Urine	203	218	232	233	9.0	**	n.s.	n.s.
Milk	117	122	119	118	4.8	n.s.	n.s.	n.s.
N balance	36	57	17	55	12.6	n.s.	n.s.	**
N partition, g out g^{-1} in								
Faeces	0.33	0.31	0.33	0.34	0.010	n.s.	n.s.	n.s.
Urine	0.39	0.38	0.42	0.39	0.014	n.s.	n.s.	*
Milk	0.22	0.21	0.22	0.19	0.007	**	n.s.	+

[1] Significance: L, linear effect, Q, quadratic effect, C, cubic effect; n.s., not significant; +, P<0.1; *, P<0.05; **, P<0.01; ***, P<0.001

Feed DM intake significantly increased as the proportion of RC in the diet increased (Tab. 2). However, this was associated with a decrease in the digestibility of several diet components (but not of N). Despite this, milk yields were significantly affected by diet with the highest yields coming from cows offered diet R66. Milk fat and protein concentrations all decreased significantly with increasing proportions of RC in the diet.

Intakes and excretion outputs of N increased linearly as the proportion of RC in the diet increased (Tab. 3). There was a significant cubic effect on N balance, with the lowest value for cows offered diet R66. The secretion of milk N expressed as a proportion of dietary N intake significantly decreased as the proportion of RC in the diet increased.

Discussion

This study investigated the effects of mixing of RC and grass silages, and confirmed earlier findings of the increased intake potential of RC silage (Bertilsson and Murphy, 2003; Dewhurst *et al.*, 2003a; 2003b; Thomas *et al.*, 1985). Increased milk yields as a result of increased DM intakes were also confirmed. However, these were associated with little or no change in yields of milk protein and fat, so that concentrations of milk components decreased with increasing intakes of RC silage. Most responses to changing from grass to RC silage were linear, although mixing the two had some benefits. Milk and protein yields were highest from diet R66, and were slightly lower on pure RC silage (R100). Increased N intakes, coupled with decreased milk N outputs meant that the apparent efficiency of diet N use for milk protein production was lower with high RC diets (Bertilsson and Murphy, 2003).

Conclusions

Milk output can be improved by feeding dairy cows with RC silage, although at the expense of milk fat and protein concentrations. Maximum milk and milk protein yields were found at a forage mixture of 0.66 RC and 0.34 ryegrass silages.

Acknowledgments

This study was funded by EU project QualityLowInputFood (QLIF; FP6-2002-Food-1-506358). Thanks to M. Leyland, J. Tweed and D. Jones for technical assistance.

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Effects of mixing red clover and maize silages on milk production and whole-body N partitioning in dairy cows

Moorby, J.M.[1], Ellis, N.M., Fisher, W.J., Davies, D.W.R. & Davies, D.R.

Key words: dairy cows, maize, milk production, nitrogen partitioning, red clover.

Abstract

Twenty-four multiparous Holstein-Friesian dairy cows in mid lactation were used in a 3×3 Latin square changeover experiment with three 4-week periods to investigate the effect of altering the ratios of red clover (RC) silage and maize silage in the forage component of their diet. Ratios (in the dry matter (DM)) were: RC10, 0.1 RC:0.9 maize; RC50, 0.5 RC:0.5 maize; RC90, 0.9 RC:0.1 maize. All cows received ad libitum access to their allocated forage with 4 kg of a standard concentrate per day. Whole-body N partitioning and whole-tract diet digestibility measurements were carried out using a subset of cows (n=9). Results are presented in order of RC10, RC50 and RC90 respectively. Feed DM intakes (19.6, 20.5, 19.5 kg DM d^{-1}, s.e.d. 0.32, $P<0.01$) and milk yields (26.1, 27.3, 25.7 kg milk d^{-1}, s.e.d. 0.54, $P<0.01$) were highest on diet RC50. Milk protein concentrations decreased ($P<0.001$) as forage RC proportion increased, and protein yields were significantly ($P<0.01$) higher on diet RC50. Urine N excretion was lowest (as a ratio to N intake), and milk N secretion was highest, on diet RC10. It is concluded that milk and protein yields can be improved by feeding RC silage as 1:1 mix with maize silage, but that the efficiency of utilisation of forage N was reduced when diets contained more than 0.1 RC silage.

Introduction

Red clover (RC; *Trifolium pratense*), requires no nitrogen (N) fertiliser for growth and is therefore an excellent crop for use in organic dairy systems. Red clover can be successfully ensiled as bales, and RC silage has been shown to have a high intake potential, leading to higher yields of milk, than grass silage (Dewhurst *et al.*, 2003a; 2003b; Thomas *et al.*, 1985). However, due to its relatively low energy density, the efficiency of utilisation of RC silage can be low, and is best offered to cows as a mix with another energy-rich forage. Maize silage offers this potential, itself being relatively low in crude protein but high in starch. The objectives of this experiment were to investigate the effect of feeding three mixtures of RC and maize silage on milk yield and composition from dairy cows, and whole-body partitioning of dietary N.

Materials and methods

Twenty-four multiparous Holstein-Friesian dairy cows in mid lactation were used in a 3 × 3 Latin square changeover experiment. Cows were allocated to one of three replicate Latin squares on the basis of milk yield recorded shortly before the start of the experiment. Three experimental diets were offered to the cows differing in the ratios (on a dry matter (DM) basis) of maize silage to RC silage: 1) diet RC10: 0.9 maize:0.1 RC; 2) diet RC50: 0.5 maize:0.5 RC; 3) diet RC90: 0.1 maize:0.9 RC. The

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maize silage was a prepared and stored as a large clamp under cover. The red clover silage was a mixture of first and second cut bales and used in a ratio of two bales first cut to one bale second cut.

In each of three 4-week periods, the first 21 days were used for adaptation to diets, and the remaining 7 days were used for measurements. All cows received *ad libitum* access to their allocated forage diets (to allow at least 0.1 of offered feed as refusals), and also received a constant allocation of 4 kg standard dairy concentrate per day. Feed intakes and milk yields were recorded throughout the experiment.

Feed samples were collected during the measurement week and composited to give one sample per period. During the last 7 days of each experimental period separate collections of total outputs of faeces and urine were also taken from some of the cows (n=9). Apparent whole-tract digestibilities of DM, organic matter (OM), N, and neutral detergent fibre (NDF) were calculated (intake in feed minus output in faeces divided by intake in feed), together with whole-body N balance (by difference of intakes and total outputs of N in milk, faeces and urine). Milk fat and protein was measured by commercial near-infrared milk analysis in 4 consecutive samples taken during the measurement week in each period.

Results

The experimental forage mixtures differed significantly in their composition as the ratio of maize silage to RC silage varied (Tab. 1), with lowest crude protein (CP) concentrations on the RC10 diet. The dairy concentrate offered to all cows contained 929 g OM kg^{-1} DM, 152 g CP kg^{-1} DM, 87.6 g water-soluble carbohydrates kg^{-1} DM, 215 g NDF kg^{-1} DM, and 52.8 g acid hydrolysis ether extract kg^{-1} DM.

Tab. 1: Mean composition of the silage mixtures offered to dairy cows during the experiment. Values in g kg^{-1} DM unless otherwise specified

	Diet			SED	Significance[1]	
	RC10	RC50	RC90		Linear	Quad
Dry matter, g kg^{-1}	333	416	514	8.7	***	n.s.
Organic matter	957	933	916	0.71	***	**
Crude protein	103	148	165	5.9	***	+
Water-soluble carbohydrates	18	53	76	8.1	**	n.s.
pH	3.73	4.14	4.57	0.044	***	n.s.
Acid detergent fibre	228	318	360	21.5	**	n.s.
Neutral detergent fibre	410	454	477	16.3	*	n.s.
Ether extract	32.7	22.8	17.0	1.35	***	n.s.

[1] n.s., not significant; +, P<0.1; *, P<0.05; **, P<0.01; ***, P<0.001

Total DM intake was highest (P<0.01) on the equal mix silage diet (RC50; Tab. 1), which led to a small increase in daily milk yields. Diet digestibility was significantly effected by treatment, with higher digestibilities of DM and OM with greater proportions of maize in the diet, but with higher NDF digestibilities with lower proportions of maize. Milk fat concentrations and yields were unaffected by treatment, while milk protein concentrations decreased (P<0.001) as the proportion of RC in the diet increased. Milk protein yield was highest (P<0.01) on the RC50 diet. Expressed in terms of kg DM consumed, milk yield was not significantly affected by dietary treatment, with a grand mean of 1.33 kg milk yielded kg^{-1} DM consumed.

Nitrogen intake increased significantly as the proportion of RC in the forage mixture increased (Tab. 3). As N intake increased, the output of N in faeces and urine also increased significantly. However, overall whole-body N balance was not significantly different between treatments. Expressed as a proportion of dietary N intake, faeces N output tended to increase with increased proportion of RC in the silage mixture, and urine N output increased significantly. Milk N output, on the other hand, decreased significantly, so that efficiency of milk protein production was highest on the RC10 diet, which had the lowest CP concentration.

Tab. 2: Effect of altering the diet ratio of maize and red clover silage on feed DM intakes, diet apparent whole-tract digestibilities, and milk yield and composition by dairy cows

	Diet			SED	Significance[1]	
	RC10	RC50	RC90		Linear	Quad
Total DM intake, kg d^{-1}	19.6	20.5	19.5	0.32	n.s.	**
Digestible DM intake, kg d^{-1}	12.1	12.1	11.1	0.19	***	**
Diet digestibility, g g^{-1} intake						
Dry matter	0.62	0.59	0.57	0.008	***	n.s.
Organic matter	0.69	0.67	0.66	0.005	***	n.s.
Nitrogen	0.61	0.60	0.58	0.018	+	n.s.
Neutral detergent fibre	0.47	0.56	0.61	0.015	***	+
Milk yield, kg d^{-1}	26.1	27.3	25.7	0.54	n.s.	**
Fat conc., g kg^{-1}	36.7	37.5	38.9	1.40	n.s.	n.s.
Protein conc., g kg^{-1}	30.9	30.6	29.9	0.24	***	n.s.
Fat yield, g d^{-1}	941	1020	1000	38.4	n.s.	n.s.
Protein yield, g d^{-1}	798	834	775	18.7	n.s.	**

[1] n.s., not significant; +, P<0.1; *, P<0.05; **, P<0.01; ***, P<0.001

Discussion

Red clover silage has been shown to have a high intake potential in dairy cows and to improve milk yields compared to grass silage (Bertilsson and Murphy, 2003; Dewhurst *et al.*, 2003a; 2003b). Compared to lucerne silage, equal yields of milk at reduced levels of intake have been observed (Broderick *et al.*, 2001). The optimum rate of supplementation of RC silage with a high-energy forage such as maize silage is uncertain. In this study, the greatest intakes of DM were observed on the RC50 diet, and despite the fact that digestible DM intakes were not the highest, the yields of milk and milk components were (marginally) highest on this diet. Increasing the proportion of RC silage in the forage mixture led to increased N intakes, but also increased N outputs, so that the most efficient diet in terms of milk N output was the RC10 diet. Increased rates of excretion of N in urine (both in g d^{-1} and expressed relative to N intake) as the RC component of the forage mix increased indicates an increased rate of uptake of ammonia from the rumen as the relative availability of energy-yielding nutrients (i.e. starch from the maize silage) decreased. This agrees with previous reports of mixing white clover silage with maize silage (Auldist *et al.*, 1999).

Tab. 3: Effect of altering the diet ratio of maize and red clover silage on N intakes, N outputs, and apparent partitioning of dietary N in dairy cows

	Diet			SED	Significance[1]	
	RC10	RC50	RC90		Linear	Quad
N intake, g N d^{-1}	366	505	528	16.6	***	**
N output, g N d^{-1}						
Faeces	140	201	223	7.2	***	*
Urine	74	120	173	5.7	***	n.s.
Milk	128	145	137	4.8	n.s.	*
N balance	24	39	-5	18.2	n.s.	n.s.
N partition, g out g^{-1} in						
Faeces	0.38	0.40	0.42	0.018	+	n.s.
Urine	0.20	0.24	0.33	0.014	***	n.s.
Milk	0.35	0.29	0.27	0.012	***	n.s.

[1] n.s., not significant; +, P<0.1; *, P<0.05; **, P<0.01; ***, P<0.001

Conclusions

It is concluded that milk and milk protein yields can be significantly improved by feeding RC silage as 1:1 mix with maize silage, but that the efficiency of utilisation of forage N was reduced when diets contained more that 0.1 RC silage. However, reduced within-animal efficiency at higher rates of RC silage use would be less of a problem at the whole-farm level if manures are used appropriately as fertilisers, distributing legume-fixed N to other crops.

Acknowledgments

This study was funded by EU project QualityLowInputFood (QLIF; FP6-2002-Food-1-506358). Thanks to M. Leyland, M. Scott, J. Tweed and D. Jones for their assistance.

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Animal health, product quality and strategies for organic pork production

Strategies for a diversified organic pork production

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Key words: Organic, pigs, pork, breed, male pigs

Abstract

Possible reasons for the low market share of organic pork may be heavy price competition with conventional produced pork products combined with no or small distinctive characteristics in appearance and quality, both regarding eating quality (flavour, tenderness) and ethical quality (production methods). The overall aim of this study is to identify strategies for a diversified organic pork production with high credibility and superior eating quality based on pigs foraging in the cropping system, use of a traditional breed and no castration. Preliminary results indicate that the use of a traditional breed, the Danish Black-Spotted pig, might be a way to produce pork, which in appearance differ from conventional pork and at the same time improve the credibility of organic pig production.

Introduction

There has been a considerable increase in the consumption of organic pork in Denmark as well as in other European countries the last few years, however, the relative consumption of organic pork is still considerably lower than e.g. organic egg and milk (Gfk, 2007). One possible reason for the low market share may be heavy price competition with conventional produced pork products combined with no distinctive characteristics in the organic pork products *per se*. A smaller consumer survey in Denmark (Beck & Søndergård, 2004) indicated that consumers who valued pork products were very prize sensitive and not in particular interested in organic products as such. On the other hand, the consumers who were very interested in organic products did not value pork products very much. This calls for a consideration that organic pork should differentiate *per se* from conventional pork, e.g. regarding cuttings and flavour. The low market share may also be due to small distinctive characteristics in the ethical quality of organic pork. In Denmark, the organic pig production of today typically includes production methods, which do not comply particularly well with the principles of organic farming - and thereby probably not with the consumers' expectation to organic pig production: Castration of male pigs, use of specialised high-producing crossbreeds, housing of growing pigs in stables with no access to pasture. None of these characteristics live up to the intentions of organic farming in terms of provision of life conditions with due consideration for the basic aspects of the farm animals' innate behaviour; use of livestock breeds well-suited for local conditions, and creation of a harmonious balance between crop production and animal husbandry (IFOAM, 2000).

The overall objective of this study is to identify strategies for a diversified organic pork production with high credibility and superior eating quality based on pigs foraging in

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the cropping system, use of a traditional breed and no castration. Specific objectives to be studied are how breed affects the performance and pork quality of different ”types” of slaughter pigs. Three categories of slaughter pigs are investigated: 1) Entire male pigs slaughtered before sexual maturity, 2) Female pigs slaughtered at more than 100 kg live weight and 3) Sows slaughtered after weaning of the first litter. Three different breed combinations will be compared: The modern crossbred (LandracexYorkshire) x Duroc (LYD), the traditional breed Danish Black-Spotted (BS) and the crossbred Danish Black-spotted x Duroc (BSD). In this paper preliminary results will be presented from the first year of the project.

Materials and methods

The experimental set-up was based on outdoor seasonal production of pigs with farrowings in the spring. 17 gilts (6 LY mated with D, 6 BS mated with BS and 5 BS mated with D) farrowed in April in individual paddocks with clover grass. The piglets were weaned at 10-11 weeks of age in June/July. The piglets stayed in the paddocks with access to the farrowing hut. The first parity sows were slaughtered shortly after weaning and six BS and five LY first parity sows were selected for meat quality assessments. The entire male pigs were slaughtered in July at approximately 40 kg live weight. Seventeen male pigs (one pig from each litter) were selected for meat quality assessments. After removal of the male pigs, three female pigs per litter where chosen to remain in the paddock. These pigs were slaughtered in the beginning of November. Back fat and meat thickness were measured at two points on the carcass with an optical probe (MK equipment). Surface colour with the parameters L* (lightness), a* (redness) and b* (yellowness) was measured on slices of the M. longissimus dorsi using a Minolta Croma Meter CR-300 colorimeter.

Results

In the following, preliminary results will be presented as numerical differences between breed combinations. The first parity sows’ litter sizes, number of weaned piglets and piglet mortalities are presented in Table 1. One BS sow was excluded from the material due to an unusual low litter size of two piglets. In average the BS sows gave birth to 2.2 fewer piglets per litter than LY sows, but weaned only 1.1 less piglets per litter due to a markedly lower piglet mortality rate (21% lower).

Tab. 1: The litter performance of the first parity sows (BS: Danish Black-Spotted, LY: Landrace x Yorkshire)

	BS (n = 10)		LY (n = 6)	
	Mean	SD	Mean	SD
Litter size (dead and live born)	9.8	1.1	12.0	2.9
Weaned piglets per litter	8.2	1.8	9.3	1.6
Total piglet mortality, % of born piglets	16.5	15.0	20.8	8.8
Weaning age, days	74	9	72	9

Danish Black-Spotted piglets grew in average 21% slower than LYD piglets (316 g vs. 399 g per day) in the period from a few days after birth to weaning at 10-11 weeks of age. There was a negative effect of castration on daily gain for all three breed combinations and in particular for LYD pigs. Across breed, the daily gain was - in average - 15 % lower for castrated pigs compared to entire male pigs (332 g vs. 390 g per day). For LYD pigs, castrated pigs grew 24% slower than entire males (351 g vs.

459 g per day). The mean weight at weaning was 25 kg, 24 kg and 28 kg for BS, BSD and LYD pigs, respectively.

The first parity sows were slaughtered shortly after weaning at a mean live weight of 115 kg and 173 kg for BS and LY, respectively. The dressing percentage was 69 % for both breeds. The LY sows were leaner than the BS sows (e.g. 14 mm vs. 19 mm back fat and 57 mm vs. 41 mm meat thickness in one of the measuring points). The BS sows scored lower in L* (48.2 vs. 50.5) and higher in a* (11.8 vs. 9.6) and b* (5.2 vs. 4.5), indicating darker meat compared to LY sows.

The entire male pigs were slaughtered at a mean age of 102, 87 and 87 days and a live weight of 39, 38 and 43 kg for BS, BSD and LYD, respectively. The dressing percentages did not differ markedly between breeds (71%, 73% and 73% for BS, BSD and LYD, respectively). There were no big differences in the thickness of the back fat and the meat of the three breed combinations (e.g. 11, 9 and 9 mm back fat and 58, 51 and 55 mm meat thickness in one of the measuring points for BS, BSD and LYD, respectively). Also for entire male pigs, the surface colour differed markedly between the breed combinations as shown in Table 2. The BS scored lower in L* than BSD and LYD and both BS and BSD scored higher in a* than LYD. BSD scored higher in b* than BS and LYD.

Tab. 2: Surface colour of slices of M. longissimus dorsi for entire male pigs (BS: Black-Spotted, BSD: Black-Spotted x Duroc, LYD: (Landrace x Yorkshire) x Duroc)

	BS (n = 6)		BSD (n = 5)		LYD (n = 6)	
	Mean	SD	Mean	SD	Mean	SD
Minolta L*	49.4	4,8	53.7	2.3	54.0	5.1
Minolta a*	8.1	1.0	7.9	0.4	5.1	1.1
Minolta b*	3.4	1.2	4.3	0.6	2.9	0.8

Discussion

The use of traditional breeds like the Danish Black-Spotted pig might be a way to produce organic pork products, which in e.g. appearance and flavour differ from conventional products. Preliminary results of this study support this theory as pork from the BS sows and young males was darker compared to pork from the more modern crossbreeds when observing numerical differences. Coming assessments will illuminate whether a difference in sensory profile also exists. In a previous pilot study, the pork from BS pigs was considered as tastier compared to modern crossbreeds (Christiansen, 2005).

Traditional breeds are generally considered as more suited for outdoor production because of their hardiness, less exposure to extreme weather situations and good mother abilities (Edwards, 2004). The results presented in this paper indicate that BS sows have lower piglet mortality, however, whether this is due to improved mother abilities is not known. Behavioural observations before and after farrowing will be included in the second year of the present project. Furthermore, it will be evaluated whether the traditional breed is able to retrieve a larger proportion of their energy need by foraging. This would be of great value in organic pig production based on pigs integrated in the cropping system.

Slaughtering entire male pigs at 40 kg live weight may be a way to improve the animal welfare in organic farming and simultaneously producing organic pork products of a particular appearance and high eating quality. It is common procedure to castrate piglets in organic farming to reduce the production of skatole as well as androstenone and thereby the risk of boar taint. It is, however, well documented that castration is associated with pain for the animal (Prunier et al., 2006) making castration inconsistent with the aim of organic farming in terms of good animal welfare. Castration is further known to reduce the growth rate of the pigs as confirmed in the present study and to reduce feed efficiency. Thus, there are some very important advantages of entire male production. It is expected that slaughtering the pigs at 40 kg live weight as in this study will reduce the risk of boar taint. Skatole concentrations in back fat of the young male pigs will be assessed in the nearest future.

Conclusions

Danish Black-Spotted first parity sows had lower litter sizes compared to the more modern crossbred Landrace x Yorkshire. However, due to lower piglet mortality, the difference in weaned piglets per litter was only 1.1 piglets. The daily gain of the piglets from castration to weaning differed markedly between breeds. In average, the Black-Spotted piglets grew 21% slower than Landrace x Yorkshire piglets. There was a clear negative effect of castration on daily gain, especially in the Landrace x Yorkshire piglets with 24% higher daily gain in entire males compared to castrated pigs. Both the Black-Spotted sows and the Black-Spotted entire males, which were slaughtered at approximately 40 kg, had higher a* scores and lower L* scores indicating darker meat compared to Landrace x Yorkshire crossbreeds. In conclusion, preliminary results indicate that the use of a traditional breed might be a way to produce pork, which in appearance differs from conventional pork and at the same time improve the credibility of organic pig production.

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Influence of amino acid level and production system on performance, health and behaviour in organic growing pigs

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Key words: lysine, production systems, growing pigs, social interactions, health

Abstract

The influence of dietary amino acid levels (recommended, 7% and 14% lower) on performance and carcass quality was studied in organic indoor and outdoor pigs fed ad libitum in a 2-phase feeding system. The outdoor pigs grew faster during phase 2 than the indoor pigs (p=0.001), although feed conversion ratio did not differ (p=0.358). Dressing percentage was higher for outdoor than for indoor pigs (p=0.011) but lean meat content did not differ (p=0.904). The results indicate a discrepancy between pigs housed in different production systems rather than between pigs directed to different dietary amino acid levels. This suggests that growing/finishing pigs fed ad libitum can compensate for dietary amino acid levels lower than the current Swedish recommendations without affecting production results.

Behaviour was affected by production system and showed that outdoor pigs walked significantly more (p=0.012) and tended to be rooting more (p=0.098) than indoor pigs. Sniffing, nibbling, pushing (p=0.001 for all) and tail manipulation (p=0.002) occurred more often indoors than outdoors. The incidence of pigs seropositive to erysipelas was higher outdoors (χ2-test; p=0.001). Ascaris suum infections were present in both production systems, whereas Eimeria sp only was found among outdoor pigs.

Introduction

The regulations for the formulation of organic pig diets limit the number of potential and approved feedstuffs that are rich in protein and have a desirable amino acid profile. In addition, the use of synthetic amino acids is not allowed (EC, 1999; IFOAM, 2002). To compensate for the dietary deficiencies in essential amino acids, a high inclusion level of protein in the organic diet is necessary, resulting in a surplus of dispensable and non-limiting essential amino acids. This can affect production results negatively and increase the losses of nitrogen to the environment. A sufficient total daily intake of protein and amino acids could probably be assured when the voluntary feed intake increases in order to maintain a high daily energy intake, according to Håkansson *et al*. (2000).

Pigs in organic production shall be able to express their natural behaviour for grazing and rooting. Roughages induce satiety and studies have shown that aggressive and harmful behaviours were reduced in roughage or straw enriched environments (Beattie *et al*., 2000). By increasing the time spent eating; roughages can keep the pigs occupied and reduce stress and aggression.

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The number of incidences of arthritis and arthrosis at slaughter have been higher for pigs raised outdoors, and according to Kugelberg *et al*. (2001) this phenomenon can be linked to erysipelas (*Erysipelothrix rhusiopathiae*). Outdoor production may cause an increased infection risk from parasites e.g. large round worm (*Ascaris suum*), because routine deworming is not practised in organic production systems.

The performed study aimed to investigate the influence of different amino acid levels on performance and carcass quality of organic pigs reared in indoor and outdoor production systems. Further, observations were performed in order to evaluate the pigs' activity behaviour and social interactions and the pathogen load was evaluated.

Materials and methods

A total of 192 growing/finishing organic pigs (L-YxH) were raised indoors (I) in conventional pens or outdoors (O) on pastures. The indoor pens had a concrete floor, with a slatted floor in the dunging area. The total area was 14.8 m^2, giving a floor area of 1.1 m^2 per pig. Indoor pigs had no access to outdoor area, but were provided with straw once daily. The outdoor pastures had a total area of not less than 0.3 hectare (375 m^2 per pig) with access to a shelter (1m^2 per pig) with straw bedding. One feeder was placed in the front of each pen and pasture and only one pig could eat at the same time from the feeder. Water nipples were placed over the slatted floor indoors and next to the feeder outdoors. In total there were 12 pens indoors and 12 pastures outdoors and each pen or pasture included eight pigs, four females and four castrates. Piglets were randomly allocated within litter to six treatments (IR, IR-7, IR-14 and OR, OR-7, OR-14), balanced according to sex and live weight. The pigs received diets containing different amino acid levels (lysine, methionine + cystine and threonine), based on standardised ileal digestible (SID, g/MJ ME) values. R was in accordance with the recommendation for growing/finishing pigs in Sweden, R-7 and R-14 contained 7% and 14% lower amino acid levels than the recommendation (Simonsson, 2006; Table 1). The amino acid supply was given as a 2-phase feed and all diets were provided ad libitum. Individual live weight and group average feed consumption were recorded continuously during the experiment and carcass parameters were assessed conventionally at slaughter. At three occasions; 60, 110 and 140 days of age, samples of blood and faeces were collected and active behaviour and social interactions of the pigs were studied.

Tab. 1: Planned standardised ileal digestible (SID) amino acid supply (g/MJ ME)

	Weight interval (kg)	Lysine	Methionine+cystine	Threonine
IR + OR	19-60	0,68	0,41	0,44
	61-113	0,58	0,33	0,38
IR-7 + OR-7	19-60	0,63	0,38	0,41
	61-113	0,54	0,31	0,35
IR-14 + OR-14	19-60	0,59	0,35	0,38
	61-113	0,50	0,28	0,33

Results

Pigs in OR, OR-7 and OR-14 treatments grew faster than IR, IR-7 and IR-14 pigs (1005, 1109 and 1000 vs. 865, 911 and 839 g, respectively; p=0.001) during phase 2 as well as during the entire period. Treatment did not affect feed conversion ratio (p=0.676), which was on average 41.7 MJ ME/kg weight gain for the entire period. All OR treatments had higher carcass weight and dressing percentage than IR treatments (p=0.006 and p=0.011, respectively) but lean meat content was similar in all treatments (p=0.904) and was on average 57.2%. No interactions between treatment and sex were found. All pigs consumed slightly less standardised ileal digestible amino acids than the Swedish recommended levels (Simonsson, 2006) during phase 1. During phase 2, all pigs except those in treatment OR had lower daily intake of lysine and threonine compared with the recommendations, however methionine and cystine was around the level recommended or slightly above for all treatments (fig. 1).

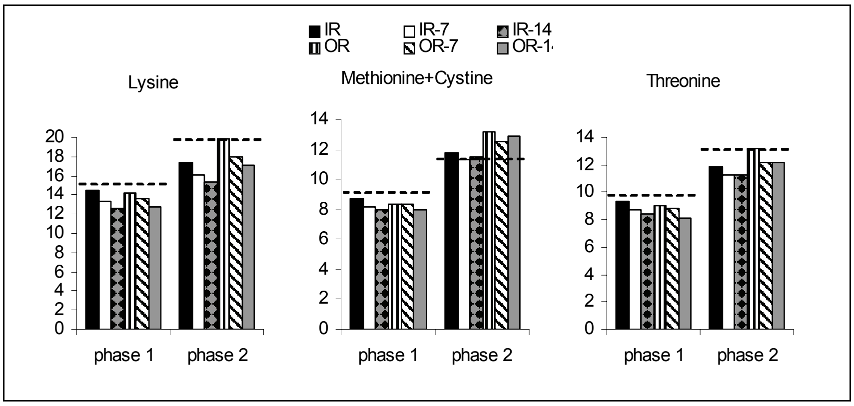

Figure 1: Daily consumption of standardised ileal digestible lysine, methionine+cystine and threonine (g/day) for pigs in different treatments compared to the recommended values (Simonsson, 2006) of daily intake.

Outdoor pigs walked significantly more (p=0.012) and tended to be rooting more (p=0.098) than indoor pigs. Social interactions such as sniffing, nibbling, pushing and tail manipulation occurred more often indoors than outdoors (p ≤ 0.01 for all). The incidence of pigs seropositive to erysipelas was higher outdoors than indoors (22 vs. 4.6%, respectively; χ2-test; p<0.001). *Ascaris suum* infections were present in both production systems, whereas only outdoor pigs were infected with Eimeria sp (χ2-test; p<0.001).

Discussion

The results in our study mainly indicate a difference between pigs housed in different production systems (indoor/outdoor) rather than between pigs subjected to different dietary amino acid levels (R/ R-7/ R-14). No significant effect of dietary amino acid level on performance and carcass quality could be observed and consequently, *ad libitum* feeding seems to have ensured a sufficient total daily intake of protein and amino acids even with 7 and 14% lower levels of lysine, methionine + cystine and threonine than the Swedish recommendation (Simonsson, 2006). The lower daily consumption of amino acids compared with the recommendations indicate that they could be too high for organic pigs fed ad libitum. Recently, Bertolo et al. (2005)

showed that growing pigs on average had lysine requirements that were 94 % of the current NRC requirements. Walking and rooting occurred more often by outdoor than by indoor pigs in our study and this could be part of an explorative behaviour in accordance with Wood-Gush *et al*. (1990). An outdoor system with pasture seems to allow pigs to be more active and perform more natural behaviours, such as foraging and rooting, than an indoor system and reduce the frequency of aggressive behaviours. The higher incidence of pigs seropositive to erysipelas outdoors indicates a potential need for vaccinations to avoid problems with lameness and deteriorated animal welfare.

Conclusions

The amino acid level in diets for organic growing/finishing pigs fed *ad libitum* could be reduced, below current Swedish standards for conventionally raised growing/finishing pigs, without any negative effects on performance and carcass quality. Reduced dietary amino acid levels can make it easier to optimize nutritionally sufficient feeds for organically raised pigs with available feed resources. This will also benefit the environment by minimizing the excretion of nitrogen.

Acknowledgments

This study was granted by Formas (The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning).

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Effects of a feeding strategy to increase intramuscular fat content of pork under the conditions of organic farming

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Key words: feeding strategy, pork quality, intramuscular fat, on-farm research

Abstract

Eating quality of pork is to a high degree influenced by the intramuscular fat (IMF) content. In previous studies under standardized conditions the feeding strategy was identified as a main source of variation for the IMF content in pork. In this study the effect of the implementation of a specific feeding strategy using a high portion of home-grown grain legumes on the IMF content of pork, was assessed under different conditions on German and Austrian farms. Results showed that IMF content ranged on a comparably high level of about 2.2 %. In contradiction to previous results under standardized conditions the factor feeding had no significant influence on the IMF. The feeding effect was overlapped by heterogeneous conditions on the different farms. IMF content showed greater variation between the farms than between groups within each farm.

Introduction

The IMF content is the prominent criterion for eating quality of pork, well known for enhancing softness, tenderness and overall liking of pork (Affentranger et al. 1996, Fernandez et al. 1999). The authors consider an IMF content above 2-2.5 % as a minimum level to influence sensory properties. The non-consideration of this trait and the unidirectional selection for lean meat in conventional production resulted in IMF contents averaging clearly below the desirable IMF values. In general, pig producers try to approach maximum rates of lean tissue deposition and carcass values by means of providing diets enriched with limiting amino acids. Results of Sundrum et al. (2000), obtained under standardized conditions, showed that diets based on organic home-grown grain legumes with an unbalanced amino acid supply have the potential to produce pork with an high IMF (> 2.5%) content and a high meat yield without causing excessively fat pigs. The present study was conducted to assess whether the previous results can be transformed into farm practice.

Materials and methods

A total number of 12 organic pork producers in Germany and Austria were involved. In the fattening period two dietary treatments (control and experimental diet) were used simultaneously on each farm in separate pens with about 20 animals per pen. On each farm one replicate was conducted. The control diets represented the feeding strategy followed on the individual farm while the experimental diet was based on a high portion of home-grown grain legumes that supplied restricted amounts of

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essential amino acids while at the same time increasing the supply with non-essential amino acids. In Germany the same experimental ration containing 47 % grain legumes (lupines and faba beans) was offered on all six farms. In Austria six farm-specific experimental rations, mixed by the respective farmers themselves with about 36 % grain legumes (peas and faba beans) were fed. Each mixture was analyzed by NIRS. The amino acid supply was separately determined by HPLC.

In Germany the genotype used was a crossbreed (Du x Ha) x (DL x DE) while the genotype on Austrian farms was a crossbreed Pi x (DL x DE). Recording of growth performance data started at the beginning of the finishing phase with about 70-80 kg and ended before slaughtering at about 120-130 kg live-weight. Carcass traits were assessed at the abattoir. Individual samples of *Musculus longissimus dorsi* (*M.l.d.)* of 10 pigs per treatment were taken from between the 13^{th} and 14^{th} rib and frozen at -20 °C before NIRS analysis.

Analysis of variance, estimation of least square means and standard errors were performed using the mixed procedure of the software package SAS 9.1.3 (SAS Institute 2004). Denominator degrees of freedom were approximated by the Kenward-Roger method. Residual were checked for normal (Gaussian) distribution and homogeneity of variance with residual plots by PROC UNIVARIATE and PROC GPLOT in SAS. The dependent variables were analysed by fitting a mixed model using farm, feed and sex as fixed factors: Farm*feed*round and farm*round were considered as random factors (Piepho et al. 2003).

Results

The experimental diet in Germany was characterized by a wide ratio between Lysin: (Methionine + Cysteine). The control diets showed a great variation in their amino acid ratio, depending on the respective mixture of the farm, but were better balanced than the experimental diet. In Austria the control diets as well as the experimental diets showed a great variation in the considered ratio of amino acids, but the experimental diets in comparison to the control diets tended to have a wider ratio of Lysin: (Methionin + Cysteine).

Performance and carcass traits of control and experimental groups on the examined organic farms in Germany are presented in Table 1. Daily live-weight gain was generally on a high level (above 800 g), but did not differ significantly between control and experimental group. Carcass traits such as lean meat content, fat and meat area showed no significant differences between both groups. IMF content tended to be higher for the experimental group (2.22 %) than for the control group (2.08 %).

Tab. 1: Mean values and standard deviation of performance and carcass traits of control (CG) and experimental group (EG) on organic farms in Germany

	Daily weight gain (g)	Lean meat content (%)	Fat area (mm)	Meat area (mm)	Intramuscular fat (%)
CG n = 113	844 ± 154	52.7 ± 4.1	20.0 ± 4.6	58.1 ± 5.0	2.08 ± 0.56
EG n = 115	823 ± 141	52.6 ± 3.2	19.7 ± 3.7	56.3 ± 4.7	2.22 ± 0.55

Performance data and carcass traits for the Austrian farms are presented in Table 2. Daily live-weight gain showed no significant difference between both groups. Lean meat content, fat and meat area were not significantly different between both groups. In Austria, the assessment and calculation of the lean meat content, fat and meat area was based on a different formula than in Germany, making the numbers for both countries being not directly comparable. Similar to the results obtained in Germany, IMF content of the experimental group tended to be higher (2.27 %) than for the control group (2.11 %).

Tab. 2: Mean values and standard deviation of performance and carcass traits of control (CG) and experimental group (EG) on organic farms in Austria

	Daily weight gain (g)	Lean meat content (%)	Fat area (mm)	Meat area (mm)	Intramuscular fat (%)
CG n = 60	794 ± 105	56.9 ± 4.0	14.9 ± 5.3	76.9 ± 5.7	2.11 ± 0.6
EG n = 69	732 ± 114	58.0 ± 3.4	13.5 ± 4.6	75.7 ± 5.7	2.27 ± 0.47

Mean values of IMF content (%) of the different farms in Germany and Austria are shown in Table 3. In Germany and in Austria the factor feeding had no significant influence on the IMF. In Germany, the interaction farm*sex (p = 0,0341) showed the response of IMF on different farms depended on the sex. Especially on one farm (farm 5) castrated male animals showed a significant higher IMF content (2.13 %) than female animals (1.74 %). Mean IMF values showed a high variation between the different farms, with a minimum of 1.88 % (farm 3) and a maximum of 2.36 % (farm 4), respectively.

For Austrian farms the factors farm (p = 0,0027) and sex (p = 0,0176) showed a significant influence on the IMF. Castrated male animals achieved a significantly higher IMF content (2.40 %) as compared to females (2.19 %). The IMF contents varied between the different farms from a minimum of 1.81 % (farm 3) to a maximum of 2.96 % (farm 6).

Tab. 3: Mean values and standard errors (s_e) of IMF content (%) on the different farms in Germany and Austria

	Germany		Austria	
	Mean	s_e	Mean	s_e
Farm 1	2.25	0.21	2,29 b	0,12
Farm 2	2.33	0.21	1,85 c	0,11
Farm 3	1.88	0.21	1,81 c	0,12
Farm 4	2.36	0.20	2,46 b	0,11
Farm 5	1.94	0.21	2,40 b	0,15
Farm 6	2.10	0.28	2,96 a	0,14

LSD (5 %) = 0.75; n = 228 LSD (5 %) = 0.17; n = 129

Discussion and Conclusions

Contrary to the previous results obtained under standardized conditions (Sundrum et al. 2000), different feeding strategies caused no significant differences between control and experimental groups on the IMF content of pork under on-farm conditions. Animals of the experimental groups in Germany and Austria both tended to a higher IMF value without being statistically different from the control groups. The reasons for the discrepancy between the results obtained under standardized or on-farm conditions are multi-factorial. On the one hand the IMF content in the control groups was already on a high level which might be due to the usage of relatively high contents of grain legumes in the control rations. On the other hand the highest IMF values in the previous study (Sundrum and Aragon 2005) were obtained with the feeding strategy beginning in the starting period, while in the study presented here the use of the experimental diet was restricted to the finishing period. The interaction between feeding strategy and IMF was probably overlapped by farm specific factors. In contradiction to the standardized conditions the rations showed great variations and were not consistent in their compositions regarding e.g. crude protein. Feed consumption also varied substantially between both groups in each farm as well as between the different farms. Variations in daily weight gain within the groups resulted in different ages at slaughter which might have an additional effect on the IMF content. An advantage of the used experimental ration was the possibility to supply fattening pigs with a ration containing 100 % organic feed ingredients and thereby meet the future requirements of the EC-Regulation with respect to bought-in feedstuffs. Due to the great variation between individual carcasses it is concluded that there is a need for a direct assessment of IMF content of pork at the abattoir to fulfil the expectations of consumers with regard to a high eating quality of organic pork.

Acknowledgments

The authors gratefully acknowledge from the European Community financial participation under the Sixth Framework Programme for Research, Technological Development and Demonstration Activities, for the Integrated Project QUALITYLOWINPUTFOOD, FP6-FOOD-CT-2003-506358.

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Occurrence of intestinal helminths in two organic pig production systems

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Key Words: fattening pigs, organic husbandry, outdoor, pasture rotation, helminths

Abstract

Organically raised pigs are at particular risk of being infected with pasture borne endoparasites, but the housing and management system may nevertheless have a great impact on transmission. In the present study pasture rotation routines on six pig farms representing two different organic management systems were compared; 1) a mobile system, in which the pigs during the summer were living in huts on pastures that were included in a long-term crop rotation scheme, while they during the winter were stabled with access to a concrete yard; 2) a stationary system, in which the pigs all year round were stabled with access to outdoor pastures in the summer time and a concrete yard in the winter. On one farm per system, the faecal excretion of nematode eggs from the pigs were analysed for a period of 3 years. Furthermore, soil samples were collected on a mobile farm to investigate levels of nematode eggs from fields with different pig/fertilizer history. The results showed that the use of a stationary system did not fulfil the actual recommendations for prevention of nematodes. The infection levels of *A. suum* and *Oesophagostomum* spp were high in the young pigs in both systems. In contrast, *T. suis* egg excretion was steadily very low in the mobile system, while the infection level increased during the observation period in the stationary system. The number of eggs in soil from the fields that had been used as pig pastures until November was larger compared to those used only until September, or that was fertilized by manure.

Introduction

Organic pig producers may have a variety of different production systems, and the housing and management system may in turn have huge impact on transmission and prevalence of intestinal helminths (Carstensen et al. 2002). Survey studies have revealed that organically raised pigs in general are at particular risk of being infected with pasture borne endoparasites (Roepstorff et al.1992, Carstensen et al. 2003) that may have an effect on animal welfare and production. Thus, organic finishers generally have high levels of milk spots in their livers, caused by migrating larvae of the pig roundworm, *Ascaris suum*. Since the use of prophylactic anthelmintic treatment is not desirable in organic husbandry, precautionary management is crucial (Roepstorff et al. 1992, Carstensen et al. 2003). Nematode eggs are deposited in the faeces but must develop in the outside environment before they become infective, and ingestion of infective eggs is the route of transmission. Ascarids mainly affects young

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animals while adults usually has acquired resistance (Roepstorff, 2003). In a single day one piglet may contaminate the environment with millions of eggs, which potentially survive for many years (Roepstorff, 2003). Although the eggs in general are highly resistant to physical and chemical factors, they may face a high mortality when exposed to prolonged desiccation, heat, UV-light, and/or microfungi. Another important pathogen is the whipworm *Trichuris suis*, which at high worm burdens might cause blood-stained diarrhoea and even death (Roepstorff & Nansen, 1998). *T. suis* has a life cycle very similar to *A. suum*, but *T. suis* seems to be highly associated with outdoor rearing, and this may be the reason why it is much more common in organic herds than in conventional herds (Roepstorff et al. 1992; Carstensen et al. 2003). The nodular worm, *Oesophagostomum* spp., is commonly found in pigs, but unlike both *A. suum* and *T. suis* it is only moderately immunogenic and therefore tends to accumulate with age in older pigs (Roepstorff & Nansen, 1998). *Oesophagostomum* spp. has a high prevalence in some organic herds while a low prevalence in others (Roepstorff et al. 1992; Carstensen et al. 2003), but the underlying reason for this difference is unknown. The aim of this study was to investigate the management in different organic pig production systems in relation to actual recommended nematode prevention routines and to increase the knowledge of the transmission and survival of eggs from pig parasites in the systems. This study is expected to contribute to a better understanding of how to control these infections in a sustainable way.

Materials and methods

Nematode prevention routines on six pig farms representing two different organic housing and management systems were compared during 2002 - 2004: 1) a mobile system (herds M1-M3) with huts, where the pigs were included in a crop rotation plan during the summer, while the pigs were stabled with access to an outdoor concrete yard in the winter; 2) a stationary system (herds S1-S3) in which pigs were housed all year round with access to outdoor pastures in summer time and a concrete yard during the winter. M1 and M2 raised their own pigs while the other farms bought the weaners, which were raised for slaughter. Most of the piglets were raised in stables during winter and in huts at the pasture during summer. During the three year study, one farm per system, M1 and S1, was chosen for investigation of the faecal excretion of nematode eggs from growers (at age 12 weeks) and fatteners (at age 20 and 23 weeks). On each of these two farms, five groups of 10 randomly selected pigs were examined every year on three occasions from May to November. Information on condemnations at slaughter was also registered. Furthermore, in 2004 soil samples were collected in May and July on one of the mobile farms (M1) to investigate levels of nematode egg contamination on fields included in a crop rotation system and with a different pig/fertilizer history: 1) six fields grazed by pigs, 2) five fields fertilized with pig manure, and 3) one field fertilized with a byproduct from yeast production (BioVinasse) mixed with water from the dunghill. On each occasion four pooled soil samples were collected per field. From May until October/November, pigs in both production systems had access to a pasture with a stocking rate of 84 – 147 m2/pig. In the mobile system, the interval for pasture rotation was 3-6 years (between grazings), whereas in the stationary system 1–2 years (Table 1). Unlike the mobile system, the pasture in the stationary system was in general used by consecutive groups of animals and the pigs also had access to a small permanent outdoor area next to the stable. In contrast, most pig groups in the mobile system were let out on a pasture that was totally included in a crop rotation system, and that had been unexposed to grazing pigs for several years.

Tab. 1: Pasture management routines in six organic pig farms representing two different housing and management systems; 1) a mobile system (M1-M3); 2) a stationary system (S1-S3)

	M 1	M 2	M 3	S 1	S 2	S 3
Groups/year in the same outdoor area	1	1	1	2	1-2	4
Rotation interval (years between grazings)	3	≥ 3	7	1	1	2
Partly permanent outdoor area	No	No	No	Yes	Yes	Yes
Stocking rate (m^2/pig)	134	114	147	94	101	84

Results

The infection levels of *A. suum* and *Oesophagostomum* spp was high already in the young pigs (12 weeks) irrespective of the system used. Approximately 50% of the 12 weeks old pigs were infected with *A. suum* and about 75% with *Oesophagostomum* spp. in both herds. In contrast, the infection level of the whipworm *T. suis* was very low in the mobile system throughout the three year study period, while the infection level tended to increase in the stationary system from the second year.

Eggs of *A. suum* were found in soil samples from all fields of herd M1. However, there was huge variation in the results ranging from a single "dead" egg in one sample, to several eggs in all four samples. Eggs from other nematodes were not found with the exception of *T. suis* that was detected in one sample from a field fertilized by manure. The mean numbers of eggs were reduced from May until July, however there was a large within plot variation. The number of eggs from the fields used as pig pastures until November was larger compared to those used only until September, or fields which were fertilized with manure.

Discussion

This study shows that the organic pig pastures in the stationary system were much more intensely used compared to those in the mobile system. In the stationary system the rotation intervals of the pastures were short (1-2 years in between grazings) and the pastures were often used by consecutive groups of animals. Also the pigs had access to small permanent outdoor areas. This is contrary to the recommendations for organic pigs, which recommends a rotation scheme including all outdoor areas (Roepstorff et al. 2001). Also, the rotation intervals should be as long as possible and a pasture rotation schedule should be strictly maintained in order to prevent parasite problems (Carstensen et al. 2003). The differences in management routines between the pig raising systems investigated in the present study indicated a higher risk of being exposed to nematodes in the stationary system. However, we were unable to confirm this by faecal examination of the fattening pigs (>12 weeks). On each of the two farms representing the different systems, already about 50% of the 12 weeks old pigs excreted eggs of *A. suum* and about 75% *Oesophagostomum* spp. Thus, the results from the faecal examinations, showed that the piglets had been infected already before they were brought into either of these pig raising systems. For the future, it therefore seems important to also concentrate on the management of the piglets before weaning. In contrast, the occurrence of *T. suis* differed between the two systems investigated herein. The number of whipworms in the mobile system was very low throughout all three years, while the infection level increased in the second year in the stationary system. Our results conforms with the Danish study by Carstensen et al. (2002), where the highest prevalences of whipworms were observed in organic pigs maintained for several consecutive years on permanent outdoor areas. Occasionally, such herds have also had clinical problems associated with *T. suis* (Carstensen et al. 2002) and the authors suggested that this may be due to accumulation of nematode eggs in the soil over the years. Such accumulation may also have taken place in the stationary farm that was investigated in the present study. The investigation of nematode eggs in the fields, revealed that fertilizing with pig manure from the dunghill was enough to cause a low level of *A. suum* contamination. The fields that had been grazed by pigs only at summertime had a low contamination similar to the manure fertilized fields. In contrast, the two fields that had been grazed during both summer and autumn displayed a more than tenfold contamination level compared to the other fields. This difference may partly be caused by the longer period of grazing and thereby more eggs being excreted on the area and partly because eggs excreted during the autumn seem to have a higher survival rate than eggs deposited during the summer (Larsen & Roepstorff, 1999; Kraglund, 1999).

Conclusions

The use of a stationary system all year round did not fulfil the actual recommendations for rotation of pasture areas. Faecal examination of 15 groups of organic pigs revealed high infection levels of *A. suum* and *Oesophagostomum* spp already in 12 weeks old pigs. The faecal results also indicated an accumulation of eggs from *T. suis* in the stationary system, which points out the need for longer rotation intervals. The results indicated that when autumn grazing is practised, the rotation intervals should be extended compared to only summer grazing.

Acknowledgments

Financed by: The Swedish Board of Agriculture, The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning and The Swedish Institute of Agricultural and Environmental Engineering.

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Multi criteria assessment of livestock systems

Organic livestock production - trapped between aroused consumer expectations and limited resources

Sundrum, A.[1]

Key words: standards, inconsistencies, conflict of aims, credibility, change in paradigm

Abstract

Literature reviews reveal that the implementation of organic standards have failed to clearly improve status of animal health and welfare on many farms in comparison to conventional production. The a huge variability with respect to this issue between organic farms indicate profound discrepancies between claim and reality of organic livestock farming. Thus, the hypothesis that the implementation of minimum standards will automatically provide benefits for the issue of animal health and welfare has been refuted by farm practice. As a consequence, organic farmers and retailers can no longer stick to the claim that organic products of animal origin are of higher value with respect to the issue of animal health and welfare. Reasons for the limited effects of the organic standards are multi-factorial and assumed to be farm specific in the fist place. On the other hand, limited availability of resources such as nutrients, labour time and investments within organic farm systems together with a high pressure on the production costs by retailers make any improvments very difficult. In order to preserve the credibility of organic agriculture and the confidence of the consumers in organic products there is a need for more transparency and for a change in the paradigm from a standard-oriented to an output-oriented approach. Credible information about the specific level of product and process qualities emerged by each farm has to be provided. Simultaneously, a high level of animal health and welfare has to be honoured by premium prices to cover the additional costs and efforts that are needed to improve the current situation.

Introduction

Standards are a characteristic feature of organic farming since 1954. The starting point for the standards was the trademark legislation that required clear criteria to identify organically produced goods (Schaumann 2002). Because the variety of production sites and the resulting product properties did not allow the identification to be linked to products in terms of quality that could be described exactly and understood analytically, the production method itself became the identifying criterion. This fundamental principle has been adopted by the EU Commission to harmonise the rules of organic farming and to make all organic systems across EU members subject to minimum standards (EEC Regulation 2092/91). One of the main objectives of the EU Regulation is to protect consumers from unjustified claims and to avoid unfair competition between those who label their products as being organic. Simultaneously, certified standards are closely linked to the expectation that they provide benefits and additional values. Consumers make a whole range of positive inferences from the label ‘organic’, including a high level of animal health and welfare on organic farms

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(McEachern and Willock 2004). Many consumers directly associate organic farming with enhanced animal health and welfare and conflate organic and animal-friendly products (Harper and Makatouni 2002). A healthy product from a healthy animal is by far the most important reason to buy organic products from animal's origin (Miele and Parisi 2003). There is, however, reason for concern that the expectations of the consumers often are not met by organic livestock farms.

Animal health and welfare as a process quality

Animal health and welfare has different meanings to different people. The attributes included in a concept to assess animal health and welfare primarily depend on who is making the definition. In the literature, there is a great variety of definitions of animal health and welfare, thoroughly discussed by Fraser et al. (1997). Hence, there is no generally accepted definition of animal health and welfare within scientific community. In general, legislators and brand label programmes are using technical indicators which refer to single aspects of housing conditions (e.g. space allowance), to describe different levels of minimum standards in relation to the appropriateness of housing conditions in terms of animal health and welfare. The EU-Regulation (EEC-No. 2092/91) clearly exceeds the minimum standards of conventional livestock production.

On-farm assessments, however, indicate that organic standards do not automatically lead to a high status of animal health and welfare that exceed the level in conventional production (Hovi et al. 2003; O'Mahony et al. 2006; Dietze et al. 2007). The results of these studies showed substantial variation both between and within farm types. Especially, the comparable high rates of mortality and morbidity interfere with the well-being of farm animals. Hence, consumer expectations are not met to an acceptable level. Reasons for the low effects of the organic standards are multi-factorial. Animal health and welfare emerges from complex interactions between farm animals and environment within a farm system. While standards represent only a small aspect with respect to the development of production diseases, the main source of variance is expected to be caused by the farm management (Sundrum et al. 2006).

Conflicting areas

Products with attributes of process quality such as animal health have in common that their unique selling proposition is not directly visible to the consumer. Only additional information will identify the characteristics of the production process of these foods. Perception of consumers is to a high degree influenced by information through media and advertising. However, neither media nor advertising campaigns define their view on animal health and welfare or provide information by which criteria the status is assessed. While different consumers show different preferences and subjective perceptions there is a huge variability of pictures in the 'eyes of the beholder' which makes it very difficult to deal with this issue without clear and reliable information.

On the other hand, organic farming has to deal with a high diversity between regions of Europe with respect to the availability of relevant resources (high quality feedstuffs, labour time, investments etc.), the perception of problems and the expertise to deal with these problems (Sundrum et al. 2006). In order to improve the unsatisfying situation, there is a need for additional efforts on many farms, encompassing among others improvements in feeding conditions (Sundrum et al. 2008), hygiene management and data handling (Dietze et al. 2007), and the implementation of feed back mechanisms to control the complex processes along the production chain. Thus, previous on-farm assessments indicate the need for a clear increase in labour time to meet the requirements of an appropriate animal health and welfare management.

Whether the additional costs will be compensated for in the long run by an increased productivity due to healthy animals and a reduction in veterinary costs remains an open question. This will depend to a high degree on the farm-specific situation and the development of the organic market and the production costs. As resulting costs of production for most organic farm types are higher than for conventional systems, price premiums are urgently needed to achieve an appropriate income (Offerman and Nieberg 2000). However, prices for organic animal products often do not even cover the previous expenditures need to implement the minimum standards. In addition, those producers who aim for a high level of animal health and welfare by increasing their efforts compete with their products on the same markets as those who widely ignore the issue of animal health and welfare and possibly gain advantages due to a lower cost basis or lower requirements for labour time.

Based on the previous results of on-farm assessments in various countries, retailers and producers can no longer claim to offer products that derive from healthy animals, without being at risk to loose credibility and confidence of consumers. While all organic livestock farmers will have to face the possible consequences deriving from the loss of credibility, those who have already invested a lot in measures to improve animal health and welfare will loose more than those who still work on the basis of derogations and comparable low production costs.

While farmers are responsible in the first place for the well-being of their farm animals, they are very limited in their freedom of decision-making as they possess little financial scope that can be used for improvements. In contrast, consumers are able to select between large ranges of products while the expenditures for food in relation to the total budget of a household have dramatically decreased during the last decades. On the other hand, the interests of retailers to increase turnover rates by offering organic food with comparable low prices contradicts with the possibilities of the farmers to investigate in substantial improvements of animal health and welfare.

For organic livestock production, consumers' interests and expectations are very important as they are closely linked to their willingness to pay premium prices being an essential precondition to cover the higher productions costs in comparison to conventional production. Therefore, it is of essential importance for organic farming to clarify on how to cover consumers' interests, to ensure consumer confidence and to avoid misleading labelling. The organic movement is challenged to ensure that its credibility and the confidence of the consumers does not get lost in the gap between claim and reality.

Conclusions

By arousing and/or not contradicting consumer expectations in relation to a high level of animal health and welfare in organic livestock production, retailers and producers of organic food are facing the risk to become victims of their own announcements. The current framework conditions of the food market contribute to a situation in which the existing potential for a high level of animal health and welfare in organic livestock production is not fully realised and the further development of quality production is hampered by contradicting expectations and perceptions. From an overriding perspective there is reason to conclude that the lack of clear objectives and threshold values concerning an acceptable status of animal health and welfare as well as the lack of control mechanisms within and outside the farm system contribute to the high variation in relation to animal health and welfare in organic livestock production. As organic standards so far have not worked properly to ensure a high status of health and welfare there is no clue that they will work in the future. It can be assumed that clearly increased feed prices and a high pressure on market prices for organic products will prevent farmers to invest efforts and money in measures which are very uncertain with respect to their profitability. To prevent the loss of credibility, organic farmers and retailers are obliged to take the burden of proof. Consequently, there is a need for a change in the paradigm from a standard oriented to a result and output oriented approach. Reliable monitoring systems for assessing the animals' health and welfare status are urgently required to accommodate societal concerns and market demands. Retailers should urge the producers to establish a regular monitoring system for animal health data, for example records of all incidences of treatment, mortality and morbidity rates, slaughterhouse data of fattening animals, and somatic cell counts of dairy cows. Producers failing to meet certain health standards in the longer term should face consequences. Simultaneously, retailers have to make sure that a high level of animal health and welfare will be honoured by adequate premium prices to cover the additional costs needed to ensure a process quality which is closely linked to the credibility of organic farming.

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Is automatic milking acceptable in organic dairy farming? Quantification of sustainability indicators

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Key words: organic dairy, automatic milking system, sustainability indicator, milk quality

Abstract

The objective of this research, was to quantify sustainability indicators of organic dairy farms using Automatic Milking Systems (AMS), and a comparative group of organic dairy farms using conventional milking systems (CMS). Milk yield per cow was higher for AMS farms but did not result in higher net return to management. Nitrogen surplus per ha of available land was higher for AMS farms, Animal health was unaffected by AMS use, as also most milk quality aspects; somatic cell count, clostridium spores and urea. Acid degree value (ADV), measured as free fatty acids (FFA) in the milk, was higher in milk from AMS users. Labour time was decreased by almost 50% for AMS users, to 2.3 min/cow/day. It could be concluded from quantification of selected indicators on economy, environment, cow health, milk quality, and labour time, that the organic dairy farms using AMS, in spite of the substantial decrease in grazing time, show potential for a sustainable development.

Introduction

The use of Automatic Milking Systems (AMS) has been increasing vastly the last few years in organic dairy production in Denmark. At the end of 2005, 9% of the 480 organic herds were using AMS. This is not surprising as organic farmers have been known to be innovative, both in system approach and technology. New technology can however provoke skepticism (Meskens and Mathijs. 2002) not at least when organic markets are based on trust and integrity for product quality and production process (Torjusen et al.2004.). A rising concern was registered among stakeholders involved in the production, addressing some sustainability issues of automatic milking (Oudshoorn et al. 2007). A survey was made of literature on AMS use (Oudshoorn & de Boer, 2005), considering possible conflicts with the organic view on sustainability and these were analyzed using focus groups with stakeholders. However no data was available for only organic AMS use so theoretical extrapolation was conducted. The issues of concern comprised economic profitability, increasing eutrophication potentials, caused by too high stocking density close to the barn, milk quality and the problems of pasturing (grazing and eating fresh herbage) the herd sufficiently (Oudshoorn et al. 2007). An accepted method for validation of these issues of concern comprises (Mollenhorst and de Boer, 2006) identification and quantification of indicators. The objective of the work was to acknowledge if the identified theoretical

concerns were correct, by quantifying indicators for these issues and validating them using CMS farmers and legislative thresholds as reference.

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Materials and methods

To validate selected sustainability indicators we chose to compare values of 9 organic AMS farms with 9 farms using conventional milking systems (CMS) for the year 2005. To make comparison possible, interdependent factors were avoided, like farms size and race. The issues of concern addressing sustainability were economic performance or profitability of the farm, on-farm eutrophication and biodiversity, labor, animal welfare including health, and milk quality aspects. For each of these issues we selected a set of sustainability indicators (SI's). We followed the definition of Bell and Morse (2003) who stated that an indicator should be an operational representation of a property, quality or characteristic of a system.Economic profitability was measured by quantifying financial result (i.e., gross income minus fixed and variable costs) and specifying some selected account items. Eutrophication was measured by quantifying N & P balances at farm gate and in specific fields used for grazing and mowing. Biodiversity was quantified by registering the amount of species in the selected fields. In addition the average field size was registered as field borders often give space to more diversity. Labor was registered as the average time used on tasks concerning dairy cows. Animal welfare and health were registered by selecting health indicators especially related to grazing, such as claw problems, mastitis, and reproduction, as well as the total amount of treatments (treatments per cow per year). Milk quality aspects concerning use of AMS were in the survey identified to the amount of free fatty acids (FFA), hygiene indicators and somatic cell count (SCC). Grazing itself was registered as well as direct influence on fat % and Urea content.

All results were tested for normal distribution and for variance and significant differences for the factor investigated (ANOVA).

Results and discussion

Tab. 1: Quantification of some general characteristic parameters, as average of 9 farms in each of the two groups: farmers with automatic milking systems (AMS) and farmers with conventional milking systems (CMS). Standard deviation in brackets.

Parameter	*Dimension*	AMS		CMS		
Dairy cows	*amount*	114	(34)	118	(38)	ns
Total area	*ha*	149	(63)	116	(57)	ns
Stocking rate	*LU ha^{-1}*	1.28	(0.32)	1.65	(0.68)	ns
Area available for grazing	*ha cow^{-1}*	0.29	(0.14)	0.25	(0.11)	ns

As a result of the partly structured selection of farms, the average herd size of AMS and CMS farms was the same (Table 1.). Stocking rate for CMS farms seems a bit higher, but due to large internal variation no statistically significant differences were found. Clearly the farms using AMS had higher milk yields than their organic colleagues using conventional systems (Table 2) but their profitability, shown as financial result, was not better. Surprisingly, as most economic assessment of AMS based on non organic farming systems show inferior economic performance for AMS compared to CMS farms (Meijering et al. 2004).

Tab. 2: Sustainability indicators for economic performance, eutrophication, milk quality and animal welfare and health. Average of 9 farms in each of the two groups: farmers with automatic Milking systems (AMS) and farmers with conventional milking systems (CMS). Standard deviation in brackets.

Indicator	*Dimension*	AMS		CMS		
Milk yield, delivered	*ECM cow^{-1}*	8539	(557)	7302	(880)	**
Financial result	*€ x 1000*	161	(54)	123	(69)	ns
Surplus N at farm level	*kg N ha^{-1}*	110	(29)	66	(40)	*
Surplus P at farm level	*kg P ha^{-1}*	8.8	(6.6)	3.4	(8.7)	ns
Surplus N grazing pasture	*kg N ha^{-1}*	92	(82)	166	(60)	*
Surplus N mowing pasture	*kg N ha^{-1}*	148	(79)	53	(80)	*
Average field size	*Ha*	5	(1.1)	5.3	(3.8)	ns
Plant species[1)] "graze"	*amount*	5.4	(1.3)	5.6	(2.1)	ns
Plant species "mow"	*amount*	3.4	(2)	2.4	(1.1)	ns
Labor used	*min cow^{-1}*	3	(1.2)	5.3	(1.2)	**
Sum vet. treatm. Summ.[2)]	*pr. cow*	0.48	(0.24)	0.33	(0.23)	ns
Sum vet. treatm. Wint.	*pr. cow*	0.40	(0.09)	0.32	(0.21)	ns
Culling rate	%	37	(6)	32	(5)	*
Grass uptake pasture	*kg dm d^{-1}*	5.1	(1.6)	6.9	(2.2)	ns
Grazing time	*hr y^{-1}*	968	(198)	2083	(788)	**
Somatic Cell Count	*10³ ml^{-1}*	219	(67)	226	(65)	ns
Clostridium spores summer	*10³ l^{-1}*	411	(661)	244	(108)	ns
Free Fatty Acids	*meq l^{-1}*	0.78	(0.16)	0.49	(0.11)	**
Applied concentrates	*Kg LU^{-1}*	7.28	(1.6)	6.25	(1.7)	ns
N balance import-export	*kg N ha-1*	8.00	(21)	-48.00	(66)	*
Available N for fertilizing	*kg N ha-1*	135.00	(26)	117.00	(48)	ns

*P value < 0.05 ** P-value < 0.001 [1)]Plant species: grass species counted as one. [2)]Sum vet treatm. summ.: the number of veterinary treatments per cow during the selected summer months (summer= Apr.-Sept.)

Surplus Nitrogen at farm level was higher on AMS farms, but in debt analysis showed that this was mainly due to larger export of farm manure by the CMS farms. The amount of concentrates used to accomplish the higher yield on AMS farms was not significant. The surplus N for grazing pastures on AMS farms was lower than for CMS farms. Explainable because the area available for grazing was the same for both groups, but the cows were outside grazing much longer for the CMS farms (Table 1 & 2). The increased time cows on AMS farms were inside resulted in higher amounts of manure collected, which could be applied on mowing fields and cash crops. No difference of biodiversity indicators was found between AMS users and CMS users. Labor time used for AMS users was dramatically lower, giving the farmer more time for other tasks, like observing the herd for possible sickness. In addition the flexibility of the labour day is larger (Meskens and Mathijs, 2002). Concerning animal health parameters, no significant differences could be registered between the two groups. It was however found that the culling rate for AMS users had a tendency to be higher. It has been reported in literature that the use of AMS provokes the culling, as some cows simply are not suitable for automatic milking (Østergaard et al. 2002). Milk quality is of major concern. Corresponding to other literature, no differences were found in SCC or Clostridium spores. However, the Free Fatty Acid (FFA) concentration in AMS milk was higher, a notorious disadvantage of AMS milking, mainly due to the higher frequency of milking (2.3 – 2.7 times per 24 hours). The absolute value of the FFA concentration is still low, in comparison to FFA values for non organic systems with AMS (Rasmussen et al. 2006).

Conclusions

Few of the selected sustainability indicators proved to be different for organic dairy farms using AMS, compared with farms using CMS. There was large variance between the farms of each group, however the production level was higher for the AMS farms. Higher feeding levels were registered for AMS farms. Animal health was unaffected by AMS use, as also milk quality aspects; somatic cell count, clostridium spores. Total grazing time per cow per year was less for AMS farms, and the free fatty acid value for AMS milk higher. However, these values were not alarming and thus organic dairy farms using AMS, show potential for a sustainable development.

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Environmental Impacts and Economic Differences in grassland based Organic Dairy Farms in Germany – Modelling the Extremes

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Key words: Organic, dairy, LCA, Economic return, Farm model

Abstract

Differences in environmental impact and economic returns between intensive and low-input organic dairy production are investigated using two simplified model farms with different amounts of concentrates being fed. In four scenarios, ecological and economic effects of restricting the more intensive farm management practice beyond the existing regulations of organic farming are analysed. In the initial situation, the intensive farm has a financial advantage of about 600.00 € per ha compared with the low-input farm, while the environmental risks caused by its production system are higher in several Life Cycle Assessment (LCA) categories. We showed for the model case that limiting livestock density and using regional grown concentrates bring about considerable improvements in LCA results, while restricting the amount of concentrates used does not. These three scenarios result in economic deterioration for the intensive farm. A fourth scenario increasing the share of pasture in daily dry matter intake (DMI) to a minimum of 50% during the grazing season has positive effects environmentally as well as economically.

Introduction

The spectrum of production systems in organic dairy farming in Germany ranges from traditional grass-based feeding systems with milk yields of about 6000 kg or less to herds fed with large amounts of concentrates yielding up to 9000 kg milk per cow and year. More intensive strategies are often justified economically, while the price paid in view of a possible aggravation of ecological impact is not accounted for. Then again, economic implications need to be considered when discussing more severe restrictions to farming practice meant for improving environmental performance. We investigated the interrelation between economic and ecological returns using two model farm types. These model farms are assumed to be perfect twins in every aspect but dairy management practice. In the initial situation, the feeding strategy was modelled extremely low-input (0.2 t DM of concentrates per cow and year, 6000 l milk yield) for one farm and extremely intensive (2 t DM of concentrates, 9000 l milk yield) for the other. The more intensive farm is adapted to four different scenarios describing restrictions that may be imposed in order to decrease environmental burdens and that are already fulfilled by the low-input farm in the present situation. We calculated the ecological changes obtained through these impositions and the resulting economic effects for the intensive farm.

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Materials and methods

The model assumptions were derived from analyses of 36 German organic dairy farms carried out between 1999 und 2007 (Deittert et al. 2008). Both farms are supposed to be grassland farms situated in one of the hilly regions in Mid-Western Germany. Both have a farmed area of 100 ha, on which 100 (intensive) or 80 (low-input) cows plus young cattle are kept respectively. Both farms have simplified farm geometry with the farm buildings being situated in the middle of a square farm area. Thus, the total of the farm area could theoretically be used for pasture. The low-input farmer practices a pasture based regime in summer and relies primarily on grass silage in winter, while in intensive system only 1 kg dry matter (DM) per day are taken in as pasture in the initial situation. The concentrates available in the scenarios are wheat and rapeseed oil cake assumed to be produced within an average distance of 100 km. In addition, imported soybean residues are used as cake and pulp. Milk yield and feeding intensity are assumed to be directly related through the energy and protein contents of the rations (GfE 2001), daily dry matter intake (DMI) is estimated according to Schwarz et al. (1996). One quarter of the herd is replaced per year in the low-input farm, while the intensive farm has a replacement rate of 40%. The cost of a heifer is the same in both models.

As the model farms are equal in every respect but number of cows, feeding system, replacement rate and milk yield, the difference in economic outcome per cow and per kg milk is calculated as the balance of the returns from milk and replaced cows on the one hand and the costs for replacement, fodder and concentrates on the other hand.

To study the environmental impacts, we did a LCA of both farms based on the methodology developed by Haas et al. (2000). The calculation of energy use comprises fodder production, provision of fuel and machinery, and production, processing and transportation of concentrates. The calculation of the climate impact - measured in CO_2 equivalents emitted per milk unit – comprises the CO_2 emissions caused by energy consumption, the CH_4 - emissions from ruminants and excrements and the N_2O emissions from excrements and fields. Results are related to one milk unit. In the evaluation of animal welfare the positive effect of pasturing and a ruminant adapted ration is taken into account. The N supply, calculated per hectares, is an indirect indicator for the potential biodiversity of the grasslands. For details of the methods applied see Müller-Lindenlauf (2008).

Besides the initial situation we considered the following scenarios:

Limitation of livestock density to 1.4 LU per ha of farm area

Restriction of the amount of concentrates used to a minimum of 20% of daily DMI

Increase of the share of pasture to a minimum of 50% of daily DMI during the grazing season

Replacement of imported feedstuff by regional wheat and rapeseed cake.

The requirements of these scenarios are already fulfilled by the low-input farm in the initial situation.

Results and Discussion

In the initial situation, the low-input farmer has a financial disadvantage of 600.00 € per ha based on actual prices for milk and feedstuff. Rising prices for concentrates diminish this disadvantage, but doubling the concentrate price would be necessary to equalize economic return of the model farms. As for the environmental effects, the low-input farm resulted in higher positive environmental impacts compared with the intensive farm in all categories except for emissions of CO_2 equivalents per kg milk (Fig 1 (a)). Since a reduction of greenhouse gas emissions is considered to be obtainable mainly by reducing the fibre content of the ration - i.e. intensification – we did not focus on this category further.

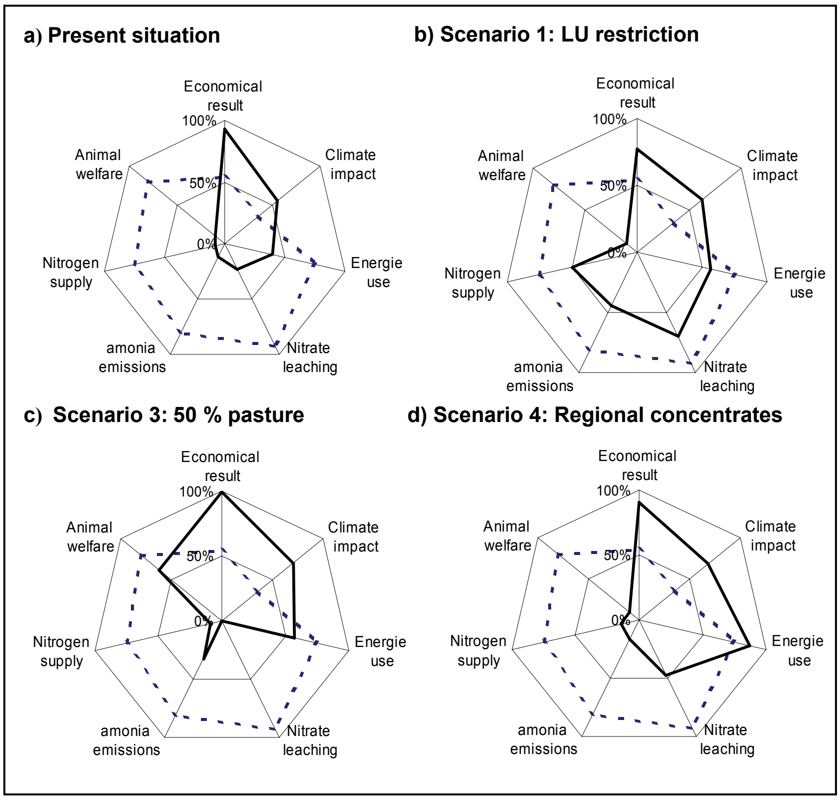

Figure 1: Economic return and environmental impacts of the intensive farming model in the present situation and under three scenarios in comparison with the extensive model farm. – – Extensive Farm, —— Intensive farm; Best results are displayed on the boundary, worst in the center. (Scenario 2 not shown because it did not lead to environmental enhancement). Climate impact, energy use and economic result: calculated per kg milk. Nitrate leaching, ammonia emissions and nitrogen supply: calculated per hectare. Animal welfare: rating value.

Energy use efficiency is considerably lower for the intensive farm and nitrate leaching potential and emission of ammonia are higher. The restricted pasturing is assumed to have a negative effect on animal welfare and the high N supply might cause negative effects on the biodiversity of the grasslands. The imposition of a livestock density of

1.4 LU per ha reduces the risk of nitrate leaching by 50% and also diminishes ammonia emissions (Fig 1 (b)). At the same time, the financial advantage of the intensive farm is reduced to 350.00 € per ha. If the concentrate is calculated to be 20% of DMI, this advantage would decrease further to 150.00 € per ha, while the environmental effects remain essentially unchanged. Imposing a minimum of 50% of pasture in daily summer DMI (scenario 3) does not only lead to improved energy efficiency, but also slightly enlarges the intensive farmer's financial benefit compared with the initial scenario. In addition, animal welfare would be enhanced. However, a prolonged grazing time for the intensively fed cows may lead to a higher risk of nitrate leaching through excrements.

A confinement to regional feedstuff would primarily improve the energy efficiency, while the financial effect observed would be small (scenario 4).

It has to be pointed out, however, that the described results do not apply to farms situated on arable land. In contrast to grassland, negative environmental effects of intensified feeding strategies are less distinct in these cases, because the import of nutrients into the farm either does not occur or can be compensated by an export of other farm products.

Conclusions

Our results show that restriction of livestock density, confinement to regional feedstuff and the use of pasture based feeding strategies are measures for reducing environmental risks caused by milk production on grassland farms. At the same time restriction of livestock density implies severe economic deterioration for the farmer of about 250.00 € per ha in the model case while for regionalization of feedstuff purchased and enhanced use of pasture the economic effects were comparatively small.

Acknowledgements

Our research was partially financed through „Bundesanstalt für Landwirtschaft und Ernährung Deutschland“ (BLE). We further express our gratitude towards the many farmers who admitted us detailed insight into their business.

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Impact of the drought on the fodder self-sufficiency of organic and conventional highland dairy farms

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Key words: fodder self-sufficiency, drought, highland dairy farm

Abstract

Eight highland dairy farms in the French Massif Central (4 organic and 4 conventional) were surveyed from 2000 to 2005 to understand the forage system functioning and the specificities of organic farms. During this period two important droughts occurred, which highly affected the fodder self-sufficiency of the organic farms, having consequences on more than a year of production. The conventional farms were less affected than the organic ones, and the farmers developed varied strategies including a reduction of the LU and the use of more maize. To maintain the stability of the milk production, organic farms had to increase the reliance on external fodder resources. The lack of security forage stores can explain the sensitivity of these farms and their incapacity to recover a good level of self-sufficiency.

Introduction

The general context of global climate change and the more frequent occurrence of severe summer drought (high temperatures, low rainfall) in the last years (Itier & Seguin, 2007) bring the farm sensitivity to the climate accident up to date. When a drought occurs, with low rainfall at the highest herbage growth period, the grassland based systems are very impacted. The farmers have to manage at the same time the livestock pasture and the building-up of winter stores, with a lack of fodder.

The adaptation strategies of the farms will be different following their possibilities of fodder and concentrate purchase, growing forage crops or changing the grazing management (Lemaire & Pflimlin, 2007). It is therefore interesting to investigate witch strategies organic farmers have developed to adapt their systems to the drought. In this article we will not study their adaptability to a new climate, but we will valuate the sensitivity to the drought of organic highland dairy farms and study their capacity to recover a high level of fodder self-sufficiency by comparison with conventional farms.

Materials and methods

This study is based on 4 organic dairy farms (O1 to O4) and 4 conventional (C1 to C4), located in the highland granitic area of the French Massif Central (800 to 1000 m), on sandy-loam soils. Organic and conventional farms are neighbours, in similar soil and climate conditions, which allows us to compare their technical performances. These farms were surveyed since 2000 and for a long-term period, so their functioning is very well known. The technical and economical data were collected and analysed every year (Charroin *et al.*, 2005).

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The main culture is grassland (table 1). Cereals are cultivated on average 9% of the useable farm area for the livestock consumption. The milk production rests on a grazing period of 150 days without supplementation and a grass-based winter diet. The milk production per fodder area is lower in the organic farms (3400 L ha^{-1} *vs* 4800 L ha^{-1}), due to lower herbage yield in organic in relation with the fertilization levels (Bouscary, 2006 ; Capitaine *et al*., 2007). The conventional farms have a more intensive milk production than the organic ones, with + 1100 L per cow. The organic farms are more specialised with 67% *vs* 53% of dairy cows per livestock unit.

Tab. 1: Characteristics of the two groups of farms (average 2000-2005)

	Organic farms	Conventional farms
Useable farm area (ha)	53,0	59,2
% of grassland	88	87
% of cereals	12	7
Stocking rate (LU ha^{-1})	1,02	1,19
Dairy cow LU^{-1} (%)	67	53
Milk per cow (L)	5 100	6 300
Milk per fodder area (L/ha)	3 400	4 800

During the 2000 to 2005 period, two years were affected by an important drought : 2003 and 2005. The indicator we used to valuate the sensitivity to the drought is the fodder self-sufficiency: ratio between the fodder produced on the farm and the total fodder consumption of the year, in tonnes of dry matter. In the following figures, the fodder yield is assessed with the information given by the farmers (for example number of hay bales and hectares cut). The fodder consumption doesn't take in account the grass consumption during the grazing period. It only concerns the forage supplies and is calculated with the farming accounts: Fodder consumption = stock beginning + fodder harvested + fodder purchased – fodder sold – stock end.

Results and Discussion

The main objective of the farmers was to maintain the milk production even in years of drought. They have therefore chosen to use the fodders supplies and then to buy some forage (figure1) and also concentrates to feed their cows.

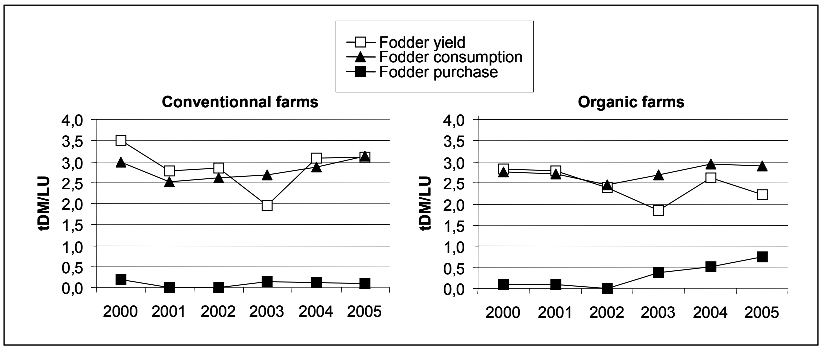

Figure 1: Evolution of fodder yield, consumption and purchase

From the year 2000 to 2002, the fodder purchase are nil or very low for the both systems. Only the conventional farms are able to maintain sufficient feed reserves, with a fodder yield surplus of 0,25 to 0,50 tDM LU^{-1} above fodder consumption. In 2003 the fodder yields fell down in both groups of farms (-1 tDM LU^{-1} and –36% in the conventional farms and -0,5 tDM LU^{-1} and –31% in the organic farms). The fodder consumption increased with the distribution of fodder during the grazing period. Only the organic farms had to purchase some fodder (0,5 tDM LU^{-1} and 14% of the consumption). In 2004, the levels of fodder yield were good again, but with still inferior to the needs in the organic farms. The second drought of 2005 did only affect the organic farms, with a new decrease of the fodder yield (-17%) and an increase of the fodder purchase (26% of the consumption).

In all farms the fodder self sufficiency (figure 2) was good before 2003 (almost always over 90%). The herd requirements were satisfied with the forage yields. In 2003 the conventional farms were affected with a loss of average 6% of self-sufficiency. Two farms were less affected (C3 and C4), but for C4 the fodder self-sufficiency has reduced in 2004: the fodder supplies were used in 2003 but not renewed in 2004, and the effect of the drought was deferred. The conventional farmers highly increased the concentrate use to maintain the milk production (+54% of concentrates in g L^{-1}). The organic farms were more sensitive with a decrease of the fodder self sufficiency from 7 to 41%, but they did not increase the use of concentrates during this first drought.

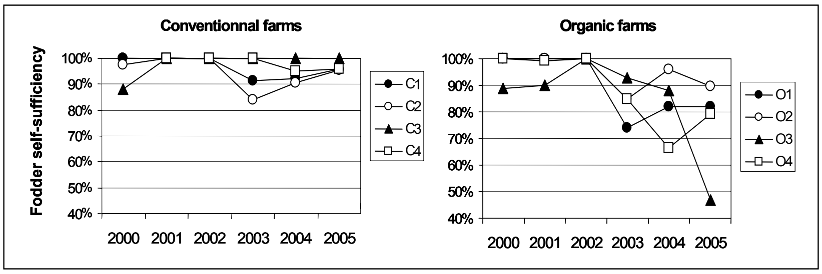

Figure 2: Evolution of the fodder self-sufficiency

In 2005, the conventional farms were not affected by the drought, and most of them had a better fodder self-sufficiency in 2005 than in 2004. Since 2003, they have developed various strategies to adapt their fodder need to the resources:

- decrease of the number of dairy cows, with an intensification of the milk production and use of more concentrates (C3 and C4)
- increase of the area of fodder maize, to increase the fodder stores (C2 and C3),
- stop of a fattening unit (heifers or beef steer) previously existing on the farm (C1 and C3),
- stop of fodder selling (C4).

For the organic farms, the situation of 2005 is very different. None of them was able to recover a good fodder self-sufficiency, in spite of a decrease of the number of cows since 2002 (average -13%). For two of them there is a new fall of this indicator. The situations are highly different between farms:

- O1 and O2 had a similar evolution, but not at the same level of self-sufficiency. O1 was more affected by the drought because of a lower security fodder stores and a higher level production (milk per cow, milk per fodder area).

- the O3 farm reaches the self-sufficiency only 1 year out of 5 (in 2002), and for the other years the average is 90%. This farm is in a period of decline, the farmer is near to the retirement and wants to reduce his workload.
- O4 suffered the most from the drought of 2003, with an effect on the years 2003 and 2004. In 2005, the fodder self-sufficiency has improved, thanks to the reduction of the fodder consumption and the milk per cow, but is still above 80%.

In organic as in conventional, we observed an intensification of the production level between 2000 and 2005 (+9% of milk per cow) with a greater use of concentrates (+20% of concentrates in g L^{-1}), even if this is not relevant in an economical point of view. The organic farms had less possibilities to reduce their fodder needs (they had no secondary unit) or to increase their fodder supplies (they did not grow maize), and the impact of the drought was therefore higher for them.

The analysis of the year 2006 will give us new indications on the ductility of the fodder self-sufficiency.

Conclusions

In highland situations, the organic farms have less possibilities to maintain their fodder self-sufficiency, in addition with their lower capacity to create fodder stocks. It leads them to a higher sensitivity to the climatic extremes. It is therefore relevant to study the strategic adaptations suitable for the organic farms to improve their self-sufficiency.

Acknowledgments

The authors wish to thank the farmers for their contribution to the study. We also thank Régine Tendille and Jean-Louis Lapoute, (Chambres d'Agriculture) and Jean-Luc Reuillon (Institut de l'Elevage) who realised with us the survey of the farms.

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Comparison of Organic and Conventional Beef-Suckler Farms in Germany

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Key words: Beef cows, Beef production, Germany, System comparison

Abstract

This study aims to compare conventional and organic farms with beef-suckler herds. Addresses were collected mainly by contacting breeding associations and farmers' magazines. 216 questionnaires were evaluated (34.1% of them organic). Beef-suckler production in Germany is an extensive production system (small farms, small herd sizes, high percentage of grassland, low soil points, etc.). 39% of farms had to fulfil special regulations for extensive grassland production and 43% carried out landscape conservation measures. Farmers specialize in beef-suckler production. 60% of them are part-time farmers. Beef production amounts to two thirds of their agricultural income. Most farmers keep only beef cattle on the farms. Other farm animals are kept in small stock sizes. This study has found only a few differences between conventional and organic farms. Organic farmers more often keep breeds of low intensity but more of them use direct marketing channels. On organic farms cows more frequently stay outside all year. Animal performances were the same in both production systems.

Introduction

In 2005, 4,163,600 dairy cows and 648,400 beef cows were kept in Germany. 4.29% of farmers worked according to organic guidelines on 4.74% of the cultivated land. However, 18.35% of all beef cows in Germany were kept on organic farms (RIPPIN & HAMM 2006). Beef cows formed the largest group of all farm animals. On 45% of 920 organic farms, beef-suckler cows were kept, which again means that they present the largest group (Hörning et al. 2004). Rahmann et al. (2004) found similar results. This study intends to find out how conventional and organic beef-suckler farms differ.

Materials and methods

Addresses of beef-suckler farms were collected mainly by contacting breeding associations and farmers' magazines. Roughly 650 questionnaires were sent out. 216 of them were sent back and were used for this examination. 34.2% of farms that returned completed questionnaires worked according to organic guidelines. SPSS statistical package (12.0) including Mann-Whitney-U-Test for non-parametric data was used.

Results and discussion

Average farm sizes and numbers of beef cows were relatively small (median 35 ha, 15 cows). Overall, beef-suckler production seems to be an extensive production system. Farms had a high grassland percentage (on average 80.9%, median 99.6%). Stocking density was relatively low (on average 0.57 cows per ha, median 0.50). In general, soil quality was low (on average 38.6 soil points, median 35.0). 38.9% of farmers had to

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meet special regulations with regard to extensive grassland production and 43.2% of them carried out nature conservation measures. All parameters mentioned above apply to both production systems.

On the farms studied, beef production was the most important part of their business. Other farm animals were kept on a relatively small number of farms (30 farms kept horses, 23 had laying hens, 22 fattening pigs, 15 sheep or goats, 8 geese, 7 dairy cows, 6 sows, 4 each had ducks and turkeys, 3 broilers). Also, average stock numbers were small (e.g. median 3 horses, 12 fattening pigs, 10 sheep or goats, 30 laying hens, 20 geese). This study found only a few differences between organic and conventional farms. On average, 60% were part-time farmers. Beef-suckler production amounted to 64.3% of their income from agriculture (median 70.0%). 42.3% of the farmers had kept dairy cows before they started with beef-suckler production. In spite of small herd sizes, farmers specialized in beef-suckler production.

Production types (> 60% of animals sold per year) were similar on organic and conventional farms. 19.7% of farmers focussed on the production of calves, which were sold to other farms for beef production at weaning age (median roughly 8 months). On 6.7% of farms, calves were slaughtered at a median age of 10 months (for baby beef). 24.9% of farms produced animals for beef production (bulls, heifers), which were slaughtered at a median age of 20 months. And 11.9% of farmers produced animals for pedigree breeding. Finally, 36.8% of farmers combined various types of production.

Calving time was the same in both production systems. However, on conventional farms, the calving season lasted longer (5.0 vs. 3.5 months). 164 farms kept one breed, 26 farms had two and 13 farms had three breeds. The main breeds found were Angus (on 41 farms), Charolais (n = 33), Simmental (n = 27), Hereford (n = 22) and Scottish Highland (n = 20). Organic farmers more often kept extensive breeds such as Galloway or Scottish Highland (26.2 vs. 16.5%) and less often intensive breeds such as Simmental or Charolais (13.8% vs. 34.6%). Semi-intensive breeds like Angus or Hereford were kept on 42.5% vs. 55.4% of farms.

More often than their conventional counterparts, organic farmers quoted breeding goals like robustness or quiet temperament while conventional farmers frequently referred to size of the animals and genetic hornlessness. Most farmers kept breeding bulls (median 1 bull per farm). Both production systems used the same share of artificial insemination (AI). Only 60 farmers in total used AI and only 16 of them used it for all their cows. The percentage of cows on the farms, which were artificially inseminated, did not differ.

145 farms provided details of feed components for beef cows. 74.5% of farms named grass silage, 73.8% hay, 26.9% straw, 11.7% maize silage and only 13.1% concentrates (cereals). On 22 farms, beef cows were only fed grass silage and on 16 only hay. Only 37 farmers mentioned feed rations. However, because many farmers fed only 2 components, calculating the average of components appeared meaningless. Amounts of concentrates for fattening animals were the same in both production systems. Organic farmers more often kept cows outside all year (43.9% vs. 29.7%) and conventional farmers more frequently owned more than one housing system for their animals (32.8% vs. 19.7%). The type of production did not have any influence on the percentages of management procedures such as pregnancy diagnoses, birth control, vaccinations, claw care, housing of sick animals, castration age, herd management computer programmes, feed analyses or body condition

scores. Performance parameters were the same for conventional and organic farms (Table 1).

Tab. 1: Comparison of health and performance parameters (average, median, 5 and 95% percentiles)

	Conventional				Organic			
	Mean	Mdn	5%	95%	Mean	Mdn	5%	95%
Age of cows (years)	7.1	6.5	4.0	12.0	7.3	7.0	5.0	11.7
Culling of cows (%)	15.7	16.1	8.3	25.7	14.7	14.3	8.6	20.0
Age at 1st calving (months)	29.4	30.0	24	36	28.3	27.0	24	36
Calving rate (% of cows)	96.6	99.5	90	100	95.3	98.0	80	100
Calving interval (days)	367.2	365	332	400	361.5	365	319.5	386.8
Calf losses (%)	5.7	5.0	0	15.0	5.3	5.0	0	10.1
Vet costs (€ per cow / year)	32.7	25.0	0	103.2	27.5	25.0	0.42	67.5

The average daily gain was roughly calculated by using marketing age (months) and final body weight (kg). More farmers provided data for slaughter than for live weights. Daily gains were higher for males than for females and also higher for weaners than for beef animals (Table 2). Daily gains increased with breed intensity (e.g. bulls of extensive breeds achieved a median of 305 g related to slaughter weight, semi-intensive breeds 562 g, intensive breeds 712 g). Due to small sample sizes (different breed intensities) a comparison between production systems does not seem enlightening.

Tab. 2: Daily weight gain (g) (number of farms, average, median, 5% and 95%)

	Live weight					Slaughter weight				
	n	Mean	Mdn	5%	95%	n	Mean	Mdn	5%	95%
Weaner (male)	46	1299	1356	507	1848	-				
Weaner (male)	33	1139	1230	314	1578	-				
Bulls	57	1032	1035	470	1541	87	570	593	237	813
Bulls	30	776	779	279	1308	46	404	411	161	659

Compared to conventional farmers, organic farmers more often used direct marketing channels, e.g. butchers' shops or restaurants., and less often slaughterhouses. However, organic farmers were able to sell only 56.6% of their animals as organic products.

Conclusions

Compared to other farmers and production branches, such as dairy cows, pigs or poultry, most farmers specialized in beef-suckler production, which they performed at relatively low intensity. Other studies found similar results with regard to organic or conventional beef-suckler farms in Germany (Balliet 1993, Buchwald 1994, Tenhagen et al. 1998, Hörning et al. 2004, Loibl 2004, Rahmann et al. 2004, Roffeis et al. 2006). Because beef-suckler production in Germany is a production system with generally low intensity (stocking density, amount of concentrates, etc.), conventional farms could easily be converted into organic ones. Conventional and organic beef-suckler farms did not differ much when it came to key characteristics or production performances. Therefore, organic farmers could have some difficulty in highlighting the advantages of their production system and in finding justifications for higher product prices. Perhaps this could explain why many organic beef producers have not been able to sell all their animals as organic produce.

Acknowledgments

We would like to thank all farmers, who participated in this study, as well as the breeding associations who provided addresses. The study was supported by KTBL, Darmstadt.

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Agripolicy: Institutions and implementations

Toward Regionalized Models of Organic Food Production and Marketing in the US: The Case of Michigan (USA)

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Key words: midwest organic model, organic marketing portfolios, small-scale organic family farm, fresh produce wholesalers and brokers

Abstract

This paper outlines some of the key features of a Midwest organic model that could provide the foundation for a regionalized organic strategy in the US. Based on the results of several recent and on-going studies of organic fruit and vegetable production and marketing in Michigan, the paper looks specifically at the profile of Midwest organic farming, the diversified marketing strategies and portfolios of Midwest organic farmers, and the challenges and opportunities identified by wholesalers and brokers for sourcing organic produce from small family farms. Two approaches to assure the viability of the Midwest organic model are introduced.

Introduction

Just under 10 years ago, the landmark Upper Midwest Organic Marketing Project signaled the need for more regionalized strategies in the US to encourage and preserve organic farming and marketing by small- and moderate-sized, independent and entrepreneurial family farms. The project specifically called for a more "holistic perspective" that would consider the "regional organic production, processing, distribution and retail infrastructure" needed to encourage organic bean, grain and dairy farming (Dobbs, 2000: 127). For Dobbs and his colleagues, such a perspective could inform strategies and policies designed to protect Midwestern organic family farms from pressures to integrate production, processing and distribution, and thereby from becoming more like the conventional or industrialized organic farming model typically found in California (see Guthman, 2004).

Despite the recent scholarly and popular attention to local and localized food systems, no comparable assessments of organic fruit and vegetable production and marketing in the US Midwest are available. Drawing upon the results from several recent and on-going studies of organic fruit and vegetable production and marketing in Michigan (USA), this paper outlines some of the key features of a "Midwest organic model" that could provide the foundation for one regionalized organic strategy in the US.

The development of such a strategy for expanding organic production and marketing in the upper Midwest and Great Lakes states will need to be based upon a better understanding of the following: the profile of organic farming in the Midwest: the diversified marketing strategies and portfolios of organic farmers; and, the challenges

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and opportunities identified by wholesalers and brokers for sourcing organic produce from smaller scale family farmers.

Materials and methods

This paper draws largely upon two surveys of organic production and marketing in Michigan: the 2006 Michigan survey of the 267 organic growers and processors certified by one of the nine certifying agencies registered with the State of Michigan (Bingen, 2007); and, on-going interviews with Michigan organic fruit and vegetable farmers about their marketing strategies, as well as interviews with 112 fresh fruit and vegetable wholesalers and brokers (intermediaries) related to buying and selling organic produce in Michigan and the Midwest. These data are complemented by insights from two years of informal discussions with both organic and conventional farmers about organic production and marketing constraints and opportunities, and the data available from the US Department of Agriculture, Economic Research Service (USDA/ERS) surveys of organic agriculture in the US from 1992 through 2005. (An organic farm census has never been undertaken in Michigan or the US).

Results

Organic Farming Profile. From 1997 through 2005, the USDA/ERS reported a 63 percent increase in the number of certified organic farmland acres in the US. In 2005, just over 8,000 US farmers had 4 million acres in certified organic production. Michigan certified organic farmland grew by 166 percent from 1997 through 2005. Based on 2005 data from the USDA/ERS, 205 certified Michigan farms represented 45,500 certified organic acres, or only .4 percent of the state's total farmland and one percent of the US total certified organic farmland acres (Bingen, 2007). Moreover, the state's organic farms are relatively small, but differ in size by type of farming (Table 1). Other states in the Midwest and around the Great Lakes report a similar profile of smaller scale organic farms (Kreider, 2004; Miller, 2006; Minn. Dept. of Ag., 2006). Data collected by the USDA, Economic Research Service also show comparable patterns of diversified organic production across the Great Lakes states (USDA, 2007).

Tab. 1: Farm size of Michigan organic farms by farm type

Farm Type	Average Acres		Median Acres		Range (acres)	
	Farm	Certified Cultivated	Farm	Certified Cultivated	Farm	Certified Cultivated
All Farms	260	237	135	110	1-2400	0.5 - 2200
Fruit & Vegetable	117	85	41	40	2-1500	0.5-600
Bean & Grain	360	340	200	186	25-2400	25-2200

Source: Bingen, 2007

Diversified Marketing Strategies and Portfolios. Each year Michigan's fruit and vegetable farmers may produce for, and sell into a mix of direct consumer (CSAs, farmers markets, farm stands), direct retail (restaurants, small grocery and health food stores) and even some wholesale markets. While most of the state's bean/grain organic farmers concentrate on wholesale markets, many of them have started to diversify into vegetables and value-added products, and are moving into more direct sales (Bingen, 2007). Wisconsin's organic farmers rely upon a similar mixed marketing portfolio (Miller, 2006).

Organic farmers regularly modify their marketing portfolios and only a few fresh produce farmers specifically define their marketing strategy prior to planting. Most of them rely upon networking with other farmers to identify buyers or markets. Personal relationships, not written contracts, tend to govern their interactions with retailers, restaurants and wholesalers. Given the importance of direct marketing in their portfolios, a growing number of these farmers are deregistering, or foregoing certification.

Wholesalers and Brokers. Thirty percent of the fresh fruit and vegetable wholesalers and brokers (intermediaries) doing business in Michigan currently handle organic produce, and 42 percent are considering entry into the organic produce market. Of these two groups, almost one-half are interested in buying Michigan organically grown produce. Organic Valley (CROPP) continues to explore ways for sourcing fresh organic produce from Michigan. But in response to various kinds of marketing pressures and publicity in the popular media, Whole Foods is the only major grocery chain that has started to purchase selected fresh produce from some small, family farms in the region.

Wholesalers and brokers identify several constraints on expanding their supply of organic produce from Michigan and the Midwest. Currently, they rely heavily on long-standing personal relationships with their suppliers (often in California), and thus look for a regular supply from Michigan and the Midwest that meets standards in order to change their current network of suppliers.

From the perspective of these buyers, several production challenges tied to the agro-ecologies of the Midwest threaten the ability of the region's farmers to meet these supply conditions. The short and variable growing season jeopardizes a regular supply, and pest and disease pressures may compromise the appearance of some produce. Finally, the continued easy and relatively inexpensive availability of fresh organic produce from California trumps the interest of most intermediaries in sourcing local and organic produce from Midwestern farms.

At the same time, many of Michigan's larger scale conventional fruit and vegetable farmers who produce for various types of processing or wholesale markets, and who could respond to wholesaler and broker supply needs, express little interest in transitioning even some part of their production into organic. Despite the increased global threats of cheap imported fresh produce to their production and marketing strategies, these farmers still do not accept organic as a viable alternative that could maintain or even enhance their livelihoods.

Discussion

The diversified, flexible production and marketing strategies of Midwestern organic farms represent a key feature of their viability and livelihoods. Yet these same strategies create constraints for intermediaries and larger retail grocers. Some fresh produce wholesalers and brokers would like to overcome these constraints by helping to create some type of collective marketing arrangements among small organic farmers. In order for such arrangements to work, farmers who have deregistered would need to (re)certify and many would need to find ways to accommodate their currently independent production and marketing styles to the longer-term planning requirements of the wholesale market. The current, yet limited, successes of some farms in working with restaurants, smaller wholesalers and grocers like Whole Foods, suggests that the creation of a viable Midwest organic model might be possible.

Conclusions

Unlike the California “paradox” in which organic farming has “replicated what it set out to oppose” (Guthman, 2004, 3), the Midwest organic model remains grounded in a small-scale family farm ideal and agrarian populism. As reflected in the evolving and diversified production and marketing portfolios, family decision making and shared responsibilities from production through marketing continue to be critical defining features of each farm’s viability.

Two approaches might help to overcome current constraints on the viability of this model. Both would involve proactive national and state government policies (cf. Smith, 2004). One step addresses the problem of deregistering by using the “criteria for variation” approach to adapt organic standards to local realities without compromising guaranteed standards (Courville, 2006). A second invites state governments to host roundtables for intermediaries and organic farmers to learn how dialogue can provide a foundation for creating successful collaborative and mutually-beneficial marketing relationships to protect and enhance organic farming in the Midwest.

Acknowledgments

The research for this paper was supported by a grant from the United States Department of Agriculture Cooperative Research, Education and Extension Service to Michigan State University, “The Transition to Organic in Michigan - Production and Marketing Constraints and Opportunities” (Special Research Grant 2005-34333-15581), and by a USDA grant, “Partnering to Cultivate Organic Agriculture in Michigan and the Midwest” (Agreement 2005-51300-02391).

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Institutions and Policy Development for Organic Agriculture in Western Balkan Countries: a Cross-Country Analysis

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Key words: Western Balkans, organic support policy

Abstract

This paper uses a comparative qualitative approach to study the dynamic of institutional changes occurring in the organic movement, State agricultural institutions and policies, and in the organic supply chain, in six Western Balkan countries. It shows that the 'Michelsen path' (Michelsen et al., 2001) is identifiable in these countries, but in a different sequence. Additionally, a number of common trends are identified in the organic sector of the countries studied, leading to a converging trajectory in institutions and policy development for organic agriculture.

Introduction

In the EU context, experiences of member states in relation the evolution of the organic sector and the institutional and policy developments have been examined in a theoretical framework developed by Michelsen (1997). This examines changes in three main elements of the institutional setting (farming representatives; state agricultural institutions and policies; and the food market) which interact individually and collectively to influence farmers' decisions to convert to organic agriculture. Michelsen and colleagues subsequently identified a seven-step path, leading to successful growth of the organic sector, consisting of four initial steps essential for the establishment of the organic sector, and three complementary steps facilitating further development. Michelsen *et al.*'s (2001) description, with the extension proposed by Moschitz *et al.* (2004) is summarised in Table 1 – part A. In the context of current pre-accession Europeanization processes undertaken by Western Balkan Countries[3] in agricultural and rural development (including organic agriculture), this paper compares development of institutions and policy for organic agriculture, providing insights into country- and region-specific variations in development, and draws conclusions on future prospects and action which could facilitate further development.

Materials and methods

The method of comparative case-study analysis (Stake, 2006) has been adopted to combine quantitative and qualitative information. This included desk analysis of over 100 official documents, participant observation, recordings of semi-structured interviews with 49 key informants in WBC and of national workshops. Qualitative material has been analysed using two separate coding stages, and triangulation between the different information sources.

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[3] Albania, Bosnia and Herzegovina, Croatia, Macedonia, Montenegro, and Serbia: within the text, these are abbreviated to AL, BiH, HV, MK, MNE, and SRB, respectively. Collectively, Western Balkan Countries are abbreviated to WBC.

Results

On the basis of the research findings, a revised sequence of the 'Michelsen path' has been developed, taking into account common features, specificities and emerging development trajectories of the organic sector in WBC (Table 1 – part B).

Tab. 1: WBC sequence of Michelsen *et al.'s* (2001) path

part A: Michelsen *et al.*'s (2001) path	part B: WBC sequence
Step 1: organic movement Step 2: political recognition Step 3: payment support Step 4: non competitive relationship Step 5: organic food market Step 6: committed institutional setting Step 7: issue of conflict (Moschitz *et al*. 2004)	Step 2: political recognition Step 3: payment support Step 1: organic movement together with Step 5: organic food market Step 4: non competitive relationship together with Step 7: issue of conflict (Moschitz *et al.* 2004) Step 6: committed institutional setting

Relatively small national organic movements in WBC are struggling to develop a clear identity. In most WBC, foreign donors and NGOs have played a major recent role in diffusing organic principles and practice, and helped shape national organic movements and structures. Many local NGOs were also fundamental to early growth. While usually connected to foreign agencies and cooperation projects, leadership came from scientists, extensionists, and consultants with long-standing commitment to organic ideals. These key individuals often work in mainstream agricultural institutions and, crucially, have developed interaction with newly created state organic agriculture structures. Thus, unlike organic pioneers elsewhere in Europe, organic organisations are not isolated from mainstream government institutions. Also, though pioneer farmers made seminal contributions to organic development, and active and committed producers are increasingly engaged in the decision-making, the movements themselves are not yet farmer-led. Sustainability of activities is of widespread concern, given reliance on external projects, and competition for project funding is predominant. This results in overlapping activities, confusion of roles, and ineffective coordination mechanisms.

Step 1 (establishment of a formalised organic community) of the 'Michelsen path' is thus not yet fully completed. The revised sequence begins with steps 2 (political recognition) and 3 (introduction of financial support), followed by steps 1 and 4 (development of a functioning market). Different organic movement development dynamics can be identified. In some countries (HV and SRB as well as in Slovenia), parallel pioneer initiatives started, as social movements, before the wars in the 1990s; these conflicts affected their subsequent development (in HV and SRB). This strand continues, and coexists with recent developments from 2000 onwards, throughout WBC, in which organic farming plays a more functional role, linked to foreign donors' agendas and requirements of EU integration processes. The latter is regularly reported as an accelerating factor: in some countries, adoption of state regulation for organic agriculture was more pivotal in establishing the sector than external support or market development initiatives.

Recently, ministerial units dealing with organic farming have been established; financial support (either project-based and/or area payments) has been introduced;

national organic logos have been created (in HV, MK, MNE); and National Action Plans have been drafted (in AL and MK). Such action is not always well established and resourced, but on balance, this regulatory institutional framework represents a significant step in building organic sector identity, role and legitimacy.

WBC governments appear to favour market development objectives, improving agricultural competitiveness and export opportunities, more than land management benefits; few links between organic agriculture and the management of protected areas have been exploited. Yet, apart from some export successes involving a limited range of products, markets for organic products is still mostly underdeveloped, and exhibit significant cross-country variation. Supply chains require improved structure and organisation, certified organic production is limited, organic processing units and technologies are inadequate, and consumers are ill-informed and confused.

Concern with market development is not exclusive to governments, but is shared by local NGOs, and also foreign donors. National organic movements play an important bridging role between producers and market actors, and in the private sector new local companies marketing organic products are keen to interact with existing movement structures and contribute to the growth of the sector as a whole. Interaction between national movements and the market provide an essential, mutually reinforcing impetus for organic sector development. Hence, the WBC-adapted sequence of the 'Michelsen path' gives greater importance to step 5 (development of a functioning market): it moves upward and is placed after step 1 (organic movement development and formalisation). In WBC, national organic movements link organic producers to both state and market, even though both of these are now developing direct interrelations with organic producers: the state through financial support, the market through individual contracts (Fig. 1).

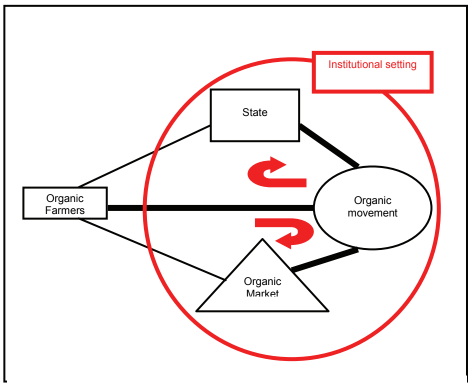

Figure 1: Interrelationship between organic farmers and the institutional setting in WBC

In contrast, relationships between organic farming and mainstream agriculture are virtually nonexistent: if contacts are reported, conflict (ideally leading to *creative conflict*) does not exist. The sectors' modest size, and limited recognition of organic agriculture in extension and research institutions, seems to prevent it from being perceived as a competing system. Also, organic agriculture is seen as one among several supported diversification options, in a period of significant agricultural restructuring in the WBC, mainly induced by Europeanization. Therefore, concluding the analysis on the revised 'Michelsen path', the combined complementary steps 7 (creation of an issue of conflict) and 4 (establishment of a non-competitive interrelations with mainstream agriculture) and ultimate step 6 (establishment of a committed institutional setting) have not yet occurred in WBC.

Conclusions

Analysis of development of the organic sectors in WBC suggests that certain actions could support and accelerate essential steps, and help initiate complementary steps on the 'Michelsen path'.

First, organic agriculture appears to have been institutionalised from the start, but often without awareness of its multi-faceted potential to meet evolving societal needs. Its recently established state structures, undergoing important learning processes, are not yet sufficient to plan and act for a sustainable development of the national organic sector, even though organic stakeholders expect much more than compliance with EU *acquis communautaire* in terms of establish promotion, coordination, and networking to develop the national sector. A clear identification and division of roles and responsibilities of all public and private actors with an interest in organic agriculture is required. *Second*, national organic movements need to go beyond lobbying to *i)* improve managerial skills; *ii)* strengthen internal cohesion, especially between members and leadership; and *iii)* consolidate their identity, broadening their appeal to a wider potential set of stakeholders. *Third*, important official platforms for dialogue and negotiation (developing National Action Plans for organic agriculture, and drafting and implementation of Agriculture and Rural Development Plans) should engage extensively with institutions and private actors, including those in mainstream agriculture, if integrated and coherent development of the sector is to be assured. *Fourth*, alongside the state, the organic movement and the market, local authorities and regional cooperation agents can play an important role in future development of organic agriculture in WBC. In short term, local authorities can implement support policies complementary to the state intervention, and, with ongoing decentralisation, they should prepare in the longer term to act as increasingly important players in the national and regional organic arena. Regional cooperation initiatives can provide assistance and experience exchange opportunities to the national organic movements; also, in connection with the needs and schedule of Europeanization process, they can design and realise flexible support programmes for capacity building of organic institutions and organisations in WBC.

Acknowledgments

Support came from the '*Training of technical experts in organic agriculture, in support of rural development and of food emergency in the Balkan area*' cooperation project, funded by the Italian Ministry of Foreign Affairs, implemented by CIHEAM-MAIB and Ministries of Agriculture in WB countries. Errors or omissions are our responsibility.

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Impact of agricultural liberalisation on the relative importance of price premiums for the profitability of organic farming

Sanders, J.[1], Stolze, M.[1] & Lampkin, N.[2]

Key words: agricultural liberalisation, price premiums, relative profitability

Abstract

In the literature, impressive evidences can be found with respect to the importance of price premiums for the absolute and relative profitability of organic farms. However, depending on the agricultural support framework, the relative economic importance of price premiums varies considerably. Model results presented in this paper suggest that the relative importance is likely to decline, if producer prices decline substantially and more support payments are transferred directly to farmers as envisaged in the framework of currently discussed liberalisation reforms in Switzerland or the EU.

Introduction

Price premiums are a way of compensating for lower yields and therefore contribute significantly to the financial performance of organic farms. They have been identified by several authors as an important factor affecting the absolute and relative profitability of organic farms (Freyer *et al.*, 2001; Nieberg, 2001; Darnhofer *et al.*, 2003). The relative economic importance of price premiums may however vary considerably, depending on the agricultural support framework. In general, the importance of price premiums is lower, if farmers receive their income mainly from direct payments and vice versa. This can be observed for example, if one compares the financial performance of organic and non-organic valley and mountain farms in Switzerland (ART, 2007).

In view of the recent agricultural policy changes in most European countries (liberalisation of agricultural markets, decoupling of price support from income support, increased public expenditures for rural development services) it is hypothesized that the relative economic importance of price premiums decreases in Europe the more agricultural markets are liberalised. The aim of this contribution is to present and discuss some modelling results on this issue. Switzerland has been chosen as an example for this investigation, since the pressure to liberalise agricultural markets and direct income transfers to farmers are particularly high in this country.

Approach

The model analysis was carried out with the sector-consistent farm group model CH-FARMIS (Sanders *et al.*, 2008). It is a comparative static, process analytical, non-linear programming model that allows a separate assessment of the impacts of policy changes on organic and non-organic farming in Switzerland. The agricultural sector is represented by thirty farm groups, which can be characterised by their farming

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system, farm type and geographic location. Book keeping data from the Swiss FADN was used as a primary source for the model. By applying farm-specific weighting factors, farm data were aggregated to sector accounts. Agricultural production is represented by 29 crop activities and 15 livestock activities. The factor allocation and production of each farm group is optimised by maximising farm income under policy and management restrictions. The restrictions cover the area of land and labour use, livestock feeding, fertiliser balance, rearing of young stock, allocation of direct payments and requirements with respect to the organic production system. A positive mathematical programming approach (PMP) was used to calibrate the production activities in the base year to observed activity levels.

Three different policy scenarios were defined that reflect the currently discussed liberalisation policies in Switzerland: AP 2011, WTO liberalisation and EU agricultural free trade. In Table 1, the assumed changes in prices and direct payment rates are briefly summarized.

Tab. 1: Assumed changes (%) in prices and direct payments rates

Area	Changes in prices and direct payment rates[1]				
	Basyr[2]	Reference	AP2011	WTOLIB	EULIB
Prices for crop products	100	90	78	73	46
Prices for livestock products	100	94	88	82	53
Prices for variable inputs	100	98	97	96	74
Prices for fixed inputs	100	105	105	105	98
Direct payments	100	100	120	120	120

[1] Average values of commodity and input groups
[2] 2001

In order to study the impact of different price levels on the financial performance, producer prices of organic farms were additionally varied in each scenario. Based on the projected price level, organic producer prices were increased linearly by up to +15% for all products and decreased linearly by -15% for livestock products and -40% for crop products. A decrease by -15/-40% approximately represents a situation where organic farms receive no price premiums. The prices for non-organic farms were not changed.

Results

According to the results shown in Table 2, agricultural incomes increase when organic farms receive higher prices, while the opposite is true when prices decrease. Furthermore, the results indicate that the impact of prices on agricultural incomes is greater for the AP 2011 than for the EULIB scenario. Income figures range from CHF 60,900 to CHF 43,200 under the AP 2011 scenario and from CHF 56,700 to CHF 40,900 under the WTOLIB scenario. A smaller variation can be observed under the EULIB scenario (CHF 50,200 to CHF 38,200). If organic farms receive no price premiums, agricultural income would be approximately CHF 5,500 to CHF 7,500 less than projected.

Tab. 2: Agricultural income of organic farms at varying price levels for organic products

Price level	Organic farms					
	AP2011	WTOLIB	EULIB	AP2011	WTOLIB	EULIB
	Agricultural income (kCHF)			*Changes to projected income (%)*		
+15%	60.9	56.7	50.2	*20*	*19*	*17*
+10%	57.3	53.5	47.7	*13*	*12*	*11*
+5%	53.9	50.4	45.1	*6*	*6*	*5*
Projected	50.6	47.6	42.8	*0*	*0*	*0*
-5%	47.5	44.8	40.7	*-6*	*-6*	*-5*
-10%	44.9	42.3	38.9	*-11*	*-11*	*-9*
-15%	43.9	41.5	38.4	*-13*	*-13*	*-10*
-15/40%	43.2	40.9	38.2	*-15*	*-14*	*-11*

Source: Own calculations based on FADN data from ART

These results are also reflected in Figure 1, which illustrates the impact of different pricing levels for organic products on the relative profitability of organic farms: the higher the price, the higher the relative profitability.

More specifically, the results of the price sensitivity analysis suggest that - under all three liberalisation scenarios – organic farms are, on average, more profitable than non-organic farms when prices for organic products increase by 5%. Under the EULIB scenario, organic farms achieve higher agricultural incomes on average than non-organic farms, even if they obtain no price premiums.

The ordinate shows the ratio of the profitability of organic farms to the profitability of non-organic farms. The red line indicates the relative performance level at which organic and non-organic farm type groups achieve the same profitability. The progression of the three curves in Figure 1 suggests a linear relationship between price and relative profitability when prices for organic products vary between +15% and -10%. Beyond -10%, prices have a declining impact on relative profitability. This response can be observed under all three liberalisation scenarios.

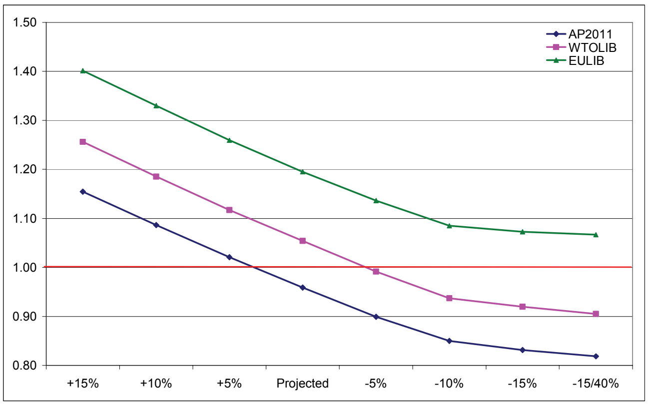

Figure 1: Relative profitability of organic farms at varying price levels for organic products

Discussion and Conclusion

The model results suggest that the relative importance of price premiums for the profitability of organic farming could decline under more liberalised market conditions. Surprisingly, Swiss organic farms would on average achieve a higher profitability compared to non-organic farms even if they would not obtain price premiums. On the other hand, it can be expected that this may not be true for all farm types. In view of the greater importance of commodity sales for profitability, this might be for example the case for organic valley farms and organic arable farms. If producer prices decline, other income sources such as direct payments and non-agricultural activities become relatively more important for the absolute and relative profitability of organic farms. Though the relative profitability could increase, the viability of farm households would be threatened, if lower prices result in a substantially lower farm income. Quantitative model have the advantage that they are able to account for complex structures and interrelations of the agricultural sector. For this reason, they may provide a valuable basis for policy discussions. However, it is important to note that the outcomes of quantitative models are closely related to the assumptions made. Consequently, such models are not employed to predict the future but rather to identify the impact of different driving forces under certain conditions.

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Potential implementation problems of the EU OAP: a failure mode and effects analysis

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Key words: Organic Action Plan, implementation problems, indicators, synergies, conflicts.

Abstract

Since 2001, the EU Commission has followed principles of good governance (EC, 2001). One of the five principles of good governance is participation in the formulation of policies and their implementation. The aim of this paper is to provide a first evaluation of the EU Organic Action Plan (OAP) and the Organic action plan evaluation toolbox (ORGAPET) combining the knowledge of researchers from different countries (AND, CH, CZ, DE, DK, IT, NL, SI, UK) with external expertise (Advisory Committee, EU Commission).

Introduction

In June 2004 the EU Commission delineated the European Action Plan for Organic Food and Farming (EC, 2004). The resulting European Action Plan for Organic Food and Farming did not originally accompany any specific policy measures, or a budget for specific policy goals. It resulted however, in the much-discussed revision of EC Regulation 2092/91. The revision process itself has been criticised with regard to insufficient stakeholder involvement (Eichert et al., 2006).

The aim of this paper is to provide a first evaluation of the EU Organic Action Plan (OAP) and the Organic action plan evaluation toolbox (ORGAPET)[2]. This has be done in two steps: the first step will provide a policy analysis of the EU OAP in order to identify the potential risks and problems associated to its implementation and assess the quality of the main indicators from the ORGAP evaluation toolbox (ORGAPET). The second step will develop strategies aimed at resolving the potential conflicts and exploiting the synergies in order to facilitate implementation of the EU OAP at national level.

Materials and methods

Concerning the first step, in order to provide an early assessment of potential risks and problems associated with specific policy-relevant areas, we used an adapted version of (process) Failure Mode & Effect Analysis (FMEA) (McAndrew & Sullivan, 1993) combining the knowledge of researchers from different countries (AND, CH, CZ, DE, DK, IT, NL, SI, UK) (Core Team) with external expertise (Advisory Committee, EU Commission) named Support Team.

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[2] The ORGAP evaluation toolbox (ORGAPET) is a collection of different evaluation tools, including participative techniques, quantitative assessments and methods to identify relevant indicators, which could be used selectively to meet the needs of a particular assessment of national or EU action plans (Lampkin et al., 2006).

The first task in FMEA is to identify and rank the most relevant problem areas of the EU OAP implementation. The core team used a special laddering questionnaire to elicit what can go wrong (list of problems) and to define the logical cause-effect structure of the problem, by identifying all possible causes of each problem. This has be done using the Means-End Chain model (Reynolds and Gutman, 1988). A cognitive map has been created, in order to visually identify links between causes and effects. Based on the results of the laddering exercises, in the second task a specific questionnaire has been submitted to the core and the support team: using 10-points Likert-type scales, for each failure mode (composed by a cause and an effect), the team has estimated the severity/seriousness (cost/impact) of the "failure", how likely is that each potential "failure" will happen (occurrence) and the likelihood of detecting the "failure" using ORGAPET indicators[1]. Once all experts have filled in the questionnaire, a Risk Priority Number (RPN) is calculated based on the product of: Detection X Severity X Probability of Occurrence. RPN will enable ranking of the most important problem areas for which the indicators provided in the toolbox may perform insufficiently. The minimum expected RPN is 1 and maximum 1000.

Concerning the second step, a policy and coherence analysis of synergies and conflicts between various actions of the EU Organic Action Plan has been performed by means of a matrix of cross impacts as specified in the MEANS framework (EC, 1999). The effects of synergies or conflicts have been rated with the help of the core team with 2 electronic consultation rounds[2]. After validation of these ratings, the calculation of the “synthetic” coefficient of synergies[3] has been performed, in order to evaluate the overall level of synergy/conflict between the EU OAP.

Results and discussion

Once the failure-modes have been defined, the core and support team have evaluated, for each cause and effect, the list of main indicators from the ORGAP evaluation toolbox (ORGAPET). The scope of this task was to verify if the main indicators of the ORGAP toolbox were able to cope with the logical cause-effect structure of the problems concerning the implementation of organic agriculture policy.

The approach to the classification of indicators used in this work is an adaptation of that used in the MEANS framework. Table 1 reports the failure modes and the relative mean RPNs. A quick inspection reveals that no single failure mode is particularly risky, since the maximum mean value is 210 while theoretical maximum is 1000.

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[1] The scale range from 1 to 10, whereas 1 refers to No effect (severity), Nearly impossible (probability of occurrence), Almost Certain Detection (detection probability) and 10, respectively refers to Extremely Severe, Extremely High, Absolute Uncertainty.

[2] The evaluation team compared pairs of actions to identify any synergy which may exist. When some kind of synergy seemed possible, a value on the following scale was chosen corresponding to the size of the effect. 2 : for a particularly strong effect of synergy; 1: for a weaker effect of synergy; -1: the same scale applied to negative synergy (conflict); -2 : the same scale applied to negative synergy (conflict)

[3] Cs+ and Cs- calculate the synthetic coefficients of positive and negative synergy for each EU OAP action. Total average Coef Cs+ and Cs- have been calculated as the average synthetic coefficients for each EU OAP measure considering all experts: μ

$$C_{s+} = \frac{Sumofpositivescores}{(Numberofpositivescores)*2}$$

$$C_{s-} = \frac{Sumofnegativescores}{(Numberofnegativescores)*2}$$

Tab. 1: The failure modes and RPNs

Cause	Effects	MEAN	STANDARD DEVIATION
Lack of stakeholder involvement	Lack of capacity building	**210,0**	**137,5**
Inadequate information and promotion campaigns	Lack of knowledge/awareness on OF	**162,8**	**84,1**
Lack of information	Lack of political interest to support OF	**159,4**	**86,9**
Weak lobbying for OF	No mandatory implementation of AP	**146,6**	**84,6**
Research not enough developed	Lack of importance given to OF	**133,1**	**90,1**
Conventional interests against organic lobby	Lack of financial resources	**132,2**	**81,5**
Different priorities among MS	General implementation problems	**130,8**	**84,4**
Different interests between EU and MS	Inadequate rules/procedures	**130,1**	**82,6**

RPNs include information about the probability of detection of the failure modes by the proposed indicators. The detection mean values (non shown for conciseness) range from 3,5 (High probability of detection to moderately high chance of detection) to 4,8 (moderately high chance of detection to moderate chance of detection) which indicate that in general – for the selected failure-modes – the ORGAPET indicators may perform sufficiently.

Figure 1 illustrates the result of the policy and coherence analysis of the EU OAP. Synergies between measures largely prevail while the opinions on conflicting actions are not shared by members of the team, as is shown by the higher standard error bars.

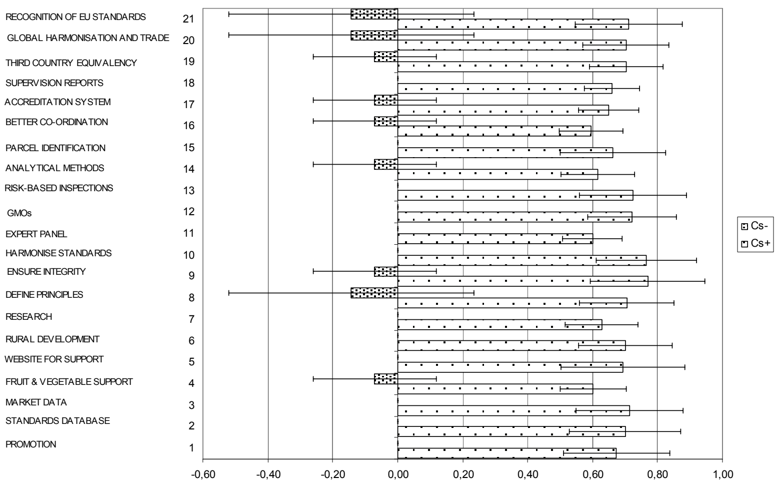

Figure 1: Synergy/conflict between EU OAP measures

The analysis suggests that Actions 9 and 10 are essential for the success of the EU OAP, given their synergetic effects. They in addition enter into synergy with many other actions. Interesting is also Action 13 with an high coefficient of synergy and number of measures with which has interactions.

By contrast, Action 4 appears a stand-alone measure, since it enters into synergy with an average of 3 actions only. Action 16 is somewhat peculiar, since it has a fairly weak coefficient of synergy (0.59) but which enters into synergy with many other actions (68). In this case Action 16 has a weak potential for synergy although having numerous interactions, since these are individually weak. In addition Action 16 combines positive and negative effects of synergy, even if the conflict seems to be very weak.

Conclusions

ORGAPET and its indicators appear as a good base for the detection of many problems regarding implementation of organic agriculture policy. The probability of detecting failure mode by ORGAPET toolbox is moderately high which means that the list of main indicators are able to face with the logical cause-effect structure of the problems. Clearly, indicators should probably be improved in order to explain in a more precise way what are the information included. This because in some cases the indicators seem to be unrealistic or just not available. Concerning synergies and conflicts among actions, there is a substantially agreement on synergies among experts concerning each specific action. On the other hand, it is clear that there is no agreement on conflicts among experts on each specific actions.

Acknowledgments

This work was produced with financial support from the EC within the project "European Action Plan for Organic Food and Farming: Development of criteria and procedures for the evaluation of the EU Action Plan for Organic Agriculture (ORGAP)". The views expressed are those of the authors and do not necessarily reflect the views of the EC, nor do they in any way anticipate the Commission's future policy in this area.

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Public support for organic food and Production, Promotion and Action Plans in Spain

Gonzálvez, V. [1] & Moreno, J.L.[2]

Abstract

Organic farming has received very limited public support in Spain in the past. This was used for promotion and supporting partly a semi-public control. The Andalusian Organic Action Plan (OAP) formulated in 2001 was the first broader policy supporting Organic farming in Spain. After this initiative the Spanish Central Ministry for Agriculture, Food and Fisheries (MAPA) has also presented a National Organic Action Plan in 2003, before the approval of the EU Organic Food and Farming Action Plan by the European Council in 2004. In the last years several regions in Spain have announced or approved OAP´s, currently in progress in different regions. This paper is presenting and analysing all this Regional and national Organic Action Plans and other organic support policies, stakeholders participation, conflicts and synergies with National and EU Action Plans and evaluation indicators, contributing to the ORGAP[3] project. Finally the paper is discussing the potential use of some evaluation tools (ORGAPET) proposed by the ORGAP.

Introduction

Organic Food and Farming sector in Spain has received a very low public support in the past, compared with other European Union (EU). In the beginning of the 90´s support was concentrated in creating the legal framework and indirect support to build up a semi-public of control systems in the 17^{th} regions, in which stakeholders are represented and voted each four year. From 1996 until 2000, the agrienvironmental schemes of the CAP were applied in many regions to support farmers to convert the farm. Some support was also given for promotion to facilitate the participation of the organic sector in national and international Fairs (p. e. Biofach).

Organic food and farming support has been substantially increased in the last ten years. Andalusia (2002-2006), has started the first Organic Action Plan (OAP) in Spain. The *Spanish Central Ministry for Agriculture, Food and Fisheries (*MAPA) has published a 3 years State OAP in 2003, but this never was put in force. In February 2007 a new State OAP Plan 2007-2010) has been presented. At Regional level, several OAP has been approved (Asturias, Baskenland, Castilla-La Mancha, Extremadura or Madrid). In Catalunya preliminary tasks are being developed to launch an Organic Action Plan. But, few instruments of monitoring or evaluation of this OAP are planned. Only in the State Spanish OAP, some indicators have been established for this purpose.

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[3] ORGAP Project means European Union Organic Action Plan: Development of impact evaluation tools (http://www.orgap.org)

Material and methods

Documents of the different OAP at National and Regional level in Spain have been consulted and analysed. Direct interviews in organic events and electronic consultation have been undertaken with Spanish organic stakeholders. All this information has been cross-checked with results of the ORGAP/ORGAPET reports.

Results

1. State Organic Action Plan (OAP)

In 2004 the MAPA organised an informal round of meetings with the organic representatives and in 2005 a National stakeholder Seminar, to discuss specific guidelines to development of Organic Food and Farming in Spain. The 3 Main topics selected were later taken into the State OAP (2007-2010). The final purpose of the this OAP was to contribute to develop the organic sector in Spain with a set of specific actions in all the organic production, processing, marketing and distribution and consumption chains and also in education and research areas.

The specific aims of the State OAP were structured in 3 main objectives: a) to promote the development of Organic Farming, in particular the primary sector, with education, research, inputs regulation, and rural development tools use and recognition of organic Farming specificities; b) to improve the knowledge and to promote the consumption and marketing of organic products, as it's the most relevant challenge in Spain, mainly stimulating the internal demand thought and adequate information for consumers, accompanied of the improvement of marketing structures of the products; c) to improve institutional collaboration, management of resources for the organic sector, contributing to a better coordination, improving comunication and the collaboration between all private and public sector agents involved in organic sector. Indicators for monitoring and evaluation were defined.

Tab. 1: Monitoring impacts indicators of the MAPA Organic Action Plan

Indicator	Sources
Number of organic stakeholders operators	MAPA - CCAA
Surface of organic Farming	MAPA - CCAA
Surface of organic farmers with agrienvironmental support	MAPA - CCAA
Expenses and number of research projects in organic farming	INIA MEC
Education and training events in organic Farming by MAPA	MAPA
Studies and dissemination Publisher in organic Farming	MAPA
Number of books publications on consumption of organic products	MAPA - CCAA
Economic value/volume of the national market of organic products	MAPA - CCAA
Declared Economic value/volume of sales data & adhoc export studies	MAPA – CCAA
Public expenditures of the MAPA for organic production	MAPA
No questions discussed in the Sectorial Conference	MAPA
No. meetings, seminars, journeys, courses done with the sector in several regions	MAPA

Source: MAPA, 2007. http://www.mapa.es/notas/documentos

A national Organic Promotion Campaign (2006-2008), launched by the MAPA in November2006 (slogan "Cultura-Lógica, Agricultura Ecológica, es cultura, es de lógica", with the topics "Environmental and sustainability aspects to stimulate new generations and also nutritional, health and quality aspects of organic products", with a budget of 2,32 millions of €, co-financed by the European Union, targeted to families and other market actors, teacher's education and consumer associations, belongs also to this State OAP.. The Campaign was concentrated in "Organic weeks", in the Regions with local and regional sector, expecting a multiplying effect.

State Support for Organic Production

There was no support for organic farming before the EU Agrienvironmental support from the CAP (Reg. CEE 2078/92). This came in force in Spain late than in other EU countries: in 1997 no aids for organic farmers was given in Catalonia and Galicia and it was stablish in Asturias and Madrid[1]. The organic farming payments are different by crop and region. In most cases, this payment is lower than in other European member states. For organic olive tree farmers in Andalusia receive only the half payment of the farmers in Tuscany (Italy). The farmers receive around 350 €/Ha.

In period 2001-2005, the number of farmers with animals receiving these aids was 3 times more and the numbers of crops organic farmers has increased a 39% more. The total number of supported farmers was increased from 7,696 (2001), to 11.293 (2005) 47% more. During the period 2000-2006 organic production was a priority aim in the Rural Development Programme in Spain, but in the new Programme 2007-2013 the organic farming is not included as a horizontal measure at National level

State Support for Research

Organic research in Spain has started, with some isolated projects initiated by individual's researchers working in public research centres, most of them SEAE members. The National Plan for Scientific Research, Development and Technology Innovation (PNIDIT, 2004-2007), has supported organic projects (19 organic research project involving 26 research groups in 13 regions, dealing with 18 different thematic). Other 43 research projects, involving 22 research groups and 2 more regions, on low input and environmental friendly agriculture practices, were also financed. Currently there is no specific National Organic Farming Research Programme. At National level the Education and Sciences Ministry (MEC) has announced the creation of the Centre for Organic Research in Plasencia (Extremadura), in the year 2008. At regional level the Andalusian OAP, created a specific Programme for organic research (1.800.000 €) for small project (max. 120.000 €). From 110 proposals, 24 were approved. A regional public Centre for organic education, research and rural development (CIFAED) was created in Santa Fe, Granada (Andalucia). Also the Instituto Andaluz de Investigación y Formación Agraria, Pesquera, Alimentaria (IFAPA), has assumed some tasks in organic research. In Valencia Region an estimation of 0,3 million € per year small innovation and experimental organic projects, are given. In Catalunya and Balearian Islands a Network "Agroecomed" has been supported involving 9 research groups from 5 public Universities and 3 public Research centres, since 2003.

Regional Organic Action Plans

Seven regions have developed OAP in Spain. **Andalusia** has finished the first OAP (2002-2006), with a budget of 33.6 millions of €. About 65 % was devoted to support production conversion, 9% was for Research, 8.6 % for improving processing of organic produce, 6 % to support organic consumption. The rest (7.4 %) was for different measures supporting in training education system, organic certification and organic sector better coordination. The plan has supported 45 projects 2.8 millions €. A second OAP (2007-2013) has been launched. **Madrid** Region launched a regional OAP (2005-2007) investing 3 millions of €. **Castilla-La Mancha** has o launched an OAP (2007-2011) investing 44 millions of €. In **Extremadura** Regional Government has also announced an Organic Action Plan for this year. In the Mediterranean also **Catalunya** has published the "White book of organic farming", in close cooperation with organic sector experts to develop an OAP. In the Nord of Spain, **Baskenland** Parliament has approved this year a Regional Law with some measures to promote organic food and farming to achieve 20 % of surface in organic farming in 2020. **Asturias** has also presented a Regional Organic Action Plan (2007-2009) investing 14,7 millions of €.

Conclusions

A low support has been devoted in Spain to organic food and farming development from public money, mostly to support organic production, indirect support of control bodies to involve stakeholders and isolated promotion actions like fairs.

Currently, 30 % of the Spanish regions have approved OAP. There is not much coordination between this plans and measures and the State OAP. As OAP are policy instruments, it's used as such by different Governments with several purposes, not as a technical tool. Most of the Regional OAP has been discussed with stakeholders, but some of them have been developed in a desk exercise by Regional Administrations Synergies and conflicts with the State OAP and EU OAP can appear but this has not been identified. SEAE has initiated a process to discuss on this topic.

No impact indicators have been defined except in the State OAP. Consequently no impacts can be measured. The State OAP indicators are more related to results.

Only an assessment of the Andalusian OAP has been published as the rest are still in progress. In this case, a general very positive influence of OAP has been shown.

After stakeholders and experts consulted, the ORGAP Project developed tools to evaluate OAP´s (ORGAPET), can be easily adapted and use in the regional OAP. But it's still necessary to differentiate between the potential users, so that relevant information to each category can be found more easily. A separation between theory discussions from practical instructions is needed. This help to evaluate very precisely OAPs and agriculture policies to support organic farming. All they considered this evaluation toolbox very useful, as each stakeholder (public and private) can choose the appropriated tools for their one analyse.

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Development of criteria und procedures for the evaluation of the European Action Plan of Organic Food and Farming

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Key words: action plan, organic agriculture, evaluation toolbox

Abstract

Within the EU funded project ORGAP a toolbox for the evaluation of the European as well as national action plans for organic food and farming has been developed (www.orgap.org). This toolbox was based on a comparative analysis of national action plans in eight countries (CH, UK, DE, IT, DK, SI, CZ, NL, ES), a meta-evaluation of existing evaluations of national action plans, workshops with national stakeholders and a European Advisory Committee, interviews with experts. Furthermore synergies and conflicts between national and the European Action Plan were identified.

Introduction

The European Commission released in June 2004 the European Action Plan for Organic Food and Farming (EUOAP). In May 2005 the EU funded 3-year research project with the acronym ORGAP started. In the project 10 partners from 9 countries (CH, UK, DE, IT, DK, SI, CZ, NL, ES) participated, as well as the European umbrella organisation of the Organic Agricultural Movements (IFOAM EU Regional group), ensuring a broad stakeholder consultation process and dissemination all over Europe.

Materials and methods

The overall objective of this project was to give scientific support to the implementation of the EUOAP by the development of an evaluation toolbox. Firstly the toolbox was tested on a selected number of ongoing national action plans (desk research, interviews with experts). Synergies and conflict areas between national and EUOAP targets were identified. Finally a policy analysis and recommendations were made.

Results

First a comparative documentation about the status quo of eight national or regional action plans for organic agriculture was made (Stolz, Stolze and Schmid, 2006).

Differences in national organic action plans

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The case study action plans vary with regard to the elaboration process, targets, objectives and the emphasis of measures on certain areas. This is due to quite different political and socio-economic framework conditions for organic farming in these countries. The organic action plans of Andalusia, Czech Republic, Slovenia and Denmark address a very broad portfolio of areas and measures. In contrast to this the Dutch, Italian and English action plans give high priority to measures targeted at market development and consumer information. The German Federal Organic Farming Scheme has a clear focus on measures related to public information. The comparison revealed that the weaknesses identified in the status quo analyses have only partly been translated to the targets and measures included in the action plan documents. This is on the one side a result of the national priority and budget setting and on the other side on the interdependcy between EU policies and national policies

Meta evaluation of evaluations of national organic action plans

For the development of an evaluation toolbox one important step was to get an insight into already conducted evaluation studies in the field of organic action plans in Europe via meta-evaluations from DE and DK and NL and partly from England/UK. The resulting report contributed to a methodological learning process, helped to optimize the ORGAPET toolbox and provided information on the content level about the success and failure of Organic Action plans in general. It showed that it is on the one hand important to build-up on *specific tailored evaluation standards and indicators,* which can measure the programs specific characteristics. On the other hand it seems to be important, when preparing a suchlike evaluation study, to rely as well on a set of commonly accepted *general evaluation standards.* (Eichert and Dabbert, 2007).

ORGAPET development

The development of the Organic Action Plan Evaluation Toolbox (ORGAPET) was a central part of the ORGAP project. It has been elaborated in an iterative process with several versions regularly updated and further developed. ORGAPET has been developed as a web-based toolbox, with links between the different elements designed to make navigation easy. The structure for ORGAPET consists of four main sections: Section A covers background/contextual documents on organic action plans, organic farming policy, stakeholder involvement and evaluation principles and procedures. Section B deals with evaluation methods relating to action plan development and implementation processes, including conflicts and synergies, coherence, implementation failure risk and stakeholder engagement. Section C is about evaluation methods relating to action plan outputs, effects on the organic sector and impacts on public policy goals and Section D is about approaches to synthesising overall conclusions including interpretation issues relating to cause and effect relationships, interactions between elements and likely developments in the absence of the action plans or specific action points. Each section is sub-divided into a number of specific topics, with an overview document providing a guide to key issues and possible solutions, and a series of annexes providing illustrative examples, specific methodological details or useful data sources. A manual will be developed to provide an accessible guide to action plan development, evaluation and the use of ORGAPET. Furthermore it should be a tool for stakeholder involvement in future action plan development and implementation processes at national and regional level as well as EU level (Lampkin, 2007).

ORGAPET testing and assessment by stakeholders and evaluation experts

An extensive testing process of an intermediate version of ORGAPET in all ORGAP EU member states showed that stakeholders and experts view ORGAPET as a useful tool. Suggestions for structural and general changes from the experts were taken into account for the revision of ORGAPET (Dabbert and Eichert, 2006).

Focus group discussions on the national implementation of the EU Organic Action Plan

Focus group discussions with stakeholders were held between November 2006 and February 2007 in 8 EU member states (Andalusia-ES, CZ, DE, DK, England-UK, IT, NL, SI,). The intention was to identify how national stakeholders perceived the EUOAP and its interplay with national policies in terms of conflict and synergy, and which strategies they would suggest in coping with implementation problems. It was not possible to discuss all aspects of the EUOAP. One topic common to all discussions was the proposal for a revised regulation on organic production, covering several recommendations of the EUOA, which is expected to be implemented by all EU member states by 2009. In addition six focus groups discussed the recommendation aiming for a more transparent European market for organic food. Instead in Italy and England they preferred to discuss the issue of funding organic food and farming policy through rural development plans i.e. as part of the general agricultural policy. The comparison of the outcome showed that only the focus groups of CZ and SI found the EUOAP important and had positive expectations to it. In the Danish group expectations to the EUOAP were positive but the EUOAP was considered insignificant. In DE, EN and IT expectations were neutral and the EUOAP was considered insufficient; in Spain (Andalusia) the EUOAP was considered insufficient and expectations negative. Only two problems appeared in most focus groups: the lack of sufficient statistical data as basis for market transparency and the GMO suggested threshold level in organic produce, where there was a common agreement that a threshold should be very low if it was to be allowed at all. All other issues were specific to the national context, suggesting that implementation problems are specific to each EU member state. The main conclusion from the analysis done here is thus that successful implementation in any member state is a matter of the balance between positive and negative aspects of all three main dimensions of implementation: willingness, capability and comprehension. These balances are unique to each member state and within each dimension. The main expectation is that more weight to positive aspects on all three dimensions will lead to more successful implementation. Furthermore the analysis showed the major importance of the conflict between the organic food and farming sector on the one hand and various threats against it from the socio-economic context, from the ideas behind the EUOAP and from its unintended impacts. (Michelsen & Tyrol Beck, 2007; Zanoli & Vairo, 2008).

Discussion

One of the main focus areas in the project was to develop a core set of appropriate indicators for ORGAPET, which then can be adapted to specific action plan evaluations. The testing showed that major problems are the data availability and limited resources for data collection, which limits the number of indicators.

Another focus area was how to measure the effectiveness and the direct effects of the policy separate from the general performance of the organic sector. What is the impact of exogenous events and how can these be addressed in an evaluation? As conclusion, it is important to focus on the performance of the measures against indicators. This does provide an overall picture on the impact of the OAP on the organic farming sector or the wider bio-physical, social and economic environment.

The third major focus was stakeholder involvement in the elaboration of action plans, which was the main topic regarding the revision process of Regulation (EEC) 2092/91 in 2006 and 2007. When looking at examples of the way in which stakeholder interests have been taken into account in national action plans, it is interesting that the approach chosen in some countries was quite differing, ranging from a broad participatory approach to a very top-down approach with a small expert group. Some made good experiences with a broad involvement not only of the organic but also the conventional sector (as in DK) or with stronger focus on market actors as in NL (Dabbert and Eichert, 2006).

Conclusions - what are the lessons to be learnt?

When planning a new or revising an existing action plan it is recommended to study first the different approaches of other action plans (e.g. market-driven versus policy-driven). When a participatory approach is chosen, then stakeholders should be involved in different phases of a policy development (agenda setting, policy formulation, decision-making, implementation, evaluation). Furthermore the experiences within in the project showed that focus group discussions may be used to gain information from the organic food and farming sector itself, while less involved outsiders should be approached in a different way, e.g. by individual interviews after data had been collected from members of the organic food and farming sector in order to ask the outsider for comments to the main arguments of the organic sector.

For the evaluation of organic action plans it is important not only to follow a general accepted evaluation standard but also to elaborate and build-up specific, tailored indicators (standards) adequate to the national action plan; here ORGAPET provides both a procedure for selection as well as examples. Furthermore it is important to differentiate clearly between depiction of facts and areas more open for interpretation through the inclusion of stakeholder (e.g. by a stakeholder reflexion workshop as in DE evaluation) and to ensure sufficient data availability and resources for data search.

Acknowledgments

The authors acknowledge the support of the EU Commission for funding this research.

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Understanding the organic consumer

Understanding the Organic Consumer through Narratives: an International Comparison

Midmore, P.[1], Ayres, N.[1], Lund, T.B.[2], Naspetti, S.[3], Zanoli, R.[3] & O'Doherty Jensen, K.[2]

Key words: European organic consumer analysis

Abstract

Consumer narratives drawing on life history, events and influences are used to explain evolving consumer behaviour with regard to purchasing and consumption of organic products. Triangulated qualitative interviews, involving 54 principal participants in major and average sized cities in Denmark, the UK and Italy form the empirical basis of the study, combined with shopping trip observation and supplementary interviews. The research uses Gardner's (2004) concept of 'change of mind' as a starting point for analysis. While cultural and geographical contexts vary across countries, a key finding is that consumer behaviour co-evolves with market development. The study concludes that potential future marketing strategies must distinguish carefully between strongly committed and occasional consumers of organic products.

Introduction

The development of the organic market in Europe has been rapid, but consumption of organic products remains relatively small as a share of overall food purchases (Dimitri and Oberholtzer, 2005; IFOAM, 2006), and may either be close to saturation or capable of more growth. Midmore et al. (2005) review the literature on consumer attitudes to organic food. However, little is currently known about the development of these attitudes over time, and understanding the likely development of future patterns of demand for organic products is difficult to achieve using conventional methods.

In this paper we report initial results of part of the QLIF project[4] (WP1.2.2) investigating reported buying behaviour of organic and other consumers. Our focus on narratives that describe the development of buying habits allows us to identify and extrapolate potential trends with reference to future demand. We describe in-depth interviews and direct ethnographic observation which allow us to explore Gardner's (2004) concept of a 'changing minds'. His approach suggests that when someone undergoes a change of mind, this process usually involves concepts, stories, theories and skills. Our analysis identifies these elements in consumer narratives, helping to obtain deeper knowledge and understanding of consumption patterns. Gardner distinguishes seven 'levers' that may influence a change of mind: reasons (assessment of relevant factors), research (procurement of relevant data), resonance (the affective component), re-descriptions (mutually reinforcing images of what will

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[4] "Quality and Safety of Low Input Food", European Sixth Framework Programme Integrated Project, No. 50635.

result from the change), resources and rewards (perceived cost-benefit relationship), *real world events* (in households, markets, etc.), and *resistances* (to change). Dick and Basu (1994) have explored product loyalty, as repeated patronage, and identified three indicators of loyalty: the likelihood that the consumer will search for alternatives, resistance to counter-persuasion, and word-of-mouth recommendation to others. Their contribution has also inspired our design and analysis.

Materials and methods

The reported buying behaviour of organic consumers and its dynamics have been investigated using a comparative analysis of qualitative interview data collected in Denmark, Great Britain, and Italy. The study design called for the collection of a broad range of ethnographic data in each country, in the form of detailed case studies of principal participants with varying degrees of commitment to purchasing organic food products. The major focus, biographical accounts of trajectories of food purchases and food consumption in the household, details events that have influenced decisions. Validation of core interviews comes from use of triangulating perspectives. Each case includes an additional interview with a close family member or friend. Accompanied shopping trips were undertaken and video-recorded, and some shopkeepers were also interviewed.

Participants, all of whom were mainly or jointly responsible for shopping and food preparation in their household, were recruited on the basis of a purposive quota sample. The sample in each country included three subgroups: 'regular', occasional' and non-users of organic food products. Half were from a large city (the capital in the UK and Denmark, Turin in Italy) and half from an average size city. At least two cases in each national sample were drawn from households comprising singles, young couples without children, families with younger children, and older couples, whose children no longer lived at home. A minimum inclusion of male participants was also imposed.

Semi-structured question guides were prepared for the interviews and shopping trip. Questions to the principal interviewee covered life history events and how these had influenced shopping and meal preparation; the first encounter with organic foods; probing why organic foods are bought, and whether there have been any changes in motivation. Following the shopping trip, participants were asked to explain their choices and also to discuss their substitution strategies if sought for products had not been available. Shopkeeper and ‘significant other’ interviews were designed to assess and complement the primary qualitative material. Interviews were recorded, transcribed, coded, and analysed using interpretive procedures.

Results

Clear variations emerge from comparison between the three countries. Italian consumers, in a context of rather more recent industrialisation and urbanisation, give strong approval to traditional meals and cooking, with the influence of childhood meals and grandparents’ cooking styles strongly favoured. In contrast, the traditional Danish meal of meat, potatoes, brown gravy and cooked vegetables is referred to by participants as a means of positioning themselves as traditional or modern consumers. Regular consumers of organic food in Denmark generally reject this tradition as being unhealthy, dull, and boring. Organic food, combined with cosmopolitan cookery, is seen as providing interest as well as health, wellbeing and environmental responsibility. In Italy, organic consumers place more emphasis on intrinsic food quality cues than do non-users, who see food preparation as the main driver of meal quality. In the UK, vegetarianism appears among regular organic consumers as natural and wholesome, corresponding to desires to be in tune with the earth and to follow patterns of nature. While regular consumers in Denmark have confidence in the organic foods available in some supermarkets, British regular consumers tend to be more suspicious of supermarkets in general. In Italy, regular consumers use a range of outlets to seek preferred products, sometimes opting for uncertified but trusted locally produced items such as cheeses, fruit and vegetables. A tendency to frequent a range of outlets, including specialty stores, is found among regular consumers in all three countries.

Almost universally, the initial encounter with organic food is not recalled in any detail. For most regular users, it has become an integral part of their lifestyle, a change of mind and habits characterised by a gradual evolution alongside increasing market availability. In terms of lifecycle, as young adults form new households, new food habits form, including experimentation with international cuisines.

For some few Danish and UK participants, life-events influencing organic choice include childbirth. Contrastingly in Italy, while changes in household composition are reflected in patterns of shopping, eating and cooking habits, they are not seen as significant for regular users, but as confirming attitudes towards healthy and quality food. Health problems trigger changes in the food habits of some households. Couple households involve reciprocal influences, sometimes with partners dominant in food sourcing and preparation taking the lead and influencing choices. Increased income also allows greater access to organic purchasing, such that the transition to financial independence is an important point for changes in food consumption.

Observation of shopping trips provided opportunities to discuss loyalty and substitution strategies. Some UK committed consumers try to buy only organic foods, while partially committed seek priority products such as organic meat and dairy products. However, narratives in most cases suggest that convenience drives the strategies adopted. Regular Danish organic consumers can be divided into the thrifty (seeking value for money) and quality orientated (deliberately choosing particular supermarkets or specialty shops). Some of the former describe how practical constraints play a role in substitution strategies while shopping, particularly with reference to saving time. In Italy, regular users' loyalty is mainly influenced by availability, and substitution mainly regards fruit and vegetables, which are often purchased from local, conventional sources. The gradual changes of mind with respect to organic foods that emerges from the narratives of regular consumers, regard tendencies to assess organic food from the viewpoint of such values as health and environmental sustainability. A concern with animal welfare and other ethical issues is also stressed by many British and Danish consumers. While some regular users are prepared to expend considerable time and effort to obtain the products they want, the extent to which purchases are actually made appears to be strongly dependent upon the availability of products and satisfaction with quality characteristics, as perceived and experienced.

Discussion

Our expectation was that the development of a mindset that is positively oriented towards organic food products would lead to changes in shopping habits. While the value-based and experience-based rewards associated with organic products are central to this mindset, it is clear that real world events in the marketplace have strongly influenced habit-formation. One pattern which emerges strongly in the UK, and reflected elsewhere, is that the purchasing pattern of many regular users far exceeds the threshold we had established for recruitment to this subgroup. It is also clear that this subgroup is strongly motivated by value-based rewards with reference to environmental and ethical issues. Commitment in other subgroups is weaker or absent, and strongly influenced by a need to obtain value for money. It also appears that, as consumer awareness and markets co-evolve, behaviour changes across all phases of the lifecycle. Some life cycle events do underlie changing food habits, but more often they reinforce decisions that have been taken on considered reflection about food, health and the environment. Mindsets with reference to organic food tend to change gradually, without abrupt 'moments of enlightenment'.

Conclusions

Comparative analysis of national findings is currently in progress. It is however already clear that far from being niche products, organic foods have become ubiquitous, and are interwoven into a variety of consumer lifestyles. It would seem likely that differentiated distribution and marketing strategies are called for that can meet the needs of highly committed organic consumers, but at the same time address scope for growth among the partially committed. There is evidence that the value-based rewards associated with organic foods are particularly important to the former subgroup, while experience-based rewards with reference to quality are important to both regular and occasional users. Price differences between conventional and organic products are perceived as having been reduced over time and wider ranges of product categories are currently demanded. Major barriers to increasing demand appear to affect the supply side, rather than consumers. A strategy focused on the development and supply of standard products, produced at relatively low prices, to discount and other retailers might appeal to those who regularly buy organic products and who exhibit a strongly thrifty orientation in their shopping habits. Yet this would fail to meet the demands of dedicated regular users, and perhaps also some other regular users.

Acknowledgements

Financial support from the Commission of the European Communities for Integrated Project No. 50635 (QLIF) is acknowledged. This paper does not necessarily reflect the Commission's views or anticipate the Commission's future policy in this area.

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Consumers willingness to pay for Fair trade and organic products

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Key words: Fair trade. Organic products. Labels. Taste. Image. Experimental method. Willingness to Pay

Abstract

More and more products are now both "organic and fair trade" but little is known about consumers perception of these double labels. In this article, we examine the importance of the "organic" and "fair trade" labels in the consumers' buying decisions and the effect on the perception of the taste of the product by the consumers in the valuation of these labels. We also propose a consumers' typology according to their degree of valuation of these labels, and analyze the motivations of their behaviour.

Three consumers' clusters were identified according to their reactions to the "organic and fair trade" label - the first cluster represents the people insensitive to the label's presence, and contained nearly one half of the sample; for a second cluster, the "organic and fair trade" labels' influence on the improving image of the products was positive and important; finally, for the third cluster, the valuation of the "organic and fair trade" label was determined by the product's taste.

Introduction

Previous studies underline the increasing interest attached by the consumers to environmental and social criteria in the choice of products, and more precisely the growing interest attached to organic and fair trade products (Tallontire and Blowfield, 2001, Codron et al. 2006, Sirieix, 2008). Indeed, organic agriculture has been developing steadily over the last fifteen years (Sahota, 2007); Fair trade, for its part, has known an exponential growth over the last few years (FLO, 2007). More and more products are now both "organic and fair trade" but little is known about consumers perception of these double labels (Codron et al., 2006)

This article thus addresses the theoretical question of the link between environmental and social concerns, and the practical question of the interest of a double label "organic and fair trade" .

Materials and methods

Our methodological process associates two approaches: experimentation and survey.

The aim of the economic experimentation is to reveal the consumer's willingness to pay (WTP) for quality or for quality's criteria by recreating a context close to the real situations of buying and consuming. We used BDM bidding (Noussair and Ruffieux,

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2004), which motivates the subjects to reveal their preferences honestly for a given quality of product through their willingness to pay.

As part of the BDM bidding, each subject submits a buying offer in terms of price for a product proposed for the sale by the experimenter. Then the experimenter draws lots for a sale price in a layout of prices defined beforehand. Each subject having submitted an offer superior or equal to the randomly selected sale price receives the product and pays the equal amount to the randomly selected price and benefits of the difference between his offer and the sale price (the randomly selected price). However, subjects having proposed a buying price inferior to the randomly selected sale price receive nothing, nor do they make any payment.

The aim of the experimental study being to observe the real behaviour of the consumers, it was necessary to implement the study to products available on the market. The choice of chocolate was motivated by the fact that this product gave us the opportunity of disposing of a variety of chocolate bars with the organic and fair trade labels.

Four chocolate bars available on the market were chosen within a variety of 8 chocolates (4 with the organic and fair trade labels, and 4 without labels) after a tasting pre-test on the basis of two criteria: the hedonistic characteristics and the price level of the product.

We constituted a sample of 102 people (72 women and 30 men) who buy chocolate, selected in a random way in Montpellier (France) and its surroundings by telephone and in an organic shop (Biocoop) by an announcement.

13 sessions were organized in strictly identical conditions. Each session contained three stages:

> Stage 1: Blind tasting of the four chocolate bars, prior to bidding for a set of 5 bars of each chocolate.
>
> Stage 2: Evaluation based on a reconstituted packing of four chocolate bars (1 neither organic nor fair trade, 1 only organic, 1 only fair trade, and 1 both organic and fair trade), prior to bidding for a set of 5 bars of each chocolate.
>
> Stage 3: Observation and tasting of the four chocolate bars, prior to bidding for a set of 5 bars of each chocolate.

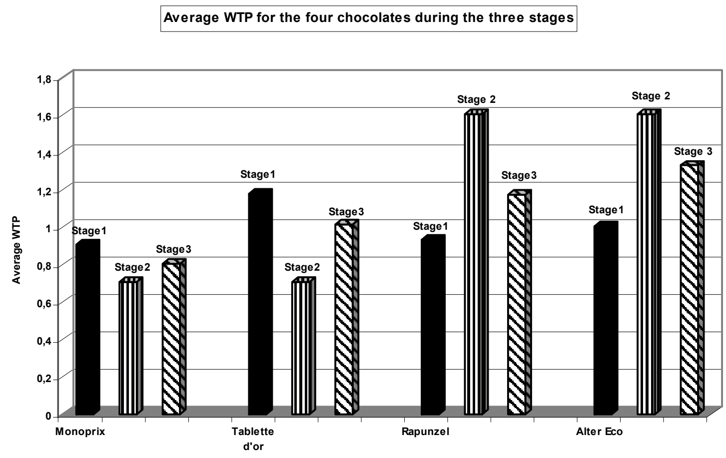
In most cases, experimental studies focus only on the direct, observable results of the bidding and on the “revealed preferences”. To complete this information, we also asked each subject taking part in the experimental study to answer a questionnaire about the motivations of his/her consumption of organic and fair trade products. This questionnaire was established on the basis of a previous qualitative study which had identified those motivations (Tagbata and Sirieix, 2003).

Results

First, we analyse the distribution and the variation of the hedonistic notes and of the willingness to pay for each chocolate during the different stages in order to assess the impact of the “organic” and “fair trade” labels on the perception of the quality and on the valuation of the chocolates. Then, we identify the different segments of consumers according to the degree of valuation of the organic and fair trade labels, and for each segment we analyse the importance of the different motivations that underlay the positive valuation of these labels.

Results show that blindly, the two "organic and fair trade" chocolates are not the most appreciated, but that they have the highest WTP when the labels are shown.

Between stage 1 (blind test) and stage 3, the organic and fair trade chocolates have known on average an increase of their hedonic notes and of the WTP contrary to the chocolates nor organic, neither fair trade. In stage 2, the WTP was revealed solely on the basis of the information visible on the product label, the chocolate both organic and fair trade collected on average the highest offering (1.61 euros), and the standard chocolate the lowest offer (0.70 euros). However, in stage 3 where in addition to the information, the chocolates are tasted, the offers for organic and fair trade chocolates are inferior to stage 2.



More precisely, three consumers' clusters were identified according to their reactions to the "organic and fair trade" label: the first cluster represents the people insensitive to the label's presence (nearly one half of the sample), for a second cluster, the "organic and fair trade" labels' influence on the improving image of the products is positive and important; finally, for the third cluster, the positive valuation of the "organic and fair trade" label is determined by the product's taste.

Discussion

Three consumers' profiles reacting differently to the "organic and "fair trade" labels have been identified. Contrary to the results obtained from most opinion polls, which supposed that ethical values were of the utmost importance in consumers' choices, our results show that nearly one half of the consumers of our sample are insensitive to the presence of "organic" and "fair trade" labels on a product. For these consumers, the price appears as the first criterion on which the choice of the products is based while the ethical arguments associated with the "organic" and "fair trade" labels are pushed into the background, behind other criteria like the taste and health issues.

However, the survey showed that for two other segments of consumers, these labels have a positive impact on the perception of the quality of the products which is materialized by a valuation of these labels corresponding to 20-30% of the product price. The organic and fair trade label thus enhances the valuation of the products. Nevertheless, the consumers' sensitivity to this label varies a lot. If the majority of consumers have the same profile as the majority of our sample, they will not be ready to pay more for organic and fair trade products, and the markets for these two types of products must not be overestimated.

Moreover, we have also demonstrated that, although the existence of a substantial WTP for the "organic and "fair trade" labels is principally linked to environmental and social concerns, some consumers condition the valuation of these criteria by the intrinsic characteristics of the product. From this result, we highlight the interaction that may exist between the perceived quality of the product and the labels in improving the image of the product.

In other respects, the WTP with tasting is lower than the WTP declared on the sole basis of the labels, which reveals a gap between the expected quality and the experienced quality. Therefore, efforts on the improving of the quality of the organic and fair trade products must be maintained.

Finally, the joint application of the environmental and social labels on the same product induces a subadditivity of the WTP compared to the willingness to pay for the two dimensions considered separately. Some consumers even prefer an organic chocolate to an organic and fair trade chocolate. Therefore, the double labelling does not have to be systematic.

Before these results could be generalised, they should be checked on representative samples in several countries.

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The US Organic Food Shopper

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Key words: consumer attitudes, profiles; organic food

Abstract

Survey data from a random sample of US food shoppers is analyzed to identify significant factors in organic food demand. Qualitative data is also collected to explore motivations, perceptions and knowledge of both organic and conventional food shoppers. Results indicate that shopping venue, food knowledge, and food beliefs are key to organic food demand. Qualitative investigations indicate some scepticism towards organic labels by both organic and conventional shoppers. Not all organic shoppers viewed the increasing availability of organic foods through conventional venues and brands positively. These shoppers perceive commercialization to run counter to creating a local food system. In addition, perceptions of organic food shoppers were diverse, often conflicting, and sometimes quite negative.

Introduction

The US represents roughly 43% of global organic food sales (Organic Consumers Association 2007, Organic Monitor 2006). Organic food sales in the US represent 3% of US food sales (Organic Consumers Association 2007), but have been growing at a rate of 20% *per annum* since 1990 (Klonsky and Green 2005). Availability in conventional grocery stores accounts for half of all sales. In addition, well-known brands are introducing or acquiring organic products and even featuring organic versions of existing products. Who are they selling to?

Most studies of US organic food shoppers focus on demographic characteristics. Many have been limited to a metropolitan area and the samples are non-random. This study utilizes data from a national survey of food shoppers. In addition to demographic variables, the analysis includes data on attitudes, beliefs, group affiliations and other behaviours. The conceptual framework is motivated by Lancaster's (1966) attribute model, Weinstein's (1988) precaution adoption process, and Guagnano, Stern and Dietz's (1995) attitude-behaviour-context model. The data are utilized in statistical models to identify characteristics associated with organic food shoppers. In addition to the quantitative analysis, qualitative analysis was used to determine perceptions, motivations, and rationale shopping behaviour. The overall objective is to identify characteristics of US organic food shoppers.

Materials and methods

The findings for this study are based on a random sample of US adult food shoppers conducted in the fall of 2003. Both a telephone (response rate 47.7%) and mail (29.1% response rate) survey were implemented (n=956). A focus group study was used to identify and refine relevant survey questions as well as to understand consumer knowledge and perceptions about organic foods (Zepeda, Chang and

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Leviten-Reid 2006). The survey data was analyzed in a probit model to identify characteristics of organic food shoppers (Zepeda and Li 2007). A switching regression model was estimated to examine how the decision to buy organic foods affected overall food expenditures (Li, Zepeda and Gould 2007). In-depth, structured interviews were conducted to investigate some of the more unusual findings and to develop a conceptual model of organic food shopping behaviour (Zepeda and Deal 2007).

The framework for the statistical analysis builds on the microeconomic model of consumer demand and theories of consumer psychology. Lancaster's (1966) concept that consumers demand a product's attributes rather than the product itself is relevant, implying consumer demand for organic production methods. Weinstein's (1988) precaution adoption model was developed to explain consumer behaviour and hazards. It provides insights into how and why some consumers are motivated to demand organic foods. He posits that there are ordered stages that consumers must pass through before acting. Weinstein's five stages can be applied to organic food demand: awareness or knowledge of organic food, personal relevance, intention to buy, opportunity, and purchase. Different factors may influence each stage.

Guagnano, Stern and Dietz (1995) provide further insights about why consumers take conservation measures. The crux of their attitude-behaviour-context model is that context is crucial for consumers' behaviours to be consistent with their attitudes. In the case of organic food, such factors as the ease of access (e.g. within or between stores) therefore may be more important to the purchase decision than professed attitudes about organic foods.

Results

Statistical analysis estimated using the 2003 survey data revealed the significant variables in the demand for organic foods were: shopping venue (context), food beliefs, and food knowledge (attitudes) (Zepeda and Li 2007). Income was not found to be significant. Of the demographic variables, only age (negatively) and education (positively) were statistically significant to purchase of organic foods. Although income and education are generally correlated, the findings do not represent an artefact of multicollinearity; when education was omitted from this model, income was still not found to be significant. Curiously, the lack of religious affiliation had a large, significant impact on the probability of buying organic foods. Lack of religious affiliation was not correlated with income either.

The focus group study revealed a degree of scepticism regarding organic food labels by both organic and conventional Caucasian shoppers. The study involved 43 participants in four focus groups (two conventional and two organic shoppers), it was recorded and transcribed; see Zepeda, Chang, Leviten-Reid (2006) for more details. African-American shoppers (none were regular organic food shoppers) were less familiar with the US Department of Agriculture (USDA) organic label, but also had more confidence in it. This seemed to stem from a greater confidence in federal agencies such as the USDA, as well as greater use of labels when purchasing foods. Overall, the focus groups and interviews yielded diverse if not conflicting stereotypes of who ate organic foods: hippies, yuppies, or "soccer moms" (affluent housewives).

Both the focus group study and the in-depth interviews (Zepeda and Deal 2007) revealed mixed feelings regarding the increasing penetration of organic foods in conventional grocery stores and brands. Some welcomed the increased availability and lower prices. Others felt that organic production methods were less important than what they perceived as building a local food system. They viewed the increasing involvement of large food retailers and brands in organic foods very negatively. These people often characterised themselves as being interested in organics foods, then becoming concerned about whether foods were produced by small, local farmers. Among both conventional and organic shoppers, local foods were viewed positively.

Discussion

In the focus group study, some conventional Caucasian shoppers viewed organic foods very negatively, characterising them as a, "rip off," and disparaging organic food shoppers as "hippies" or "yuppies." This perception of organic food shoppers was investigated in a study involving in-depth interviews (Zepeda and Deal 2007). Both conventional and organic food shoppers characterised organic food shoppers as hippies and yuppies, though organic food shoppers tended to characterise the stereotype as a transition from hippy to yuppie. Both organic and conventional food shoppers associated organic foods with higher income households, some characterising organic shoppers as a "suburban soccer mom." The characterisation of organic shoppers as affluent housewives, whose children play what is viewed in the US as an elitist sport, refers to seeming concern about what one's children ate, but implies that class-consciousness or conspicuous consumption are the real motivation.

Since the survey data reveal that there is no relationship between income and organic food purchase, the perception that organic shoppers are high-income undoubtedly stems from the fact that in the US organic foods generally (but not always) are more expensive than conventional foods. However, few US households buy many organic items, and the survey data reveals that there is no significant difference in the level of *per capita* food expenditures between organic and conventional shoppers. Therefore, organic food purchasers are not buying organic foods at the expense of other household expenditures. So while organic shoppers may pay more for the few organic items they buy, they must be spending less on other types of foods.

In-depth interviews were also used to investigate another finding from the statistical models, the large significant relationship between organic food purchase and lack of religious affiliation. Perhaps it should not be surprising that a religion variable would be significant in a US study; religion plays a central role for many in the US. Neither organic nor conventional shoppers initially saw a direct relationship, but when told that the survey data showed there was a correlation, several explanations were offered. Organic food shoppers felt that a person who was a freethinker towards religion would likely be freethinking towards other things, like food. Conventional shoppers offered other perspectives. One was that those who were not involved in religious activities had more time to concern themselves with things like how their food was produced. Still another was that technologies like pesticides were gifts from God and therefore could not be inherently harmful. Another belief was that cause and effect were dependent upon God's will, therefore conventional food buyers need not concern themselves with what one ate because God will take care of them.

Interviews with organic shoppers, particularly among those who preferred local over organic foods revealed not just commitment but activism in creating a local food system. It was clear that food choices were an important part of their identities. Many referred to farmers they purchased from in almost parental terms, "they take care of me," and like-minded people as part of a community they were creating. This might explain the negative attitudes towards "corporate organic;" they view it as undermining their vision of their food system that connects food buyers to food producers.

Conclusions

Focus groups and interviews of US shoppers reveal diverse if not conflicting perceptions of who shops for organic foods. They are characterised as hippies, yuppies, or soccer moms in a disparaging way. However, survey data reveals that income is not related to organic food purchase and food expenditures are not higher among organic food shoppers. It also reveals that lack of religious affiliation is significantly correlated with organic food purchase in the US. Shoppers were surprised at this relationship, but provided explanations, ranging from theological, to time allocation, to desire for an alternative community. Overall, the qualitative and quantitative data indicate that the demographics are poor predictors of US organic shoppers, while attitudes, norms, values, and context are the key predictors.

Acknowledgments

This project was supported by the National Research Initiative of the Cooperative State Research, Education and Extension Service, USDA, Grant #2002-01772 and is gratefully acknowledged. Gratitude is expressed to all the research participants.

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The EU health claims regulation and its impact on the marketing of organic food

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Key words: health claims, consumer behaviour, marketing, communication strategy

Abstract

The so-called EU health claims regulation changes the legal framework for all health-related statements on food and in advertising. As health reasons are a major motive for purchasing organic food, organic market actors have to consider the opportunities and threats posed by the new regulation. This contribution discusses the relationship between the organic attribute and the health claim attribute on the basis of a literature review and expert interviews. We argued that there is no scientific basis for depicting organic products as 'healthy as such'. The use of health claims for and on organic food can be problematic as well as promotive. Whether health claims are favourable or not depends, among other things, on product characteristics, the target consumer group and the future use of claims on competing conventional products.

Introduction

The regulation (EC) No 1924/2006 on nutrition and health claims made on foods, called health claims regulation, applies to all nutrition- and health-related claims on food packages, in food advertising, and even trade-marks. Its aims are, first, an EU-wide harmonisation in the handling of claims, and second, protection of consumers from misguidance with regard to the 'healthiness' of products. A health claim is defined as 'any claim that states, suggests or implies that a relationship exists between a food category, a food or one of its constituents and health' (EU 2007). It should be noted that important details of the regulation have yet to be worked out by the European Food Safety Authority (EFSA) and the EU jurisdiction. Between 2007, when the regulation came into effect, and full implementation around 2010, businesses operating in the food market will have to adjust to several major changes that the regulation will impose. The regulation is, in essence, an inversion of the current approach: from now on claims will be prohibited unless explicitly allowed. It also demands that decisions about the healthiness of products conform to 'nutrient profiles' - certain favourable nutritional requirements that have to be defined by the EFSA.

The organic movement supports the objective of enabling consumers to choose healthy food: health is, after all, one of its principles, along with balanced ecology, fairness, and care (IFOAM 2007, p. 1ff.). There are several indications that organically grown food can be healthier than conventional food (a review: Vijver, Huber 2007, or as examples: Brandt et al. 2006; Mitchell et al. 2007). Furthermore, consumers choose organic products mainly and increasingly because they think they are healthier (Calverley, Wier 2002). In order to maintain further market growth, it is therefore of particular importance to secure the current general perception that organic products are healthy. On-package communications and advertisements for organic products

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have already made more or less explicit reference to health or health-related well-being for some time. With the EU health claim regulation coming into force, the question is whether the regulation is (un)favourable for organic food products and to what extent organic market actors are aware of and prepared for the challenges and threats. This paper structures the discussion by means of three main questions and identifies possible future paths of development and strategies for businesses operating in the organic market.

Materials and methods

Secondary research in the form of a literature review was conducted, tackling: 1) the requirements of the regulation in comparison to the present legal environment; 2) positions taken by organic market actors and experts; and 3) the assessment of the regulation's future impact by market experts or pressure groups. In addition to the literature review, primary research was carried out in the form of semi-structured telephone interviews with market actors. Three food products, spaghetti, strawberry yoghurt, and fruit muesli, were selected as examples in these interviews because products in these categories already carry or are most likely to carry health claims in the future. Fifteen articles belonging to eleven processors and retailers were chosen, and the people responsible for marketing these articles were contacted. Five of the experts interviewed in July 2007 worked for German organic processors and two for a big German retailer. The interview-study does not constitute a representative sample. The interviewees were asked whether they were keeping close track of developments regarding the new regulation and how they assessed its impact on their own marketing activities, the wider competitive environment, and consumers' attitudes and buying behaviour. The interviews were recorded digitally and transcribed. In the following, quotations from the interviews are written in italics.

Results

The relationship between organic products and health claims can be discussed in terms of three strategic questions. Each question asks whether a certain level of relationship is possible, starting with the nearest possible relationship.

1. Are organic products always healthier, and does this constitute a health claim 'as such'? There are many indications that organic products are healthier than their non-organic counterparts in several ways. Nevertheless, this does not apply to all food categories. Even if there is scientific support for claiming that a certain food category is healthier when grown or produced organically, it is not guaranteed that every single product unit has the same beneficial effect on health, as required by the regulation. The reason is that organic standards are process-, but not product-oriented. Organic products therefore cannot be labelled with a health claim solely because they are organic.

2. Is it beneficial to add a health claim to organic products: Would consumers react positively to this combination? With organic standards on the one hand and the health claims regulation on the other, organic producers face two conflicting concepts. Organic products stand for a holistic approach to, among other aims, health (IFOAM 2007, p. 2). The regulation, in contrast, allows only claims for single substances and their specific impact on health, as e.g. in so-called functional foods. Since the typical organic consumer *'is sometimes more sceptical'* (towards claims), a health claim according to the health claims regulation on an organic food product might be viewed with suspicion, and the consumer might well reject the product. Nevertheless, the contrary is also arguable. First, the health claim could be regarded as solely exemplifying the overall perception of healthiness. Second, a health claim on an organic product might be more credible with the background of a positive perception of the organic sector and its products. Third, the regulation allows claims for 'natural' substances. This suits the image of organic products: *'An organic consumer would assess a product which is e.g. high in omega-3-fatty-acid by means of a natural process positively and buy it'*. A certain percentage of today's organic consumers might not in fact perceive the combination as contradictory. Several of the experts interviewed stated, for example, that *'today, the target group "organic consumer" is no longer homogenous'*. A distinction ought to be made between *'the original, real organic consumer'*, in other words, the *'organic consumer of the past',* and the *'conventional consumer, the lifestyle-consumer'* of organic food. The experts associate these two groups with the distribution channels 'specialised organic shops' vs. 'conventional food retailer'. The 'conventional' organic consumers not only perceive health claims as not contradictory, they even tend to appreciate such products and are used to the combination of different additional benefits and trends in the food market. Therefore, adding health claims to organic products might or might not be seen positively by the consumer. Lastly, it is also a question of the product category. One expert argued that the best way to choose which products should carry claims would be to judge from the amount of questions asked on service hotlines regarding their nutritional value, and stated that more questions are asked if a product is already perceived as being healthy.

3. Can the use of health claims on conventional products hamper the market development of organic products due to conventional products being perceived as healthier? The most important motive for purchasing organic products in Europe is health (Midmore et al. 2005). So-called functional food products, which by definition encompass all products carrying a health claim, make use of the same motive. It is arguable that consumers might regard organic or conventional functional food as being equally desirable as healthy products. An increased use of health claims on conventional products might therefore represent competition for organic products. This is more probable *'where organic processors compete with the conventional, thus in conventional retail shops'*. Organic processors might want to make a distinction from functional foods by communicating their holistic approach, but the regulation does not permit claims about general health benefits alone. Such a claim has to be accompanied by a single substance claim. This could be the reason that several experts stated, for example, that *'here, the regulation indeed is restrictive and does not permit us to communicate the benefit as we would like to do'*. The costly substantiation of single substance claims, in turn, will largely be accessible to big multinational companies with enough resources to finance research. On the other hand, a sharp handling of the regulation might restrict and reduce the excessive use of health-related statements in the conventional food market, allowing for the few remaining claims to be perceived as more credible. Experts remarked that the requirement for scientific substantiation might increase the credibility of claims, and that it is important not to exaggerate the use of claims, but to choose *'the right dosage'*. The impact that health claims for conventional products have on organic products' sales is therefore dependent on the future application of the regulation in practice and the reactions of competing operators in the market.

In total, there is no general answer to the question of whether the regulation will have a positive or negative impact on the organic market and marketing activities taking place in it. The result of the survey reflects the fact that the organic sector itself is heterogeneous. It is not surprising then that because of the heterogeneity of the organic market and the open questions regarding the future details of the regulation, the standpoints of the experts interviewed have also been heterogeneous. In addition, several interviewees were quite ambivalent towards the regulation. On the one hand, they tended to regard its impact on their marketing activities as negative; on the other hand, they expected to gain new consumers through the use of claims on their products.

Several factors determining the impact the regulation and health claims will have on the organic sector have been identified: 1) origin of the substance in question (natural versus artificial/added); 2) credibility of the processor/trade mark or the organic sector as a whole; 3) perceived healthiness of the product category; 4) distribution channel in question (associated with the existence of competing conventional products and type of consumer); 5) consumer characteristics; 6) future reactions of competitors (organic as well as conventional); and 7) future handling of the regulation by EU authorities and the legal practice.

Conclusions

Organic market actors should pay close attention to the legal development and that of the market trends in reaction to the regulation. A tailored decision about possible adaptations of one’s marketing strategy should be taken for every product in the product range in question. This decision might take into account the factors identified in this survey. It is noteworthy that although some of the interviewees’ companies sell products on which the on-package communication will probably have to be changed in order to meet the requirements of the regulation, they tended to express the view that there is neither the wish nor the need to change claims on their products. This might lead us to conclude that, at present, the organic sector might not have dealt sufficiently with the regulation and the requirements and opportunities linked with it.

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Consumers and their impact on food and farming systems in North America and Germany – Examples relating to GMO issues

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Key words: Organic Consumers, rural development, Biodiversity, Genetic Engineering, Labelling of Ge-food, feed and seeds.

Abstract

Consumers in North America and Germany tried in different ways to impact their regional farmers, supermarkets, regional as well as national politicians, food related laws as well as food based land use systems in order to be able to continue consuming ge-free foods and to get sufficient information on all levels of the food chain enabling them to do so. As much success as consumers in the US and Germany had with the initiation and establishment of ge-free regions, US consumers did not succeed with their ge-food labelling campaigns. Only in Vermont a ge-seed Labelling law could be passed. In Germany ge-food, ge-feed and ge-seed have to be labelled by law. German Consumers and low input farmers tried to get also products derived from ge-feed included in ge-labelling laws. It seems a consumer influenced compromise that a new German legislation is about to be adopted which would allow for an easier Non-GMO-Labelling of food. Yet consumer opportunities to make informed choices about the food they eat seem to be still limited, especially in North America with the practical absence of federal ge-food, feed and seed labelling laws. Thus a few years ago, actors of the organic and natural food Industry teamed up to launch the so called Non-GMO Project, which shall soon open its Verification Program to the North American natural and organic food industry, offering a standard for ge-free or Non-GMO verification.

Introduction

Consumers directly and indirectly impact food and farming systems all over the world, e.g. by choosing where and what they buy, by requesting information about the food they eat (see e.g. Howard 2005), by voting for certain local food law initiatives (see e.g. Pick 2007) or certain regional and national politicians and their political (food) programs. Since a couple of years consumers in many regions of the world seem to be especially concerned about genetically modified plants and foods (about the difficulty to control GM plants see e.g. Clark 2004 or Brauner et al. 2002). Consumers can use a variety of influence possibilities to impact food and farming system and this paper tries to highlight the ones especially used by regional actors like consumers to successfully react on GMO issues in certain regions of North America and Germany.

Materials and methods

Expert Interviews in North America (California, Vermont, Ontario) and Germany (primarily in Mecklenburg-Western Pomerania and Baden-Wuerttemberg) together with literature surveys examined different levels of involvement, challenges faced and

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achievements of consumers and other regional actors initiating or participating in the process of creating ge-free regions, ge-labelling laws or ge-free supermarkets.

Results and Discussion

To arrange the various research results more clearly, they were displayed in Table 1 and will partially be explained and exemplified in the following paragraphs:

Tab. 1: Consumer impact on food and farming with regard to GMO issues - Selection -

Consumer impact food and farming	Examples from North America	Examples from Germany
because a majority of consumers wishes to eat ge-free foods and wishes to protect natural Biodiversity of garden or farm seeds	54% of North Americans said 2006 they were unlikely to eat GMOs, 38% said they were likely to eat them*	74,9 % of German consu-mers do not want ge-foods 18,3 % were indifferent about GMO issues 2006 **
by lobbying their local, state and federal politicians for sufficient Labelling Laws	Oregon and California Labelling Initiatives Vermont Seed Labelling Law	Recommendations to improve existing Federal Labelling Laws for ge-foods to include products derived from ge-feed
by shopping in natural food Stores, Coops and organic supermarkets	North American organic food market is with about 14% the fastest growing in the world. Its sales were estimated to be 11.9 Bill. Euro in 2005***	Organic food sales in Europe was approx. 12,5 Billion Euro 2004 Germany was app. 3,5 with a growth of 13%***
by donating benefits to ge-free Initiatives	Members of the COOP Super-market in Mendocino County	Donations of regional actors in Ueberlingen
by initiating and encouraging ge-free supermarket initiatives	Big Carrot Project later deve-loped into the NON-GMO Project in North America	Edeka Projects in Mecklen-burg-Western Pomerania
by voting for or en-couraging county administrators and farmers to vote for ge-free counties	County Laws in Mendocino County, Marin County, Trinity County and Santa Cruz County	County Resolutions in Main-Tauber County Oberallgaeu County
by voting for or en-couraging administrator to vote for ge-free cities	City of Eureka, California Town Resolutions in Vermont	Town Resolutions in the Town of Tuebingen Town of Reutlingen
by talking to the source of their food for further information	consumer education events provided by Coop and organic supermarkets in Mendocino or Marin County	consumer education leaflets and movies provided by the ge-free region of Ueberlingen
by engaging in Community supported Agriculture	Community supported Agricul-ture in San Luis Obispo Coun-ty (see also Strochlic 2004)	Farmer-consumer-networks, direct marketing
Sources: Expert Interviews in North America and Germany, *Pew Initiative on Food and Biotechnology 2006 ** gfk Market Research 2007, ***Willer and Yussefi 2006.		

Consumers have been often successful in their efforts to impact GMO issues, as Table 1 shows. They initiated and/ or supported for instance the introduction of many County Laws in California. In four of these it is now prohibited to grow ge-plants commercially (for details see Pick 2006 and 2007). Consumers also impacted County Resolutions in Germany where the County administrators decided to lease County land only to such persons who will farm it without the use of ge-plants. Similar Resolutions have been passed for Towns in Germany and Vermont.

Regarding the labelling of GMOs, Consumers and other regional actors have not been as successful, especially in the United States. Whereas Consumers in Germany campaign for stricter versions of exiting Labelling Laws for GMO' s which would include products derived from ge-feed, Consumers in North America have to cope with the practical absence of any kind of mandatory ge-food, feed or seed labelling, with one exemption. In the State of Vermont, consumers, farmers and their representatives succeeded a few years ago with their labelling initiative and as a result a seed labelling law for ge-seeds got passed, the first and only of its kind in the United States. Other, especially ge-food labelling initiatives like the one in Oregon failed to be successful due to highly financed and Biotech Industry dominated counter Initiatives.

Rather smaller natural and organic grocery stores in California and Ontario started in 2001 and 2003 - in response to their customers who were concerned about ge-foods - their own initiative to discover the GMO status of their food assortment. The aim was to offer the stores' consumers an informed choice. One organic coop supermarket, The Big Carrot, was found to be an international role model in its consistent way of working together with its food processors and wholesalers in order to keep the food assortment in the store ge-free. Whereas in Germany by contrast the investigated co-op supermarkets like Edeka work directly with the farmers and obligate them to grow only ge-free seeds or feed their farm animals only ge-free food if they want to sell their produce under the supermarkets' brand.

The Big Carrot Natural Food Market in Toronto, Ontario implemented a non-GMO policy which simply discontinued those product lines that were not confirmed by the manufacturer to be non-GMO. But the absence of an authoritative standard for non-GMO created problems for this effort. In 2005, The Big Carrot teamed up with stores in California to form the Non-GMO Project, with the common goal of creating a standardized meaning of Non-GMO for the North American organic and natural food industry. (see also The Non-GMO Project 2007)

Since the spring of 2007, the Non-GMO Projects Board of Directors includes representatives from a lot of stakeholder groups of the natural product industry, like consumers, retailers, farmers, and manufacturers. Soon the Project expects to open its Verification Program to the industry, offering a Standard for non-GMO that is both meaningful and achievable. (see the Non-GMO Project 2007)

The implementation of any kind of label, especially one with such high oversight costs, has a tendency to higher the prices for the labelled products in this case for organic and natural food products. This kind of cost distribution is against the polluter pays principle. As much as consumers prefer to make an informed choice, they might not want to and should not have to pay for these extra costs which will likely arise.

Conclusions

Consumers tried in different ways to impact relevant actors and actions in order to be able to continue consuming ge-free foods and to be able to continue choosing from the natural and organic Biodiversity of garden seeds to plant in their garden. Therefore they need sufficient information on all levels of the food chain, including labelled seeds, enabling them to do so. Whereas in Germany consumers can make somewhat informed choices if they want to avoid ge-food, feed and seed, informed consumer choices in North America are more difficult in this regard. Although the vast majority of Consumers would prefer GMO's to be labelled, the Federal Governments of the United States and Canada do not consider mandatory labelling of these crop seeds, food and feed. In this Environment, the organic and natural food Industry of North America networked together and formed the Non-GMO Project Initiative for Non- GMO verification in order to be able to provide consumers at least with some kind of GMO related Verification. Its purpose is to protect organic and natural products from GMO contamination by setting certain standards. One question that remains open is who should pay for these GMO-related extra costs. The polluter pays principle would require that this is not the natural or organic food or seed consumer.

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Consumers motivations for buying local and organic products in developing vs developed countries

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Key words: local products, organic food, food miles, consumers, developing countries

Abstract

Despite numerous studies reporting on organic consumer profiles, little is known on consumers motivations for buying local and organic products. More precisely, do consumers prefer local products because they want to support local producers or do environment and the question of food miles matter in their choice ? Besides, very little is known about organic consumers in developing countries, since most surveys are generally conducted in developed countries. Our purpose is to fill this double gap. By conducting qualitative surveys based on individual interviews in four developing countries (Brazil, Egypt, Uganda and China) and two European countries, France and Denmark, we plan to study consumers choice for organic products from supermarkets, farmers markets or local organic food network respectively. Products are selected to cover examples of imported organic products that compete with comparable products of local origin.

First results from Brazil and France show that French consumers are more concerned by the environment than Brazilian consumers, but that most consumers in both samples are not concerned by food miles and their subsequent environmental impacts. Results also shed light on different patterns related to commitment of supporting small or local farmers, and suggest implications for policy makers.

Introduction

The double situation on the one hand of increased demand for organic food and belief in Organic Food and Farming as a development pathway, and, on the other hand, the increased conventionalisation and globalisation of Organic Food and Farming, is the starting point for the Global Organic research project GLOBALORG (www.globalorg.dk). Four case studies in developing countries (Brazil, China, Uganda, Egypt) will be compared to two case studies in Europe: France and Denmark.

The objective of GlobalOrg project is to study the urban economic factors influencing consumer preferences respectively for short versus long procurement systems supplying organic food in developed and developing countries.

The project consists of three tasks:

To document the urban socio-economic development of the chosen areas

to document the various organic food procurement networks and

to study consumers motivations and barriers to buy, and meaning of, organic food.

This article presents some results from the third task, with a focus on consumers motivations for buying local and organic products in Brazil and France respectively.

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Materials and methods

Individual interviews were conducted in each country, with 25 consumers in Brazil, and 28 consumers in France, who buy organic products from farmers markets, supermarkets or local organic food network. Products were selected to cover examples of imported organic products that compete with comparable products of local origin.

More precisely, interviewees had to compare a local and organic food product, a local and conventionally produced food product, and an imported organic food product. They had to

- (1) answer questions related to their attitudes and consumption intention (related to environment, health, price,..),
- (2) describe the person who typically buys and consumes each type of product
- (3) describe the person who never buys or consumes each type of product,
- (4) react after reading a discussion between three invented consumers (one who buys local or imported organic food, regardless of the mode of distribution or length of the distribution chain, the second one who only buys local and organic products and prefers not to buy them in supermarkets and, the third one who buys conventionnally produced local products),
- (5) discuss on the basis of open questions about food miles, mode of distribution, and producers.

Results

In the French sample, local organic food is highly appreciated. However, the invented consumer who prefers not to buy them in supermarkets is the least appreciated profile. On the contrary, the invented consumer who prefers organic food, and does not pay attention to the fact that it is local or imported, is the most appreciated profile by most consumers. Most respondents do not see major differences between locally grown and imported organic food as regard to environment.

However, two kinds of attitudes are noteworthy within the sample. First, according to some respondents, buying imported organic food is necessary since tropical products such as bananas cannot be produced in France. Others explain their consumption of imported organic food by the fact that the products are both organic and fair trade products. So the respondents described consumers who buy imported organic food as both environmentally conscious, but also involved in the support of small producers in poor countries. When we stressed the fact that many of organic imports to France are from the southern hemisphere countries, implying long distance transport and bad environmental effects, they answered that in that case supporting producers from poor countries is more important than preserving the environment. For example, a consumer stated: “To me, imported organic food is fair trade food. And buying fair trade products is sharing another vision of the world.”

In sum, whatever their attitudes regarding imported organic food, respondents do not really take distance and its environmental impacts into account. Even for organic consumers who declare to be environmentally oriented, food miles do not really matter, since organic consumers regard themselves as making a trade-off between food miles and other product attributes.

In Brazil, the image of local product is very strong: Brazilians are proud of their local tropical products, and do not see the use of imported products, apart from some processed food. They think 1), foreign products are too expensive 2) they do not like them because they think that transportation can lead to a loss of product quality, and 3) they do not trust foreign products. One respondent added that it seems snobbish to buy unnecessary imported products.

Some Brazilian interviewees also describe the consumption of local organic products as a political and ethical act. They are in the same time part of producers associations and actively support organic producers. Most Brazilian interviewees do not seem aware of nor concerned by Food miles; only one respondent spontaneously mentioned food miles and the consequences of transportation on environment.

Discussion

In both samples interviewees express their preference for local and organic products, for different reasons: Brazilian respondents do not trust foreign organic products and therefore reject them. French interviewees are less reluctant to buy organic imported products. Environmental concerns seem more important in the French sample than in Brazil, where the consumers emphasized the closeness and support of local organic producers. However, in both samples the interviewees do not take into account pollution due to transportation, and only one consumer in each sample spontaneously spoke of food miles. This result is consistent with results from a previous study on consumers of conventional food products in France, who do not care about food miles (Sirieix et al., 2007).

Finally, support of organic and local Southern producers were for both the Brazilian and French interviewees a common motivation.

The differences between countries may be explained by the following points:

First of all, in Brazil there is still no state regulation or a Brazilian brand for organic food products. It is left to a wide range of local and/or internationally accredited certifiers, to guarantee that the products are following the rules of organic production methods. This could have an influence on the question of trust as well as on knowledge towards organic products from abroad.

Secondly, Brazil is a huge country so the question or notion of 'local' is different from its perception in France; this notion has to be specified in next surveys.

Thirdly, in Brazil organic food products sold through supermarkets are fairly new and very expensive compared to organic products sold through box-schemes, farmers markets or direct at farm shops. The consumers interviewed do not have a comparable choice between different outlets as in Europe.

On a theoretical level, the impacts of the findings of this study mainly relate to

- the links between personal values and behaviour (Wier et al., 2006), individual values, altruistic values (benevolence and universalism) and the related question of consumer reflexivity (Giddens, 1991). For example, in Brazil, imported organic food is more rejected than in France, but in both samples, consumer concerns and internal conflicts are linked to both individual and altruistic values: some French consumers are willing to buy organic imported products such as bananas because they like them (individual value of pleasure), and others because they think that buying fair trade organic products allow them to support small producers from developing countries (altruistic value). Some Brazilian consumers reject organic imported food because they think the quality is lower (individual value of pleasure), and others because they want to support Brazilian organic producers (altruistic value).

- the links between local and/or organic consumption and social embeddedness. This relation is connected to the values of social mobilization for sustainable agriculture (Moreno-Penaranda, 2006) and the role local organic food networks can play in this regard (Seyfang, 2006).

Implications for public policy and marketing of local and organic products are important. Using an environmental argument such as 'food miles' to support certain supply channels may not generate the expected results as shown by our empirical investigation. In our survey, Brazilian consumers do not pay attention to food miles, but buy in local organic network to support small farmers and local economy, incorporating localisation, community-building and collective action as anticipated by Seyfang (2006).

Obviously our study is exploratory in nature, due to our limited sample size at this stage. The results should therefore be considered as a first step in a broad survey.

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Influence of Young Children (3-6 years) on Organic Food Consumption in their Families

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Key words: attitudes, organic food consumption patterns, children, morphologic interview

Abstract

Our interest was to analyse families with young children (3-6 years) to understand their consumption patterns of organic foods. To understand the influence of children on organic food consumption, as well as the role and impact of kindergarten, we studied the attitudes, habits and behaviour of 24 mothers and one couple through qualitative interviews. We found that children positively influence the consumption of organic food in the families, and that organic foods served in kindergartens is highly accepted by the parents. Five consumer types were identified based on the criteria of motivation, knowledge and economic aspects. Three conflict fields influencing the decision making process for organic food. Consumption of organic products is not a linear development process but can change in different life periods.

Introduction

To date organic products are highly esteemed as healthy products. Factors like "quality of food" as well as "freshness of products" are main arguments in favour of organic products. Modern life-styles are therefore associated with the use of organic products. On the contrary, previous habits and additional efforts required for purchase and meal preparation are arguments against organic products. Income restrictions and the high prices of organic products are key arguments against organic food consumption (see BMLFUW, 2003: 68f). Nevertheless, persons with high income also follow other preferences. Health, especially of the children is an important argument for the use of organic products. It is apparent that parents prefer to buy organic food for their babies (see Oppermann 2001: 43). In public kindergartens in the city of Vienna, approximately 50% organic food is an obligatory part of lunch. However, our interest was to get a deeper understanding on how children in the home affect the consumption patterns of parents. We especially studied the influence of young children (3-6 years) on nutrition patterns in families and the status and significance of organic products in kindergartens. Additionally, we studied the factors influencing the private consumption of organic food (see Kannacher, 1982:2).

Methods

In autumn 2006, a total of twenty-five qualitative interviews were done in Vienna (Austria) and its environs. Those interviewed were 24 mothers and one couple with

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children. Except one household, all consumed organic products in different intensities. First contacts with interview partners were at playgrounds and more were recruited with the snowball method. Most of the interviews were done in homes. For data collection, we used the morphologic interview (Fitzek 2000). Data analysis was done by coding the interviews based on the terms selected from literature, e.g. habits, attitudes, knowledge, motivation etc., following environmental psychology models e.g. from Ajzen & Fisbein (1977) (see also the following two paragraphs).

Our general theoretical background is the description and reconstruction approach of morphologic psychology, which is used in the marketing and media-impact research (Fitzek 2000). The aim is to concentrate and structure all collected phenomena in the interviews, which are linked with the influence of young children on the decision making process, for or against the consumption of organic food in their families. Finally, these conscious and unconscious everyday life correlations are reconstructed in different models. (1) Our first interest was, if there is a relationship between home consumption patterns and the acceptance of organic food in kindergarten. (2) Based on a modified definition of attitude, which is a result of motivation, economy and cognitive object assessment (Kroeber-Riel & Weinberg 2003), we classified consumer types. Attitudes are the result of consolidated and memorized opinions (Kotler & Bliemel 2001: 348). They influence the behaviour only if the consumer is cognitively involved. (3) In addition, we investigated, if there is a main factor influencing the decision making process, regardless of the attitude and intensity with which people actually consume organic food. (4) Following the morphologic approach, we used figurations, in our case, tension fields between two different positions for decision-making concerning the purchase of organic products. (5) Finally we studied if the consumption of organic products is a linear and irreversible process or an attitude which vary under different situations in daily life.

Results and discussion

The age of interviewed persons was between 28 and 43. Net-income was between € 1,000,- to € 4,000,- per month. The education level of the mothers in this group was generally high. Families with two children were predominant.

Result 1: Acceptance of organic products in kindergartens

The kindergarten meals were evaluated from “very awful“ to “balanced and appropriate for children“. The opinions were always linked with the attitudes and habits within the family household. Critical comments on organic products in the kindergartens were accompanied by a lower consumption of organic products at home. Nevertheless, there was a high acceptance on 50% organic food in kindergarten and the response on a future 100% organic food in kindergarten was always positive.

Result 2: Attitude between motivation, economy and knowledge of organic food

In contrast to a general acceptance of organic foods in kindergartens, home consumption was a diverse mixture of part-time bio-product consumption. We identified five types, based on the criteria of motivation, knowledge as well as economic arguments.

Type 1: nearly always Bio-consumers: Nutrition is given a high priority; that organic are best for the children, own health and the environment. The knowledge on organic products is high.

Type 2: often Bio-consumers: Following the motivation of type 1; they have high income, but also prefer conventional products from supermarkets.

Type 3: sometimes Bio-consumers: This type favour bio-products, but are less informed and less motivated. If the price is not too high and if there is an occasion, they chose organic products.

Type 4: sometimes Bio-consumer for selected products: Type 4 also favour bio-products, but the information is limited, and they purchase sometimes only selected bio-products.

Type 5: sometimes one-product Bio-consumer: They are open for bio, but their information is very limited, they are constrained by the budget and therefore they buy a bio-product once in a while.

Result 3: Children as the driving factor

In most cases, the impulse to purchase organic products, leading to increased home consumption was influenced by children. Following a child-birth experience, mothers changed their feeding patterns, using more organic products in their daily menu and mostly for the whole family. The most quoted argument for organic products is the need to secure the health of children. Besides that, concrete health problems of their own children or of other family members led to an increased consumption of organic products. „Ohne Kinder wäre Bio noch nicht so wichtig", which means "without children, organic would not be so important." (23)

Result 4: Tension fields in the decision making process

The decision making process for purchasing organic food is often accompanied by conflicts between different motivations, knowledge and economic potentials.

We identified three tension fields:

- High resolutions to consume organic produce versus high challenge to transfer this resolution into practice (they do not really know how to do so)
- High expectations on organic food versus doubts or uncertainty concerning the quality of the products
- Organic products are preferred but it is difficult to realise this because of economic restrictions (there are other competing expenses)

To point it out, the consumers are in a situation to decide between offering best food for children, doubts in the quality and financial challenges. This can be described with the following three conflict types (see Scheuch, 2007: 55): (1) Appetence conflicts: there are more alternatives but only one to be choosen; (2) Aversions conflicts: where two or more alternatives are not favourable but for one is to decide and the questions is how to avoid negative consequences; (3) Ambivalence conflicts: any alternatives have desirable as well as undesirable attributes.

Result 5: Phases of live and influencing factors on the use of organic products

Attitudes are based on consolidated and memorized opinions. This is also in line with the theory on habits (Triandis 1977). Following this theoretical positions, we would conclude, that if consumers once decided for organic products, they will not change this habit in future. However, our results showed that changes in social settings does affect the use of organic products. An example is a one-time 100% bio-consumer, who reduced the consumption of organic products with a new partner; and after a break, the consumer increased to the old level and influenced the partner to adopt organic products. Also divorce, house building, holidays or other expensive activities influence the organic food consume patterns. „Es gibt Phasen, wo man mehr oder weniger darauf (auf Bio) schaut", which means " / there are situations in life, where other aspects than organic food are more important." (5)

The influence of life situations on consume patterns explains that the preference for organic products is a complex construction of decisions, but not a linear development process. This fact explains also, that consumer typologies only describe a stage of personal development, which cannot be generalized or predicted with precision.

Conclusions

Kindergartens could be a place of first encounter to organic products for some parents. Therefore, it is obvious that private/ public organised educational institutes are able to influence consumer attitudes, especially if more knowledge is available. Also, young children provoke a (n) (re)orientation to organic food consumption and lead to modified consumption habits of the whole family. The decision making for or against organic farming is a complex process between firm convictions and a multitude of other preferences and challenges. In a multi-optional society (Gross 1994), consumer attitudes and behaviour is not a linear construct, the consumption habits are not always sustainable, because changes in life can modify them. From the scientific point of view, there is need to study families with elder children, to investigate if the trend of using organic products continues as the children grow, or whether other preferences led to a change of attitudes and behaviour.

Acknowledgments

We thank our interview partners for their patience and willingness to spend their time and to reflect on these often very personal concerns.

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Public procurement: constraints and barriers

Overcoming constraints and barriers for organic public procurement – Applying the theory of loosely coupled systems to the case of organic conversion in Danish municipalities

Mikkelsen, B.E.[1]

Key words: public food systems, organic public procurement, organic foods, organic conversion, public foodservice

Abstract

Organic food and farming has been an integrated part of agricultural policies in most European countries for many years. In some cases this priority has resulted in strategies aimed at increasing public procurement of organic foods. Public service provision in schools, institutions and kindergartens include consumption of huge amounts of foods. This paper analyses three Danish local government cases of introduction of organic foods in public foodservice in order to study what kind of influence this has had on the governance of public foods. The findings suggest that organic food policies seem to result in a rethinking of public food provision and the creation of virtual public food systems. The findings also suggest that these developments have been fuelled by a sub optimal functioning of the foodservice supply chain and that this in turn has forced administrators to see food procurement in a new horizontal perspective in which different types of public foodservice is looked upon as a whole. The findings suggest that the emerging organic food policies have modernised the way in which public food is governed and that organic foods have created a sense of public political consumption. The paper discusses the opportunities that this development creates for the organic food sector and in particular whether the development can open up further the public as a sales channel for organic food.

Introduction

Traditionally public food service has been regarded as a necessary but simple add-on to other public services such as hospital treatment, day care in kindergartens, education at schools etc. Morgan and Sonnino (2007) have characterised it as a ”mundane activity in prosaic settings” and in general public food is associated with low status and characteristics such as low pay, high labour turnover, high rates of dismissals, accidents, and absenteeism (Lucas 1996). Food service has traditionally been looked upon as a part of “something else” and as Mintzberg (1983) argues, for organisations such as hospitals, nursing homes or schools the task of cooking food is not being regarded as the core competence.

However the increasing attention given to institutional settings approaches to promotion of healthy eating as well as the call for more sustainable public food consumption has created a considerable pressure on this sector to innovate and modernise. In a number of countries sustainability policies have been launched aiming at increasing the volume organic foods in the public (Rimmington 2003). The aim of this paper is to analyse Danish cases of organic conversion in public foodservice in order to determine what kind of influence organic conversion has had on the

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governance of public foods. In addition the paper investigates the fabric of “systems” that public food seems to be embedded in and discusses how public procurement of organic foods can take of advantage of the systems way of thinking. The paper uses the notion of *loosely coupled systems* (Weick (1976) to portray the idea that public food is part of “systems”. The term is often used in design of software systems to underpin the necessity of being able to integrate incompatible system technologies as well as the ability to disassemble the functional components again. For loosely coupled systems to work there must be a shared common language that ensures messages retain a consistent meaning across participating units of the system. This approach specifically seeks to increase flexibility in adding or replacing units and changing operations within individual units. In the life of organizations there are many examples of loosely coupled systems, projects being a good example..

Materials and methods

The study is based on cases of organic food procurement polices in Copenhagen County, the City of Copenhagen and the Western Zealand County in Denmark. All projects were carried out from 1996 and onwards and were evaluated using external consultants and research partners. These processes informed the current study. In all three cases three types of actors in the public food environment functioned as the main informants: local government coordinators of organic conversion projects, local government procurement officials and local institutional food service managers. The Western Zealand County included 12 hospitals and institutions including worksite dining facilities at the institutions. In the city of Copenhagen municipal case the study was informed by in depth studies at 3 nursing homes and by the evaluation/monitoring process of the overall conversion project in 1200 municipal food service units. The case included all the different types of food service that the city of Copenhagen operates i.e. schools, kindergartens, nursing homes, worksites catering, community centre catering as well as other institutional catering units. In the Copenhagen County case the study included 12 institutions including hospitals, nursing homes and institutions for clients with special handicaps or needs. he data was produced by means of semi-structured interviews as well as by means of questionnaires. In addition, seminars involving catering kitchen managers and purchasers were used to inform the study as well as group interviews and explorative dialogue. A participatory approach was used in which external “lectures” by suppliers of organic foods and specialist in organic catering consultants was used. Information contained in reports seminars and meetings were used in the subsequent analysis as well as documents and minutes from administrative units, political committees etc. also contributed important information to the process. In the case of Copenhagen county some of the interviews with stakeholder were carried out by telephone using an open-ended interview guide which had been sent to the interviewees beforehand. Data collection were structured around the following themes: the outcome and effects of organic conversion, product-related as well as organisational barriers to implementation, workload and operational procedures, food quality and supply aspects of organic food supply, procurement contracts, quality requirements for organic food and procurement policies, characteristics of suppliers and supply situation of product groups and product chain networking. The results from interviews were coded and refined in a series of steps, resulting in an identification of themes, issues and statements that were common to most stakeholders.

Results

The results of the interviews in all cases clearly demonstrated the complex nature of organic conversion in public food service. Unlike the process taking place among private consumers in the retail sector, the decision making process in public food environments follow a set totally different rules and norms. The data from all cases identify a number of obstacles and constraints to organic procurement, but in addition it also shows a pattern of solutions to these challenges. Findings from interviews with kitchen level managers showed that networks with other kitchens were seen as important in order to exchange practical conversion experiences. Kitchen level managers also underpinned the need for organic supply chains to operate more smoothly and that supply chains should drive innovation in order to secure supply of organic food in right quantity and convenience level. Managers were calling for improved assistance to help implementation of organic foods and for better in-service training opportunities. ain findings from interviews county /municipal conversion project officials were that most conversion related tasks were seen as being the same across kitchen boundaries. In general kitchens were regarded as being able to benefit substantially from central coordination. Especially the challenges related to conversion project fund raising, liaison with the political level as well as to project management activities were underpinned as important tasks for municipal/county level coordination. Project officials also stressed the need for central coordination in order to secure minimum critical masses of organic food across kitchen boundaries. Findings from interviews with county /municipal level procurement officials were that in general the performance of organic food service supply were seen as sub optimal. Practical coordination of food procurement tasks at municipal level necessary as well as elaboration of product specifications and procurement contracts were seen as important tasks that should be centrally coordinated across kitchen boundaries.

Discussion

The findings suggest that organic conversion in Denmark have contributed in creating a notion of food systems and that these new arrays present a field for further penetration of organic foods. The application of systems approach to public food is also found elsewhere across Europe (Morgan & Soninno, 2007). In cities like Rome, London and Paris public procurement schemes are emerging aiming at building in sustainability issue in food procurement contracts and thus underpinning the importance of public procurement in a political consumerism context. In some cities healthy eating and sustainability issues are being linked due to the apparent interaction between them (Mikkelsen et al 2006). New public food systems with a minimum critical mass have been created and a new type of governance of this area seem to be emerging. This new emerging view of public food service is paralleled by a development where municipalities are exploring the frontiers of public service and health care provision by engaging in new types of organisational constructions. Hence public private partnerships and other hybrid constructs with both private and public money are emerging. Common to these trends are that they require a move from the traditional catering production unit approach to a systems approach. This is due to the fact that for both health and sustainability objectives to be implemented successfully, a cooperation that stretches across both intra-organisational as well as inter-organisational boundaries is crucial. And such systems need governance, because they don't govern themselves. Kitchens can be managed but systems need governance. The "glue" which now suddenly is needed is not necessarily there and therefore municipalities must begin thinking horizontally across the food local area and consider obligations such as kindergarten, school, institutions, hospitals etc. Local government should appoint new types of horizontal public food agents which would have to have to be supplied with the necessary competence. Te development has been fuelled by a sub optimal functioning of the foodservice supply chain. This in turn has forced administrators to see food procurement in a new horizontal perspective in which different types of public foodservice is looked upon as a whole. It has also forced public administrators to engage in more committed type of supply chain cooperation. As a parallel organic food consultants and businesses should react to this new development and begin to handle relation with the public in a more strategic manner. The notion of loosely coupled system seems to be a convenient frame work to explain both the way in which food service units are to their parent organization. The notion can also help explain the way in which different food service units seem to be linking together horizontally as a result of the conversion trend. For instance a loosely coupling allows local government to redesign the way food is provided by substituting in house food service production with outsourced food provision. Similarly an in-house food service unit can be changed to provide food for several institutions. At the same time the notion can be used to explain the new type of cohesion between food service units that formerly has been operating in isolation. This has the potential to influence innovation and user driven change process such as processes related to demands for food quality, sustainability and healthy eating.

Conclusion

The Danish local government cases show that the emerging public organic food polices have resulted in a new pattern in provision of public food in sectors such as schools, kindergarten and health care and nursing institutions. Food has become and object of political consumption, and organic food procurement strategies have forced administrators to see food procurement in a new horizontal perspective due to practical barriers in the supply chain. This has in many cases led to the creation of public food systems that formerly did not exist. This development offers huge possibilities for the organic sector since political consumption including organic food to an increasing extent are seen as strategic issues to which local government must relate.

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Juveniles' organic food preferences and how parents deal with them

Riefer, A. & Hamm, U.[1]

Key words: Family, Children, Organic Food, Grounded Theory

Abstract

According to recent research it can be assumed that expenditures for organic food in families with children are declining as children get older. For organic food marketing this raises the question which kind of changes in families' organic food consumption appear over time and why they appear. For this purpose qualitative interviews with juveniles and parents were conducted and phenomenon-based relationship models designed. The phenomenon „parent's dealing with changed food preferences of juvenile children", which is presented here, provides an insight into juveniles' demands regarding organic food products and parents' strategies and actions to deal with these. Thereby sweets, salty food snacks and chocolate spreads turn out to be organic food products mainly rejected by juveniles. As main reason for rejection the criteria of taste can be identified. Dealing with their children's preferences, parents follow the two strategies „making concessions" and „not making concessions". Product type, product attributes, consumption situation and price emerge as subjectively meaningful conditions for the interviewed parents. According to the results, marketing strategies for the organic food products concerned should mainly be targeted to juveniles' demands on taste on the one hand and parents' demands on ingredients on the other.

Introduction

Being an important institution of socialisation of children and juveniles, the family plays a decisive role for the acquisition of nutrition styles generally and sustainable nutrition styles specifically. For the marketing of organic products from a long-term perspective it is therefore indispensable to study the consumption behaviour of families rather than to merely focus on individual consumption behaviour. Therefore a differentiated analysis of the consumption of organic food in families over time is necessary. In this study, we investigate to what extent and at which time changes in the consumption of organic food in families appear. Moreover, the question for reasons of change in the organic food consumption of families arises. Explanatory approaches for this are already known from studies about motives for purchasing organic food. Thus, pregnancy and childbirth are turning points promoting motives for purchasing organic food like health. In contrast, children's adolescence, household formation, and economic or social crisis can be turning points for setting up or reducing organic food consumption (Kropp et al. 2005, p 41). Comparing the consumption of organic food in families according to different family life cycle stages expenditures for organic food in families with young children (oldest child under 15 years old), can be found to be higher than in families with older children (eldest child between 15 and 19 years old) (Michels et al. 2004, p 20; Wier et al. 2005, p 18). Accordingly, it can be assumed that

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expenditures for organic food in families decline with an increasing age of the children. Reasons for changes of families' organic food consumption can be deduced and assumed from previous studies. However, detailed descriptions of single phenomena did not exist.

Materials and methods

The research interest is to discover causal relationships between the development of organic food consumption in families from the subjective perspective of consumers. To do this, a qualitative research approach is most appropriate. Data is collected by means of the problem-centred interview (Witzel 2000), which is a combination of narrative and semi-structured interviews. Problem-centred interviews therefore allow the interviewee to narrate the development of organic food consumption on the one hand while, on the other hand, the interviewer can focus the interview thematically. The study is designed in multiple aspects according to research style and analysis method of the Grounded Theory (Glaser and Strauss 1967). For this, a research design of three waves of data collection and analysis, of 10 interviews each, has been created. In that way, the sampling criteria for the second and third wave can be adapted to the findings gained in the previous wave. For the first wave of data collection interviews were conducted with 10 parents, mainly responsible for food purchasing in their household. In these households organic food had been purchased frequently for a longer period of time, and at least one child of 12 to 18 years was present. The analysis of the interviews was strongly orientated to the coding procedures of the Grounded Theory according to Strauss and Corbin (1990). Based on the interviews, relationship models were worked out. These were enriched by the results of 10 additional problem-centred interviews with juveniles of 13 to 18 years about their attitudes and preferences as well as their purchasing influence on family decisions with regard to organic food. The emerging relationship models gave explanation about changes in organic food consumption in families with children. In the following example the phenomenon „parents' dealing with changed food preferences of juvenile children“ is presented.

Results

The phenomenon „parents' dealing with changed food preferences of juvenile children“ emerges from all categories referring to organic food consumption. This differs from former consumption habits of the family and is caused by the demands of the interviewees' juvenile children. Differing food demands were expressed in statements about organic food products in the household which were rejected by children as well as statements about children's preferences for conventional food products. It is found that differing food preferences of children mainly appear in the product categories sweets, salty snacks, cereals, chocolate spreads and milk products. This corresponds to the results from the interviews with the juveniles. In contrast to the children, parents also mention lemonades on conventional quality as typical products preferred by their children. For the juveniles frozen pizzas are of relevance, too.

As causal condition for changing food preferences of children, parents refer to children's pre-adolescence or adolescence. This is explained by the development of juveniles' differing food demands. From the parents' perspective reasons for rejecting organic products by their children are motivated by the criteria taste, texture, price, packaging and image. Their children's reasons for accepting or even preferring organic products are animal welfare and taste from the parents' perspective. Motives for rejecting organic products named by the juveniles themselves are less varied than their parents'.. Taste turns out to be the central criteria for rejection. Beside taste, packaging as well as price - in cases where particular food products have to be financed by pocket money - is mentioned occasionally. Juveniles' identify health, food security and animal welfare as relevant criteria for organic food consumption. From the analysis of how parents deal with children's changing preferences, two opposed strategies emerge which can be entitled as „making no concessions "and "making concessions", both depending on certain contexts (product type, product attribute and consuming situation and conditions. The first strategy is expressed e.g. in the action of insisting on purchasing organic food products. One mother tells that she stubbornly only buys organic breakfast cereals although her children prefer conventional ones and these cost more. As she says her children consume a high amount of breakfast cereals per day and conventional ones are of high sugar content and possibly of gene-modified ingredients. She obviously fears health problems for her children. The second strategy is expressed, for instance, in the action of purchasing conventional lemonade and chocolate spread only for special occasions like a television evening or Easter and Christmas. The relationship model in figure 1 gives an overview over how parents deal with children's changing food preferences and different intervening and context conditions like price, kind of product, product attributes and consuming situation.

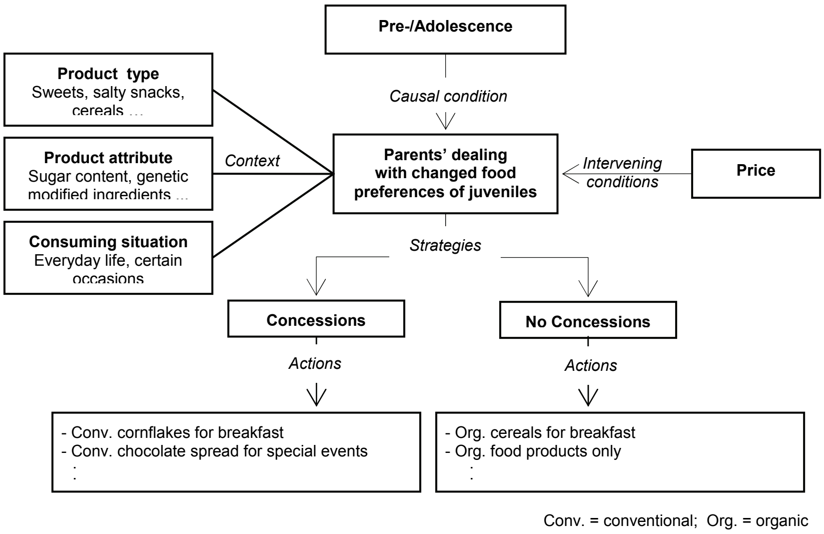

Figure 1: Parents' dealing with changed food preferences of juveniles

Discussion and Conclusions

As known from other studies, children influence purchasing decisions about sweets and snacks in their families considerably (Levy and Lee 2004, p 325; Mangleburg 1990, p 813). If young target groups are to be introduced to organic food products early in order to win them as future consumers, exactly this class of goods are possible starting points for marketing strategies. As seen, organic sweets, salty snacks, chocolate spreads and breakfast cereals do not always fit juveniles' taste demands. Therefore, much effort should be made to modify these products in a way which suits the taste of juveniles. At the same time, organic food products have to fulfil the demands of parents who are in the role of the final decision maker (Blackwell et al 2001, p 356) for the main part of household expenditures. For them, criteria like quality of ingredients or sugar content turn out to be of significant importance. Children can also be in the role of the decision maker for sweets and snacks when they finance these from their own pocket money. In this case, price is an important barrier for juveniles to purchase organic sweets. If organic retail brands are to be attractive for the whole family some organic sweets could be calculated with low premiums to attract children and win them over to consume organic products.

Acknowledgments

We are grateful to Ute Gilles for interviewing the juveniles and doing the analysis.

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The successful use of organic food products in eating out: A German case study

Rueckert-John, J.[1]

Key words: Sustainable food consumption, organic food products, eating out, organisational change

Abstract

Food consumption in western industrial countries seems problematic in the context of sustainable development. Organic agriculture and organic food products have a high significance in the German debate about sustainable food consumption. An important question for socio-scientific research is how a higher acceptance and consumption of organic food products can be promoted. This presentation will not focus on food consumption of private households – as it is customary – but on organisations of eating out. The empirical proof is given by a recent research by the author about the use of organic food products in catering facilities as promoted by the Federal Ministry of Food, Agriculture and Consumer Protection in Germany. From a theoretical perspective the presentation will firstly consider how a change towards sustainable nutrition with organic food products in catering facilities can be both conceptualized and examined. Secondly, the applied methods will be described. And finally, based on the theoretical assumptions the important empirical results will be presented. The study shows that concepts of sustainable nutrition are long-term learning and conditioning processes of the organisations.

Introduction

Food consumption has become problematic in western industrial countries and does not seem to be sustainable yet. In the current western context less the basic food supply of the population rather the outcome of the industrialized production of food is under discussion. This situation leads to questions about the handling of food prosperity and about malnutrition as a result of super nutrition. A non-sustainable nutrition in western countries means that the nutrition is problematic for health, if herewith the increase of different illnesses like cardiovascular diseases and obesity is connected. First of all today's nutrition in Germany and other western countries is problematic for the environment. The field of nutrition occupies directly and indirectly one-fifth of the total primary energy and material supply of all consumption fields (Wuppertal Institute 1997). Therefore organic agriculture and consumption of organic food products have a high significance in the discourse about sustainability in Germany supposing such agriculture and organic food production have a positive environmental effect. That means the consumption of private households as well as the consumption sector of eating out, the canteen kitchens.[2] In the context of this debate the presentation will discuss the possibilities of a more sustainable nutrition

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[2] Definition of eating out: All food and beverages preparation and intake outside home (DGE 2000). The eating out consumption is divided into two main sectors: the hotel and restaurant industry and the communal feeding.

based on organic food products in catering facilities. The central question is: How is sustainable nutrition in organisations of eating out possible? It brings a new focus on a long neglected field of food consumption. Nutrition in eating out receives great relevance from the perspective of sustainability because it bears enormous potentials for change.

Materials and methods

Organisational structures can be described as decision premises, frameworks of expectations resulting from former decisions. Thus the organisational structure realises a basic stability under ever-changing conditions. They ensure essential redundancies of the organisation in a way that operations (as single events of usual decisions) are always linked up in the same way. Decision premises contain the possibilities of deciding whereby the risk of decision can be absorbed. According to Luhmann (2000) different types of decision premises of the organisation can be differentiated. The *determinable decision premises, which are built in reference to oneself,* are important for the organisation. That means aspects like tasks, personnel and the way of communication, which are bundled to a particular position. Furthermore a second type of premises is important for the organisation, which are *the decision premises in the organisation are non-determinable and self-referential*. That means organisational cultures, especially social values as components of organisational cultures are often barriers in a change process. A third type of *decision premises is non-determinable and built-up in reference to others*. These kinds of premises refer to connections into the environment of the organisation.

The change of those decision premises is the main empirical focus of the observation of processes introducing organic foodstuff. Change in organisations is widely discussed as an evolutional change (Luhmann 2000) along its elements variation, selection and retention (or re-stabilisation). Based on the assumptions of organisational structures change can be observed as deviation from those. Firstly, one can focus on the disturbance of the decision premises, the redundancies, in the form of problems or conflicts. The application of existing premises is not longer possible. The organisation as social system gets under pressure and therefore it reflects on alternative premises. Secondly, now the selected variation which can find acceptance during the process when deviation increases circularly, comes into the empirical focus. The selected variation is often indicated as solution of a problem. Thirdly, since the selection leads to a rush of complexity the organisation must respond to it with re-stabilisation. That means, the new decision premise must be integrated in the organisational system and must be communicated to the actors in the environment of the organisation. The strategies of re-stabilisation can provoke subsequent irritations, which must be handled by the system. The circular cycle restarts.

This organisational model served as the heuristic for the recent research by the author about the use of organic food products in organisations of eating out (Rueckert-John 2007).[1] The first part of the study concentrated on describing the status quo of the use of organic food products in eating out based on a quantitative and representative

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[1] The precedent study was called “The use of organic food products by food supply services: status quo, difficulties and success factors, opportunities for development and needs for political action” (Rueckert-John et al. 2005). It was conducted between 2002 and 2004 and was promoted by the programme of organic production of the Federal Ministry of Food, Agriculture and Consumer Protection in Germany.

survey. The second part researched difficulties and success factors with a qualitative research design. Therefore seven best-practice-cases were analysed: a kindergarten, a university canteen, a staff canteen, a catering business, a hospital and two restaurants. In each organisation semi-structured interviews were used questioning relevant actors of the organisation and actors in its environment. In the following part of my presentation I will focus on the results of the qualitative case studies (Figure 1).

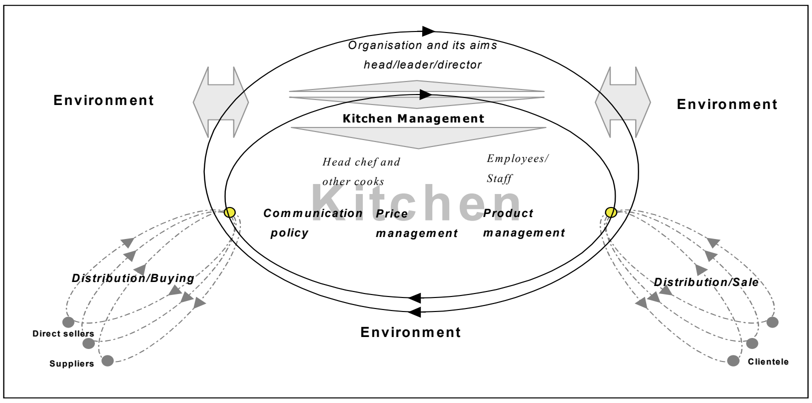

Figure 1: Research design of the case studies

Results

About decision premises, which are built in reference to oneself: Programmes of sustainable nutrition in organisations of eating out pursue aims health, environmental safety and nutritional competence, which are communicated as semantics of naturalness. These are leading aims for all observed organisational programmes (e.g. about product, price, distribution and communication strategies). The occasions for the change of nutritional programmes often were reactions to irritations like BSE or other nutritional problems. The study shows that concepts of sustainable nutrition can be successful, if all relevant actor groups and not only the initiator will participate in the decision-making process in the organisation. Otherwise it is very difficult for the kitchen chef to promote it, if relevant actors like the head of an organisation, are not interested in an alternative nutrition concept.

About decision premises, which are non-determinable and self-referential: Organising the purchase of products is an important task of the kitchen chef. Criteria for a sustainable product choice are derived from the aims of a sustainable nutrition. It follows the leading aim naturalness. The observed kitchens order mainly organic food, regional, and seasonal as well as fair trade food products. Moreover strategies of a sustainable product use must be compatible with existing organisational structures (e.g. financing programmes) and conditions of the environment. For example, the use of organic food products must be affordable in facilities of communal feeding like kindergartens or hospitals. Furthermore, sustainable nutrition needs sensible strategies of financing, which should consider structural conditions of the organisation and the social environment as well as point out synergies between different motives. For example, a reduction of meat is one applied price strategy of the analysed organisations. This strategy has also got a value of health. Regarding the kitchen staff, the performance of their specific tasks and their acceptance of programmatic values are very important. For this purpose a permanent communication of sense and updating of sense offerings are necessary. Successful forms of communication are meetings with the kitchen staff and also their involvement in the planning and in decisions about the realisation of sustainable nutrition.

About premises of decisions, which are non-determinable and built-up in reference to others: For a successful implementation of a sustainable nutrition concept in businesses and facilities of eating out structurally adequate suppliers and direct sellers are required. A trustful cooperation is one indicator for the success of sustainable nutrition concepts. To safeguard the clientele's acceptance of sustainable nutrition a structurally compatible communication strategy with specific offers of sense is needed. This means for the observed organisations of communal feedings for example forms of nutritional education like parent-teacher conferences in the kindergarten or seminars about healthy nutrition in the hospital. The actors use often sensorial forms of communication. In the restaurant it is a face to face communication of the cook and service stuff with the guests. In staff canteens the actors practice different forms of a more faceless communication (information letters, posters, intranet platform). Two patterns of safeguarding the clientele's acceptance could be found: factual expansion (inclusion of additional task in the organisation) and social expansion (additional offers of clientele participation) of the nutritional programmes.

Discussion and conclusions

The results of the empirical study show that concepts of sustainable nutrition are learning and conditioning processes, which are not short-term but rather long winded changes of social structures meaning in the case of organisations a change of particular decision premises. A more sustainable nutrition can at best be inspired by policy, society and scientific discourses. But it has to be always accepted in the systemic contexts, the organisation, via a specific sense making. Therefore, the change of existing nutritional concepts can be understood as a structural change of organisations with manifold consequences, which are located on different organisational levels. The benefit of this research can be seen in a theoretical and empirical extension of the term "sustainable food consumption" by an organisational perspective. It has brought a new focus on a long neglected field of food consumption.

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iPOPY – innovative Public Organic food Procurement for Youth. School meals – and more!

Løes, A.K.[1], Nölting, B.[2], Kristensen, N.H.[3], Spigarolo, R.[4], Strassner, C.[5], Roos, G.[6], Mikkola, M.[7] & Mikkelsen, B.E.[8]

Key words: consumers, food policy, iPOPY, supply chain, nutrition and health

Abstract

One of eight pilot projects in the European CORE Organic programme, innovative Public Organic food Procurement for Youth, (iPOPY) will study efficient ways of implementing organic food in public serving outlets for young people (2007-10). By analysing practical cases of school meal systems and other food serving outlets for youth, we will identify hindrances and promoting factors in the participating countries (Denmark, Finland, Italy and Norway). Policies, supply chains, certification systems, the young consumers' perception and participation, and health effects of implementation of organic policies and menus are focussed in iPOPY. The main aim is to suggest efficient policies and comprehensive strategies to increase the consumption of organic food among young consumers in a public setting, and fostering sustainable nutrition. Interdisciplinary project tools under development will be presented along with the first project results, which will be available by June 2008.

Introduction

The project innovative Public Organic food Procurement for Youth (iPOPY) is one of eight pilot projects conducted under CORE Organic (www.coreorganic.org); a joint funding research programme among 11 European countries (2007-10). The iPOPY project is funded under the thematic area "Marketing research". The CORE Organic funding body network demands knowledge and practical evidence that will contribute to increase the consumption of organic food. Governments, companies, producers and caterers are increasingly committed to public procurement of organic food, but many challenges remain. The iPOPY project will analyse systems of public organic food procurement in four countries and suggest, on the basis of these empirical results, efficient policies and instruments for increased consumption of organic products in public food serving outlets for youth. In this paper, the project is presented in its initial stage, emphasising the goals and methods to achieve them. By June 2008, results will be available from the project work packages and presented.

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Project background, goals and structure

Many European countries aim at an increased organic production and consumption, and the responsibility of the public sector to buy organic is recognised. Whereas organic food and - production have traditionally been linked to bottom-up processes, national and local public top-down policies are gradually developed on public procurement of organic food. However, national level decisions are often tackled inappropriately when implemented on a more local level (Kristensen et al. 2007). To be realised, political decisions are dependent on the enthusiasm of many secondary actors which have the power to contribute to, or hamper an implementation of organic food. Further, political aims are often conflicting and may counteract each other. Hence, knowledge is required about strategies and instruments that may increase the efficiency of national POP policies when these are implemented on a local level.

The aim of iPOPY is to study implementation of relevant strategies and instruments linked to food serving outlets for young people in some European countries. School meal systems are the most important way of public food provision for youth, but other areas such as kindergartens, hospitals and music festivals are also of interest. Within this field, the supply chain management, procedures for certification of serving outlets, stakeholders' perceptions and participation, and the potential of organic food in relation to health and obesity risks will be studied in four explorative work packages (WP2-5), whereas WP1 takes care of the project co-ordination.

The research project is a co-operation between Norway, Denmark, Finland and Italy. German researchers also participate, funded by the Research Council of Norway. The project coordination is placed at Bioforsk Organic Food and Farming Division (NO).

Methodology: An interdisciplinary analytical framework and national comparisons

Public organic food procurement for youth (POPY) is a complex phenomenon that varies considerably across European countries. There is a need for cross-national comparisons of POPY systems to reveal determinants that are central for the development of such systems, as well as experiences and best practices that may be adopted by other countries and regions. National reports are developed for this purpose and published on the project web site. Furthermore, a complex reality calls for interdisciplinary research integrating diverse disciplinary knowledge about policies, supply chains, perceptions and learning as well as health and nutrition. To synthesize these diverse results, a common analytical framework is under development, using the methodology of constellation analysis (Schön 2007). Due to the large variety of POPY systems in the four project countries we initially focus on school meals. In the first stage of this work, the project team has suggested central actors and framework conditions and described their relations, which make up a POPY constellation. This preliminary version was visualised and "mapped" (Fig. 1). It serves as a heuristic tool for the research project. The visualisation points out central actors and framework conditions of the system, and allows for describing sub-constellations that form coherent sections of the overall constellation. Four sub-constellations, reflecting the four explorative iPOPY WPs, seem to shape the outcome of public organic procurement: policies of POPY, providing a regulatory framework; supply chain management; consumer perceptions, practices and learning; nutrition and health (Nölting et al. 2007).

An important aspect of the mapping of constellation and sub-constellations of the POPY phenomenon is that connections between actors as well as framework conditions are identified and described. Further, the visualisation may reveal "blind spots" and possible dynamic and feed-back loops between the sub-constellations. An important part of the procedure to develop the framework is to stimulate the discussion in the project across work packages, and to formulate hypotheses for further research.

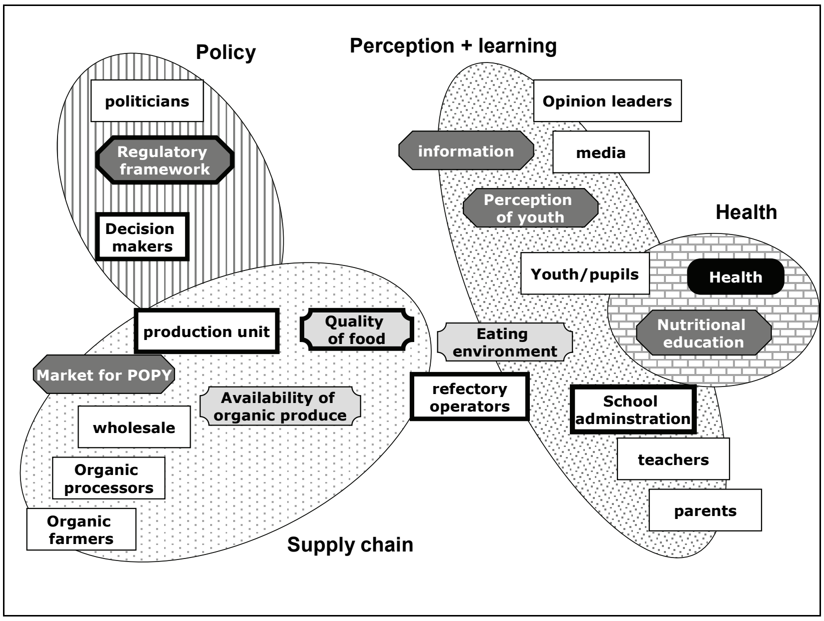

Figure 1: Mapping the constellation of public organic food procurement linked to school meals

A coherent common terminology across work packages and disciplines is an essential part of this bridging concept. Altogether, the mapping process, the identification of central actors and framework conditions as well as common and clearly defined terms will provide an analytical framework to serve as a common point of reference for the research conducted in the work packages and ensure the comparability of national analyses and case studies.

Coming results

The first outcome of iPOPY will be national reports describing the situation with respect to school meals (WP2), and to which degree organic food is included in school meals, in the four iPOPY countries. There is a huge variation between the countries with respect to school meal traditions, ranging from Italy, where all children receive a subsidised warm lunch daily and both local and organic food is heavily supported by public legislation (Morgan and Sonnino 2005), to Norway, where children may subscribe to daily milk and/or fruit servings. In Finland, warm lunch is served for free but the share of organic food is low. In Denmark, various approaches to cold and warm lunch meals are being developed, with a considerable public support for organic; however, the implementation of organic food still has a long way to go.

The certification systems of organic production, processing and serving outlets in DK, FI, IT, NO, Germany and the EU in general will also be described in national reports (WP3). The aim of this work is to discuss and suggest general regulations and certification procedures for food serving outlets. By June 2008, initial results will also be available about supply chain management (WP 3), and relations between organic food and healthy eating (WP5). Positive attitudes towards organic procurement among catering managers have been shown to be associated with healthier menus in worksite canteens (Mikkelsen 2006), and iPOPY-WP5 will study whether this pertains also to young people, where a positive attitude towards organic food would be especially important to establish.

The overall iPOPY perspective is that food policies are crucial to achieve efficient public procurement systems of organic food, and analysis of actor networks (Hajer and Wagenaar 2003; Scott 2001) will be performed in WP2 based on information from other WPs. Drivers and constraints for public organic food procurement will be studied, as well as best practice cases, to develop and propose comprehensive strategies for POP that are practically and contextually adaptive. By responses from municipal stakeholders as well as actors in the school environments, these results will highlight the relationships between organic procurement polices, food and nutrition policies and the actual serving practices.

Conclusions

At the ISOFAR conference, the project will be presented emphasising the instruments developed to analyse and synthesize results across WPs. Results from national descriptions of public organic food procurement systems for youth will be presented and compared, and a first discussion will be raised about how these results can be utilised to describe and explain each other.

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Economics and strategies on organic farms

Do organic livestock farms in Switzerland earn higher work incomes?

Lips, M.[1]

Key words: work income, organic farming, conventional farming

Abstract

In order to analyse the influence of organic farming on work income per standard working day, a multiple regression is carried out for Swiss farms engaged in livestock production, using farm accounts as a data basis. The work income of organic farms is CHF 24 (20%) higher per standard working day than that of farms participating in the "Proof of Ecological Performance" programme.

Introduction

Compliance with organic farming guidelines incurs additional running expenses over and above those of farms run according to Proof of Ecological Performance[2] (PEP) guidelines. Organic farms achieve better prices and receive higher direct payments. An analysis based on farm accounts is intended to provide information on their relative profitability by defining work income per standard working day by means of regression. The analysis concentrates on farms engaged in livestock production because the difference between organic farming and PEP concerning production technology is minor than for arable crops.

Offermann and Nieberg (2006) compare income for organic and conventional framing for several European countries. For Switzerland they report a higher income of 25 %, while the differences in Austria and Germany are 23 and 2 percent respectively. In an analysis for Germany von Münchhausen et al. (2007) demonstrate that there is any additional income and employment effect of organic farming vis-à-vis conventional systems.

Materials and Methods

Reference farms for the accountancy year 2005 from the Farm Accountancy Data Network (FADN) of the Agroscope Reckenholz-Tänikon Research Station ART (ART 2006) are used for the analysis. Work income per standard working day serves as a yardstick for profitability. Standard working day refers to a working day of a person who is completely capable of work. As the measurement does not distinguish between employees and family labour, it allows a statement to be made on the remuneration for all work done. Equation 1 illustrates the method used to calculate work income per standard working day. Since, in addition to the remuneration of family labour, agricultural income also includes the rate of return on own capital, the own-capital interest claim must be deducted; the Government Bond interest rate is applied here.

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[2] For the Proof of Ecological Performance, various criteria must be met, such as e.g. the condition that 7% of the utilised agricultural area must be run as an ecological compensation area (Agridea 2006). The overwhelming majority of livestock farms in Switzerland achieve the PEP.

Labour costs are then added on. Finally, we divide by the number of standard working days.

Equation 1:

$$\text{Work Income per Standard Working Day} = \frac{\text{Agricultural Income - Own Capital Interest Claim + Labour Costs}}{\text{Number of Standard Working Days}}$$

For the analysis, we focus on livestock farms, with five different types being used: *Commercial milk* (type 21 of Swiss FADN), *Suckler cow* (type 22), *Other cattle* (type 23), *Combined pigs/poultry* (type 53) and *Combined other* (type 54). Lips and Eggimann (2007) conducted separate analyses for all farm types. Multicolinearity resulted because of the small sample sizes. Pooling the five farm types and increasing the number of observations would be one way of reducing multicolinearity (Dougherty 2006). Table 1 shows a number of key figures, such as work income per standard working day.

Tab. 1: Key figures of Swiss livestock farms

	Unit	Organic	Proof of Ecological Performance	All
Number of farms		399	2033	2432
Utilised agricultural area	ha	20.7	20.3	20.3
Livestock units	LU	23.0	29.7	28.6
Standard working days	days	475	480	479
Work income per standard working day	CHF/day	132	120	122

Source: ART 2006

For the analysis, we use data from 2432 farms, 399 (16.4%) of which farm organically. This figure is higher than the percentage of organic farms in Switzerland, which is at 9.9% (Schweizerischer Bauernverband 2006).

Regression Analysis

Work income per standard working day is determined by means of multiple regressions. Organic production is used as a dummy variable, assuming the value of 1 for organic farms and 0 for PEP farms.

The factors used are applied as further independent variables. Besides the assets (balance sheet), the capital/labour ratio, measured in assets per standard working day, is used. Also available as further independent variables are structural details (number of livestock units, animal density, area), production details (concentrate costs per cattle livestock unit, percentage of cattle out of total livestock, free-stall housing) as well as various key figures from the balance sheet. The structure of the outside costs are deduced from the latter. The costs for plant production, animal husbandry, para-agriculture, work by third parties, machines, and the remaining structural costs (costs for buildings and fixed facilities) are expressed in relation to total outside costs, and enter the regression as blocks of costs.

Starting from an ordinary least square (OLS) estimate with all variables, a step-by-step exclusion is performed by means of an F-test. Here, the statistical significance of two estimates is compared, with one estimate containing additional explanatory variables. If the F-test on the 1% level shows no significant difference, preference is given to the estimate with fewer variables.

Results

Table 2 contains the regression of the work income per standard working day. Around 20 % of the variance can be explained.

Tab. 2: Regression for Work Income per Standard Working Day

	Unit	Coeffi-cient	Std. Error	T-Value	P-Value
Intercept		230	14.6	15.8	< 0.001
Organic farming	Dummy	23.8	3.77	6.3	< 0.001
Percentage of family labour	%	0.74	0.09	8.5	< 0.001
Share of loan capital	%	-0.25	0.05	-4.8	< 0.001
Livestock unit	LU	1.81	0.12	15.3	< 0.001
Animal density	LU/ ha	-13.9	2.30	-6.0	< 0.001
Cattle out of total livestock	%	-0.35	0.07	-5.3	< 0.001
Concentrate costs per cattle LU	CHF	-0.01	0.00	-2.6	0.011
Free-stall housing	Dummy	8.33	3.13	2.7	0.008
Cost percentage of animal production	%	-1.84	0.21	-8.8	< 0.001
Cost percentage of machines	%	-2.20	0.27	-8.2	< 0.001
Cost percentage of work by third parties	%	-1.52	0.47	-3.3	< 0.001
Cost percentage of para-agriculture	%	-1.31	0.30	-4.3	< 0.001
Percentage of structural costs	%	-1.96	0.21	-9.5	< 0.001
Mountainous area	Dummy	-10.4	3.39	-3.1	0.002

R^2 = 0.215, F-Value = 47.2 df 14/2417, P-Value < 0.001; N = 2432

The findings clearly demonstrate that organic farming has a positive impact on work income, resulting in an additional CHF 24 per day. The coefficient is significant on the 1% level. Referring to the average income of CHF 122 per day (Table 1), it represents an increase of 20%. Computed for one year (280 working days), this corresponds to CHF 6720.

If the percentage of family labour rises by 1%, this raises work income by CHF 0.74. An additional percent of loan capital reduces income by CHF 0.25.

An additional livestock unit (LU) increases income by CHF 1.81. The animal density has a negative influence.

Farms with a high percentage of cattle out of total livestock tend to have lower income. An additional Swiss Franc for concentrates per LU lowers income by CHF 0.01. If the farm is equipped with a free-stall housing income is around CHF 8.3 higher.

The different values of the coefficients of the cost percentages are to be interpreted to the effect that the work income per standard working day depends on the cost structure; otherwise, the coefficients would be identical. If, for example, the cost percentage of work by third parties rises by 1% and the percentage of machines falls by 1%, this improves work income per standard working day by CHF 0.68 (CHF –1.52 instead of CHF –2.20).

Farms in the mountainous area achieve a work income CHF 10.4 lower than farms in the plains. The corresponding variable for the hilly area is not significant, and was excluded by F-test.

Conclusions

The regression shows that for farms that raise livestock, organic farming leads to an approx. 20% higher work income per standard working day. Accordingly, changing from PEP production to organic farming is a way for individual farms to increase their income.

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Gender Effects on Adoption of Organic Weed Management Techniques

Lohr, L.[1] & Park, T.A.[2]

Key words: technology adoption, information sources, count data, weeds

Abstract

Nearly 21% of U.S. organic farmers are women, compared with 9% of all U.S. farmers. Little research has isolated the factors influencing adoption of organic farming practices by male and female organic farmers. Male organic farmers adopt more weed control practices than female organic farmers and use a different portfolio of techniques. Results from a count data model and a national survey of U.S. organic farmers were used to decompose observed gender differences in technology adoption into a characteristics effect and a coefficient effect. The analysis shows that 40% of the adoption differential is due to differences in characteristics of male and female organic farmers. Education, experience, information sources, and institutional support are key factors causing the gender gap in number and type of adopted practices.

Introduction

Organic agriculture offers special opportunities for enhancing support for female farmrers because women account for 21% of all U.S. organic farmers but only 9% of all U.S. farmers (Walz). To provide effective programming, causes of differential management decisions based on gender must be identified. More than 75% of both male and female U.S organic farmers in a national survey by the Organic Farming Research Foundation (OFRF) (Walz) ranked weed management as the highest research priority. More than 70% of both males and females used five or more practices for weed control while only 6% required that many strategies for disease/nematode management. Our objective is to determine the factors that cause gender differences in adoption of weed management practices by organic farmers.

Materials and methods

Our method is an extension of the Blinder-Oaxaca (BO) decomposition (Oaxaca) to a count data model. The technique decomposes observed differences in the adoption of weed management techniques across male and female farmers into two components. The first component, called the characteristic effect, represents the adoption differential attributable to the characteristics of male and female farmers. This component reveals how a disparity in adoption rates is driven by a characteristic (such as education) that differs between male and female farmers. The second component, called the coefficient effect, measures the relative strength of a characteristic (such as years of experience) on male and. female decisions to use weed management practices. We extended Fairlie's model for binary outcomes.

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[2] As Above

We hypothesized that the selection of a given technology is related to other weed management strategies already used, and others that are available but not yet adopted, which enables us to analyze the complementarity effect of technology on adoption. Our hypothesis explicitly recognizes that the total technology package, rather than individual practices, maximizes a farmer's utility. To account for the interrelationships of weed control strategies with other management decisions, we used a count data model for the portfolio of weed management technologies.

Analysis on a scale broad enough to accurately reflect the production conditions must be drawn from a national survey that is representative of all organic farmers. Of the 1,192 responses to the 1997 national OFRF survey, 716 contained enough data for model analysis. The survey and results are available from the OFRF (Walz). A comparison of organic farms in the survey with data for all U.S. farms shows that the sample of organic farmers is representative of the size categories, farm income categories, and crop mixes for all U.S. farms (Lohr and Park).

In the survey, organic farmers who described themselves as using a given weed management practice on an occasional or regular basis during a year were defined as "adopters" while farmers who rarely or never used a strategy were classified as "non-adopters." The dependent variable was the number of adopted practices for weed control selected. On average, both men and women adopted six weed control practices, but men were most likely to adopt mechanical tillage while women were most likely to adopt hand weeding. Fewer than 40% of all U.S. farmers use crop rotations (39%), tillage methods (35%) and adjustments to planting dates (8%) compared with 70% to 90% of organic farmers using these methods (Walz, USDA).

The independent variables in the model included farm structure variables for sole proprietorships (male=74%, female=71%), corporation (m=7%, f=3%), managing organic and conventional systems on the same farm (m=25%, f=14%), percent of acreage allocated to vegetables and herbs (m=33%, f=47%), percent of acreage in field crops (m=44%, f=28%), average farm size (m=149 ac, f=40 ac), and farm income (m=42% <$15,000, f=70% <$15,000). Farmer demographics measured were completion of a college degree or higher educational level (m=55%, f=67%), part-time farming (m=64%, f=58%), experience as organic farmer (m=10.0 yrs, f=9.9 yrs), and number of different sources contacted for organic information weighted by the frequency of contact with that source (m=14.8, f=15.3). Regional variation in institutional support was captured by dummy variables for the federal administration of grants and support for sustainable agriculture including four regions – West, North Central, Northeast, and South. South was omitted in the regression.

We estimated the count data regression model of the weed management portfolio separately for male (n=562) and female (n=154) using Poisson estimation. We decomposed each variable's contribution to the difference between male and female farmers' weed management portfolios using the characteristic and coefficient effects.

Results

In this model, characteristics shares are positive if they contribute to males adopting more practices and negative if they contribute to females adopting more practices. The sum of the characteristics shares is the total effect of male vs. female differences in the variables on weed management portfolio choice. The decomposition analysis shown in Table 1 indicates that 40% of the technology adoption differential was explained by differences in characteristics of male and female farmers.

Tab. 1: Decomposition analysis of weed management practices adopted – male vs. females

Variable	Characteristics Effect Estimate	Share	Coefficient Effect Estimate	Share
Sole Proprietorship	-0.010	2.6	-0.087	-2.5
Corporate	-0.015	-3.7	-0.016	-4.2
Mixed farming	-0.036	-9.1	-0.029	-7.5
Percent Vegetables	0.089*	22.9	0.552*	141.9
Percent Field Crops	0.229*	58.8	0.053	13.6
Organic Acreage	-0.021	-5.4	0.174	44.6
Organic Income	-0.024	6.3	-0.647	166.2
Part time Farmer	0.022	5.5	-0.115	29.7
Years Organic Experience	0.004*	0.9	-0.410*	-105.2
Education	-0.045*	-11.6	-0.029	-7.4
Information Sources	-0.019*	-4.9	0.197	50.7
West Region	0.017*	4.3	-0.878*	-225.7
North Central Region	-0.105*	-27.1	-0.569*	-146.1
Northeast Region	0.072	18.5	-0.733*	-188.3
SUM	**0.156**	**40.2**	**0.233**	**59.8**

* Asymptotic t-value significant at α = 0.10 level.

The variable with the largest effect influencing choice of weed management practices was percent of acreage allocated to field crops (59% characteristics share) followed by the percentage of acreage in vegetables (23% characteristics share). While men allocated 44% of acreage to field crops and 33% to vegetables, women allocated 28% to field crops and 47% to vegetables. Although experience in organic farming averaged 10 years for both, male farmers' choice of weed management practices influenced by education (4% characteristics share). Education had the largest impact for female farmers in narrowing the gap in number of practices adopted compared with male farmers (-12% characteristics share), while the use of information sources had a smaller but statistically significant impact on female weed management adoption (-5% characteristics share). Both variables' mean values were nearly the same for male and female farmers, with both having at least some college education on average, and about 15 information sources contacted, weighted by frequency of contacts.

The decomposition illustrates the potentially misleading implications of looking at unconditional differences in mean values of variables across males and females to try to determine causes of gender differences. For example, average farm size was 149 acres for male farmers and only 40 acres for female farmers, but the size of the organic farm operation was not a statistically significant factor contributing to gender gaps in weed management adoption rates. Similarly, despite and average income difference of $85,000 in favor of male farmers, income from organic farming is not a significant determinant of the number of practices chosen by men vs. women. A qualitative analysis alone would not correctly identify the reasons for differences. The coefficient shares show the degree to which individual variables affect the gap between number of practices adopted by men and women. Positive coefficient shares are associated with variables that increase the gap and negative coefficient shares show variables that narrow the gap. The sum of the coefficient shares was 60%. The percentage of vegetable acreage widened the difference between men and women (142% coefficient share). The coefficient associated with acreage in field crops showed this variable did not significantly influence the adoption decision across gender. The coefficient effect for experience in organic farming resulted in a narrowing of the adoption gender gap (105% coefficient share). he coefficient effect for information sources was positive, indicating that the technology adoption decisions of male farmers were more responsive to information than were the decisions of females. The sign of this coefficient effect reversed the characteristics effect. Women sought more information sources than men, but the number of contacts was less likely to influence their weed management decisions.

Discussion

Female farmers are concerned about weed problems but do not add more practices to address them, a response that is different from that observed for males. The survey reveals that male farmers have a proclivity to supplement mechanical tillage with crop rotations, cover cropping, and hand weeding methods when expanding their portfolios of practices. Female farmers follow a different pattern when considering additional weed control methods, with hand weeding, crop rotations, cover cropping, and mulching as the preferred techniques. The percentage of acreage in vegetable crops should favor these practices, but the factors that influenced women's decisions to add more weed control techniques were education and frequency-weighted number of information contacts. Women seem to be selecting their portfolio based on knowledge-seeking, while men select their weed management strategies based on crop mix and organic farming experience. This suggests that men are passing along knowledge through shared or observed learning, while women conduct information seeking to obtain the same information. The coefficient shares indicated that the gender gap in number of weed management practices is narrowed by farm experience and widened by percentage of vegetable acreage and number of information sources consulted.

Conclusions

Weed management remains the most difficult problem faced by U.S. organic crop farmers. Women's weed management decisions rely on knowledge-seeking, while men rely on past experience. Educational efforts to improve the success of female farmers should account for this difference.

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Financial success of organic farms in Germany

Nieberg, H.[1] & Offermann, F.[1]

Key words: farm economics; profitability; farm comparisons

Abstract

The conversion to organic farming is financially rewarding for many farmers in Germany. The majority of the organic farms make a profit above that of comparable conventional farms. A comparison of successful with less successful farms, measured by the average difference in 'Farm Net Value Added' to comparable conventional farm groups, highlights that the success of the conversion is less dependent on structural and site-specific factors than on the management ability of the farmers – above all in the area of marketing.

Introduction

Organic farming in Europe shows a very dynamic development. In the past fifteen years, the organically farmed land area in Europe increased more than ten-fold, and demand for organic products is continuously growing. Whether in the future a significantly larger number of farms converts to organic farming than previously is dependent on various factors, but above all on the financial viability of organic farming. Against this background, the question emerges of whether and for whom the conversion to organic farming is particularly profitable. This article aims to provide an overview of the profitability of organic farms in Germany and to analyse in a explorative way the question of which factors are most important for successful conversion to organic farming.

Materials and methods

The analysis is based on data from the German Farm Accountancy Data Network and comprises of two different approaches. First, FADN book-keeping records from the last 11 years are used to analyse the development of profits of organic and comparable conventional farms. Second, detailed insights into the differences in the financial success of conversion are gained by using FADN data from the fiscal year 2005/2006.

"Family farm income plus wages per annual work unit (FFI+W/AWU)" was chosen as an indicator for financial success. This is the most commonly used performance indicator in Germany and allows the consideration of farms of different legal structures. The selection of the conventional farms was carried out in accordance with a differentiated, internationally harmonised method (see Nieberg et al 2007) using various natural and geographic factors, resource endowment (ha UAA, milk quotas) and general farm type as selection criteria.

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To identify the most important success factors for a conversion, a comparison of successful and less successful farms was carried out. In order to evaluate whether the conversion to organic farming was successful, the difference in 'farm net value added' (FNVA) to conventional comparison farms is used as a measure of success. FNVA represents the return to all land, labour and capital and thus allows a comparison on a farm individual level irrespective of differences in ownership of these factors.

Results

a) Analysis of time-series data

As illustrated in Figure 1, the average profit plus wages per annual work unit on the organic farms is higher than the profit of comparable conventional farms in eight of the 11 years. In the fiscal year 2005/2006, the organic farms achieved on average profits more than 21 % above the profit of the surveyed conventional farms. It is however important to note that the average reflects only part of the reality. Furthermore, there is a great variation within the sample.

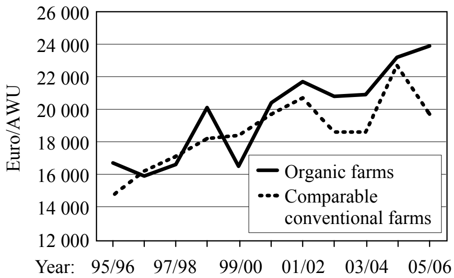

Figure 1: Development of FFI+W per AWU

Source: Own calculations based on German Accountancy Data Network

b) Analysis of book-keeping records from the fiscal year 2005/2006

Past studies often focused on the differences in profitability within the group of converted farms (Gubi, 2006; Nieberg, 2001). This analysis in contrast looks at the differences in relative profitability, i.e. the farm individual profitability under organic compared to conventional management, using data of the fiscal year 2005/2006. The analysis shows that 11 % of the analysed German organic farms achieved only half as high a FNVA as their conventional counterparts. On the other hand, 14 % of the analysed organic farms were able to realise double the FNVA of their conventional comparison partners.

In order to gain a deeper understanding of the difference between particularly successful (double the FNVA) and less successful farms (half the FNVA), the organic farm sample has been split in two corresponding groups. The comparison of these two groups provides the first clues to the factors determining a successful conversion. As can be seen in Table 1, astonishingly the two groups differ in regard to only a few factors:

The clearest, and in most cases statistically significant, differences can be found in the producer prices. As was expected, the successful farms realise much higher prices for their products. One potential explanation for this results is that successful farms are more involved in direct-marketing

The successful farms also achieve somewhat better natural yields, however statistically significant differences where found only for dairy yields. In addition they tend to produce in a more market-oriented manner. They have a larger arable areas and cultivate more organic cash-crops such as potatoes and vegetables.

Tab. 1: Comparison of successful and less successful organic farms (Year 2005/2006)

			Organic farms with half as high	doubly high
			Farm Net Value Added as compared to conventional reference farms	
Soil Index		BKZ	34	32
Share of Part Time Farms		%	33	28
Total Labour Input		AWU/100 ha UAA	4,2	2,8 **
Paid Labour Input		AWU/100 ha UAA	0,3	0,4
Agricultural Training				
No formal agric. training		%	17	5 **
Certificate of apprenticeship		%	50	38 **
Certificate at Technical School/Master Farmer		%	20	31 **
College/University degree		%	13	23 **
General Farm Type	Arable Farm	%	40	41
	Grazing Livestock Farm	%	57	51
	Mixed Farm	%	3	8
Farm Focus (Principal type of farming)				
Arable crops: Specialist cereals, oilseed and protein crops		%	27	18
Arable crops: Cereals and root crops combined as well as mixed cropping		%	6	18
Specialist dairying		%	30	36
Specialist cattle-rearing and fattening		%	13	0
Total Utilised Agricultural Area		ha UAA	59	98 *
Share of Rented Land		% of UAA	60	56
Share of Arable Land		% of UAA	55	63
Share of Cereals		% of arable land	53	54
Share of Legumes		% of arable land	5,4	6,6
Share of Potatoes		% of arable land	2,0	4,1
Share of Vegetables		% of arable land	0,6	1,0
Stocking Density		LU/ha	0,8	0,7
Number of Dairy Cows		Head	25	35
Number of Suckling Cows		Head	18	41
Number of Breeding Sows		Head	-	4
Number of Laying Hens		Head	44	548
Yields/Performance	Cereals	t/ha	3,2	3,4
	Field Beans	t/ha	1,8	3,3
	Potatoes	t/ha	14,8	16,9
	Milk	kg/cow	4293	5154 *
Producer Prices	Cereals	€/t	207	306 **
	Potatoes	€/t	360	424
	Milk	€/kg	0,326	0,351 **
	Fattening Bulls over 1.5 years of age	€/head	524	901 *
	Fattening Pigs	€/head	194	248 *
Share of Farms with Direct Marketing		%	47	62
Direct Payments and Other Subsidies		€/ha	598	605
Thereof: Organic Payments		€/ha	190	166
Labour Costs		€/ha	69	118

BKZ: Soil climate index; AWU: annual work unit; UAA: utilised agricultural area; LU: livestock unit
** significant at $p < 0.05$; * significant at $p < 0.1$ (t-test and Wilcoxon-test).

Source: Own calculations based on German Accountancy Data Network (2005/2006)

- The general farm types are nearly similarly distributed in both success groups. Some differences exist with regard to farm focus: in the group of farms with a relative low financial performance compared to the conventional reference farms, specialised cereal, oilseed, and protein crop farms and specialised cattle rearing and fattening farms are more frequently represented, whereas the more diversified crop farms are comparably more frequently represented in the group of successful farms. Thus, an interesting question for future research is: Which level of specialisation/diversification promises the best chances for a successful conversion?
- The group of less successful farms comprise of more farmers that have no agricultural training. In contrast to this, successful farms are more often managed by farmers that hold a degree of a technical college or university. A good agricultural education seems to be an important factor for success.
- Interestingly, the quality of the farm-site (measured here on the basis of the soil-climate index) does not seem to have an influence on the success of the conversion. Conversion can thus be successful both in the case of advantageous and non-advantageous natural conditions.
- On average, the more successful farms were significantly larger than the less successful farms, which may however be due to regional differences in farm structure (East vs. West Germany) and requires further analysis on a regional level.

Conclusions

In the past, the conversion to organic farming proved to be a financially rewarding choice for a number of converted farms. However, great differences exist in the level of success. Thus, great chances lie in the conversion to organic farming but also risks. The fact that above all the levels of realised producer prices are of great significance allows the conclusion that the success of the conversion is less dependent on structural and site-specific conditions, but rather on the management ability of the farmer, particularly in the area of marketing. In order to be successful, the organic farmer, just like his/her conventional counterpart, must have entrepreneurial skills and a high level of competence in production, but above all in marketing. Given the large number of possible hidden variables influencing the success of organic management, the results of this analyse are of explorative nature. More insights would be gained by applying a multivariate analysis.

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Diversification and specialisation as development strategies in organic farms

Zander, K. [1]

Key words: diversification, specialisation, organic farming, socio-economics, Germany.

Abstract

Unsatisfying economic performance, continuous work overload or the entrance of the younger generation are often the starting point for reorientation of the farm's organisation in order to increase the farm's efficiency. Theoretically, farmers are faced with two main options when looking for a viable farm strategy: diversification or specialisation. Based on a quantitative and qualitative survey of 40 farms, the results show that the decision to either diversify or specialise is usually a multi-dimensional issue. Only the analyses of the interactions between many different factors may help to understand the decision processes on farms. One central result of the study is that the personality of the farmer is the key driving factor in the decision on specialisation or diversification. The study also reveals that, whereas cost reduction is observed to be a valuable strategy in conventional farming, it seems to be of very limited relevance in organic farming in Germany

Introduction

Unsatisfying economic performance, continuous work overload or the entrance of the younger generation are often the starting point for reorientation of the farm's organisation in order to increase the farm's efficiency. Usually, two main possible strategies can be distinguished. Specialisation in one or few farm activities aims at reducing production costs and is often associated with an increase of farm size. The second main option is diversification by increasing the number of activities. This strategy usually goes along with a closer contact between farmer and consumer and an increase of return, so that cost saving becomes less important.

Three types of diversification are to be distinguished in organic farming:[2] horizontal diversification is an extension of the existing range of activities, e.g. starting a new farming activity like potato production. Lateral diversification is related with the entrance into new product-market-areas, without a physical relationship with the former activities. This can be agro-tourism, catering or the production of renewable energies. Finally, vertical diversification (vertical integration) refers to pre– or post–agricultural production activities like on-farm processing or direct marketing.

The question of the optimal farm organisation with respect to the number of farm activities realised and the way they are combined with each other has long tradition in farm economic research, starting in the first half of the 20th century. The following impact factors were identified: natural production conditions, locality of the farm, infrastructure, general price and cost relations as well as the necessity of creating high

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[2] See Jacobs (1992).

soil fertility by adequate crop rotation and the use of manure, the use of own fodder, break down of work peaks, risk management and the personality of the farmer (see e.g. Aereboe 1919, Brinkmann 1922, Weinschenck and Henrichsmeyer 1966, Kuhnert, 1998). These factors determine the optimal farm organisation and the number of farm activities and thus a farm's degree of specialisation or diversification.

The aim of this contribution is to identify the key driving forces for the strategic decision regarding specialisation or diversification in organic farms. The results should help farmers to decide whether to opt for specialisation or for diversification.

Methodological approach

The study was designed as an explorative study and thus the results are not representative for all organic farms in Germany. Interviews were realised on 40 successful organic farms with a clear decision for diversification or specialisation in the past. These farms were selected in close cooperation with organic farming extension workers and are supposed to serve as good examples for other farms in an orientation phase.

The survey combined quantitative and qualitative elements in face-to-face interviews. The qualitative part was mainly used when asking farmers to report on their farms' history in an almost narrative way, pointing at important events. A short initial interview with 12 advisors of organic farming revealed that the personality of the farmer was seen to be one key driving factor in determining the farm's development into specialisation or diversification. To grasp this issue the DISC personality concept was used in close cooperation with the extension workers. DISC is a commercial product initially developed for management purposes and it clusters people in four main dimensions: dominance, influence, steadiness and conscientiousness according to their behaviour (CIC 2007, Persolog 2007). This tool was supplemented with five items aiming at classifying personalities according to the "Big-Five" personality dimensions (Rammstedt et al. 2004). With respect to the farmers' behaviour and attitudes in their daily work some additional statements were included as well.

Results

The group of surveyed farms contains all farm types and farm sizes located in different natural conditions. In analysing the results it has to be differentiated between the mere agricultural production on the farms and the whole farm system. With respect to the underlying question clear specialisation and diversification strategies can be identified in pure agricultural production: 13 farms chose the way towards specialisation, 14 farms diversified and 12 farms remained almost unchanged with respect to the number of agricultural activities.[1] But looking at the farm organisation in general, the picture is quite different. At this level, 80% of the farms have diversified their whole farm organisation, either horizontally, laterally or vertically. Most important activities besides agricultural production are direct marketing (82%)[2] and on-farm processing (46%). This causes the rather high endowment of labour of 7 agricultural work units

[1] One farm had to be skipped for not being a successful farm with demonstration capability to other farms.

[2] Direct marketing is understood in a wider sense and includes marketing directly to the consumer and marketing via retailers (see Kuhnert 1998).

per 100 ha on average on the surveyed farms, while the average number of labour units in organic farms is reported to be about 2 units per 100 ha (BMELV, 2006).

Aiming at the identification of similarities, four main groups of farms were created according to the development strategy realised. There is the group of farms that diversified with respect to their agricultural production and also to other activities like e.g. on-farm processing, direct marketing, renewable energies etc. (Type 1). Another group of farms stayed with about the same diversity in agriculture, but diversified in vertical direction (vertical integration) (Type 2). The third group specialised and now concentrates on few agricultural products (Type 3), while the last group specialised at the whole farm level, as they reduced their farm activities and ended up with a rather simple farm organisation with one or few agricultural activities (Type 4).

Looking at the key driving forces for the decision to specialise or to diversify, there are no differences between the farm types with respect to endowment of land or the increase in acreage in turn of the farm's development. Almost all farms increased their farm size largely over time. The availability of highly qualified family or employed labour however is a precondition for a successful diversification. An aspect becoming ever more important is specialisation within the diversification by spreading responsibilities to various persons. The differences between the four groups became most obvious with respect to the personality of the farmer himself. For the summary of the results see Table 1.

Tab. 1: First results on differences between farm types according to their strategy regarding specialisation or diversification

Farm type	Features
Type 1	Farmers are always outgoing but are less direct and decisive and they like to work in a collaborative way. Diversity is of high importance for the farmer. They have good marketing opportunities. Two generations work on the farm. Highly motivated family or employed labour.
Type 2	Farmers are decisive and very extraverted. Diversity is of high importance for the farmer. They have good marketing opportunities. Two generations work on the farm and family or employed labour is highly motivated.
Type 3	Farmers are outgoing, correct and even-tempered. In the term of the farms' development they often passed Type 1 or 2, now concentrating on most successful farm activities. Most pragmatic organic farmer.
Type 4	Farmers are not outgoing, instead rather steady and introverted. They like to be independent. Quality production is highly ranked. Very low availability of (family) labour. Specialised also in the past.

Conclusions

One important conclusion drawn from the results presented here is that diversification and specialisation in organic farms is a very complex issue. Farmers cannot simply be classified into the diversifying farmer on the one hand and the specialising farmer on the other hand. There are various forms of diversification in organic farms, and there is also diversification with specialisation in one and the same farm. Only the analyses of the interactions between various factors may help to understand the decision processes on the farms. However, the personality of the farmer turned out to be the key driving factor in the decision on specialisation or diversification.

Most of the surveyed farms chose the way towards diversification on the level of the whole farm enterprise. An important motivation for the farmers to opt for the vertical integration was to be able to earn their livelihood by keeping the added-value of their products on farm. Only 10% of the farmers were "real specialisers". However, even these farmers care about the marketing of their products, such as engaging in farmers marketing associations or cooperatives, or being so large that good conditions can be negotiated on the markets. Thus one important result of this study is that pure cost reduction as observed to be a valuable strategy in conventional farming seems to be of very limited relevance in organic farming.[1]

However, this study used an explorative approach and it does not aim to be representative for the whole organic sector in Germany. The selection of study farms might be biased as the cooperating extension workers all are from organic farmers' organisations. It is likely that "cost minimising farms" are not members of organic farmers' organisations, but only follow the EU council regulation on organic farming (EU VO 2092/91).

Acknowledgements

We are grateful for the funding of the underlying research by the German Bundesanstalt für Landwirtschaft und Ernährung (BLE).

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[1] This result is supported by Nieberg and Offermann (2007), who found comparatively high prices as a major reason for high profits in organic farms.

The Impact of Labor and Hiring Decisions on the Performance of U.S. Organic Farms

Lohr, L.[1] & Park, T.A.

Key words: labor management, seasonal workers, elasticity of complementarity

Abstract

An increased emphasis on the viability and growth of local food systems which reduce "food miles" has promoted efforts encouraging farmers and processors to sell and distribute food products to local consumers. The elasticity of complementarity is used to predict adjustments in relative wage payments if organic farmers commit to local selling. We use comprehensive U.S. data on organic practices to show that a commitment to local sales leads to lower organic farm incomes. Policies that promote a shift to local sales would lead to decreased use of seasonal workers and higher wages for seasonal workers with smaller adjustments in the wages of year-round workers.

Introduction

The Organic Farming Research Foundation (OFRF), in its survey on organic production constraints facing U.S. producers, documented labor as significant production problem for these farmers. Respondents to the Fourth survey rated both high labor costs and the availability of labor to produce organic crops as among the most severe problems constraining production. Labor did not even appear on the list of production problems in the Third OFRF survey. Concerns about the availability and cost of on-farm labor were prevalent across all farm income groups but were identified as a more significant constraint among female than male organic farmers.

The limited research on labor issues for organic farms has focused on the employment dividend when organic farms employ more workers than similar sized conventional farms. A Soil Association study confirmed that organic farms in the U.K. support 32% more jobs per farm than non-organic farms (Maynard and Green). The Soil Association calculated that an expansion of organic farming to 30% of total U.K. farmland would lead to an increase of 28,000 jobs, or a 10% rise in on-farm employment. Duram (p. 79) highlighted research linking organic farming and rural development suggesting that there are “inherent values within the organic movement that could act to encourage local food networks and local community involvement.” Lipson’s analysis of organic marketing and fair trade marketing mentioned a growing awareness of the social and economic benefits of local and regional food sourcing but makes no assessment of the impact on producers.

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Materials and methods

The first objective of this research is to explain how earnings for agricultural workers respond to changes in use of on-farm inputs (including farm size and hiring decisions) by evaluating elasticities of complementarity. The analysis distinguishes between the use of year-round and seasonal agricultural workers, an important feature of the workforce for organic farms. A production function for organic producers is estimated which incorporates indicators of the operational and environmental constraints facing farmers.

A second objective is to evaluate how earnings of agricultural workers on organic farmers respond to specific farm-level change in marketing practices. The agricultural marketing issue we examine is the increased emphasis on the viability and promotion of local food systems which reduce "food miles" and transportation costs while offering consumers the benefits of locally grown food. A Leopold Center report from Iowa State University highlighted the importance of food systems which allow farmers and processors to sell and distribute food products to local consumers. The report recommended that Iowa farmers, retailers, and food brokers "pursue opportunities to market produce and meats locally and regionally" while also diversifying production and processing practices to meet demand for local food. The production function approach provides an economic framework showing how producers are affected when focusing on sales to local markets and can be used to predict adjustments in relative wage payments if organic farmers commit to local selling.

Analysis on a scale broad enough to accurately reflect the production conditions is drawn from a national survey that is representative of all organic farmers in the United States. The data for this analysis is based on responses to the Fourth OFRF survey representing all crops grown organically and all regions in which organic crops are produced yielding 787 observations with complete information. Vegetable crops and herbs were grown by about 28% of the farmers in the sample, with a typical crop mix of at least four different vegetable crops. Fruit, nut and tree crops were produced by about 21% of the sample, with a lower degree of diversification which averaged about two crops in this category. Field crops were the predominant production category, with 51% of farmers allocating acreage across an average of two field crops.

The two inputs are labor and acreage, which are under the control of the producer and can be changed annually depending on the planned output for that season. The labor input is represented by year-round workers and seasonal farm employees. The average farm in the sample used two year-round and five seasonal paid employees. The majority of organic farm operations (52%) relied on both year-round and seasonal workers with of farm 34% hiring only seasonal workers and 14% using only year-round workers. Employment of both year-round and seasonal farm workers is more closely correlated with farm income than is farm size and the relationship is even stronger for organic farms with higher incomes.

Results

We developed an indicator of the farmer's sales to local markets and examine how this variable influences both farm performance and farm-level employment outcomes. The local selling indicator measures the number of commodity categories in which the producer sold all products within 500 miles of the farm. The variable is based on sales information for organic products across four broad commodity groups as recorded in the OFRF survey. The four commodity groups are (1) vegetables, including herbs, floriculture, mushrooms, and honey, (2) fruit, nut and tree products, (3) grains and field crop products, and (4) livestock products. The survey was designed so that producers were first queried about the marketing outlets they used to sell organic products, with sales across three broad categories identified to assist producers in organizing this information. The marketing outlets were direct-to-consumer outlets, direct-to-retail sales, and wholesale markets.

The local selling indicator measures the number of commodity categories in which the producer sold all products within 500 miles of the farm. Consider a producer who sold all of the vegetable products within 500 miles of the farm while some portion of other organic products were sold to more distant buyers. The local selling indicator has a value of one for this producer. Over 68% of producers sold their entire production of at least one commodity category within 500 miles of their farm. For convenience we refer to these farmers as locally committed organic farmers. Sales in local markets are emphasized by both male and female farmers as 66% of males and 72% of females have a positive local selling indicator.

Estimates from the production function are evaluated according to their impact on farm incomes for the organic farmers. An important result from estimation of the production function shows that producers who focus on local sales achieve farm incomes which are 15% lower than other producers. Empirically we find that a commitment to local sales leads to lower farm incomes, an impact which has not been mentioned in discussions about supply chains for organic products. The advantages of short supply chains characterized by close proximity between producers and consumers are frequently highlighted but the effect on organic farm incomes has not been quantified. Lockie et al. comment that "direct sales strategies do not abandon the promises of convenience, product diversity, and value-for-money on which mainstream retailers trade – they simply align them more overtly with values such as community building and the reduction of food miles (p. 186)."

Discussion

Corporate or non-family partnerships who sell locally apparently are taking advantage of better marketing strategies in their operations. The incomes of these organic farms are 44% higher than other farms. One clear performance indicator that distinguishes the corporations or non-family partnerships is that they are better able to manage labor as the majority of these farms indicate no problems in hiring employees for production or marketing in their OFRF survey responses. In addition, these operations use a wider variety of marketing programs targeted to local sales outlets including farm events and demonstrations, local advertising and promotional efforts, product samples, in-store demonstrations and the use of organic certification labels and seals. Cooperative extension marketing specialists and growers association could examine these operations to learn what strategies they employ.

The model is useful in assessing farm-level employment effects associated with sales to local markets. Organic producers who specialize in local sales operate smaller farms compared with national sales producers. The model indicates that smaller farm sizes imply that the marginal value of seasonal labor decreases and hires of these workers decline. Organic farms with a local sales emphasis employ fewer total workers and hires of both year round and seasonal workers are smaller compared with other farm operators. The use of seasonal workers is about 50% lower while the demand for year-round workers is 40% smaller when farms engage in local sales.

Employment of both year-round and seasonal workers would decline with increased emphasis on local sales due to smaller farm sizes. Policies or incentives that promote a shift to local sales by organic farmers would lead to decreased use of seasonal workers and higher wages for these workers according to the estimated production function. An important finding is that increased reliance on seasonal employees reduces wages for these workers relative to the earnings of the year-round workforce.

Conclusions

Decisions to hire and train year-round vs. seasonal workers are a key management decision for organic farmers and information about how this hiring decision is related to organic farm performance is rarely available. The estimated production function confirms that farm size (organic acreage) and both types of farm workers are complementary inputs. Incentives that encourage farmers to expand employment of year-round and seasonal workers will raise the marginal product, and therefore the rate of return to organic acreage. Proponents of organic marketing associations will be able to use the results to demonstrate farm-level employment effects associated with sales to local markets by organic farmers.

Organic farmers who specialize in local sales operate smaller farms compared with producers who sell across a diversified set of local, national, and export markets. A commitment to local sales leads to lower farm incomes, a side effect which is has not been mentioned in discussions about supply chains for organic products. Employment of both year-round and seasonal workers would decline with increased emphasis on local sales due to smaller farm sizes. Policies or incentives that promote a shift to local sales by organic farmers would lead to decreased use of seasonal workers and higher wages for these workers according to these results.

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Factors explaining farmers' behaviours and intentions about agricultural methods of production. Organic vs. conventional comparison.

Canavari, M.[1], Lombardi, P.[2], & Cantore, N.[3]

Key words: Organic farming, ethnocentrism, local origin, conversion

Abstract

We investigate the factors explaining behaviours and attitudes of farmers towards organic practices. Among a wide set of motivational, economic and environmental variables, we focus on those factors related to ethnocentrism of farmers and the importance of local origin labels. We find that ethnocentrism cannot explain neither the present status of farmers (organic vs. conventional) nor their future intentions about the adoption of agricultural methods of production. However, the absence of local origin labels is significantly affecting the choice of conventional farmers who do not convert to organic farming.

Introduction

Organic farming is receiving growing attention from policy makers and scientists over time. The reason would lie on the fact that it provides a beneficial environmental impact in terms of biodiversity and greenhouse emissions and on the healthiness of products obtained by natural methods of production. An abundant scientific literature focussing on different stages of the organic supply chain underlines the high social value of organic farming. Production, distribution and consumption issues are strongly analysed by scholars aimed at investigating the reasons and the driving forces behind the diffusion of organic food. In particular, this paper adds to the strand of literature focussing on the production side. Previous literature about production of organic food raised two main research questions that can be summarised as follows:

- Are organic farms efficient and profitable?
- What are the motivations behind the conversion from conventional to organic farming?

As the first research question previous studies confirm that though input costs for organic farms are much higher (Padel and Lampkin, 1994), organic farms are generally more profitable because of the higher premium prices and the policy subsidies (Lien *et al*. 2006, Kerselaers 2007). However, the market share for organic products is small and the organic market is still a "niche market".

Acs *et al*. (2007) by an inter-temporal optimisation problem stress that the conversion period in which farmers sell at stable prices is the main problem for organic farmers. An interesting scientific literature finds that other than economic reasons, technical, ideological and social reasons can explain farmers' choices about the adoption of

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organic production practices (Stock 2007). Our paper stems from this strand of literature. In particular, we will investigate the impact on organic farmers' behaviours and intentions deriving from crucial factors such as economic, technical, individual, environmental and social ones.

Previous scientific literature points out that organic farming represents an opportunity to valorise the local development of rural areas. The original contribution of our work will be the investigation of the ethnocentrism and products local origins labels as key variables affecting farmers' behaviours and future intentions about the conversion towards organic agricultural practices. We focus on these two variables because they represent two different but complementary concepts. Ethnocentrism is the subjective attitude towards the local origin issue, whereas the presence of local origin labels represents the external condition for farmers concerning the valorisation of local products (Shimp & Sharma, 1987). Moreover, another novelty of our paper is that differing from previous studies assuming a relationship between ethnocentrism and consumers' behaviour we test the same hypothesis for farmers' choices about the production practices. In the next paragraph, we will explain the methodology, in the section 3 the results, and finally we will draw our conclusions.

Methodology

We drive a survey of 332 farmers in the Emilia-Romagna Region (organic, conventional and mixed producers) out of a sample of 874 initial selected individuals by a non-probabilistic sample (phone interviews, fax and e-mails). We outlined the survey instrument based on a literature review and qualitative analysis (focus group).

We run three logistic regressions. In the first regression, the dependant variable is a binary variable expressing the status of farmers (organic or non-organic agricultural production practices). In the second logistic regression, the dependant variable is a binary variable expressing the intention of farmers who adopt conventional and mixed (organic and conventional) methods of production or who adopted in the past organic methods of production to convert to organic farming. In the third logistic regression, the dependant variable is a binary variable expressing the intention of organic and mixed farmers to convert to conventional practices.

For each of the three logistic regressions we use the same set of independent variables. They can be summarised as variables concerning the social status, the characteristics of the organic farm, the motivational factors (economic, ideological, fashion and innovation attitude of farmers) the business constraints, the ethnocentrism and another group of heterogeneous variables which cannot easily included in a specific group such as the social pressure variables.

Our set of variables is very wide (about 70), therefore we use a principal components analysis to reduce the dimensionality of the motivational and the business constraints factors. We then use a stepwise forward procedure based on the Likelihood Ratio in order to select only the variables which are significant or which provide significance to the regression estimation. In the next section, we present the results.

Results and discussion

From our results, we can underline some interesting findings. To summarize we cite only the ones that seem to us more important. In the first regression (Table1) we underline that the probability to adopt organic practices is affected by ideological motivations such as the environmental protection, animal welfare and health care. Conversely, the adoption of organic practices is more limited when farmers show the perception to believe that organic farming introduction follows a fashion trend. Internal financial and technical farm resources and difficulties in creating associations and consortia among farmers are other factors, which represent an obstacle to the adoption of organic practices.

Tab. 1: Factors affecting the intention to convert to Organic Farming

Variables	B	S.E.	Wald	Df	Sig.	Exp(B)
Suitability of the territory towards organic practices			9,966	4	0,041**	
1= I disagree	-2,561	0,887	8,346	1	0,004***	0,077
2= I partially disagree	-0,332	0,547	0,370	1	0,543	0,717
3= Neither agree nor disagree;	-1,044	0,681	2,352	1	0,125	0,352
4= I partially agree	-0,096	0,532	0,032	1	0,857	0,909
Favourable opinions of relatives and friends on OF			11,477	4	0,022**	
1= I disagree	-1,123	0,921	1,488	1	0,223	0,325
2= I partially disagree	-1,074	0,690	2,425	1	0,119	0,342
3= Neither agree nor disagree;	-0,922	0,651	2,006	1	0,157	0,398
4= I partially agree	0,698	0,509	1,882	1	0,170	2,009
Farm size (hectares)	-0,004	0,002	2,900	1	0,089*	0,996
Personal satisfaction			11,574	3	0,009***	
1= very satisfied	-1,370	1,048	1,709	1	0,191	0,254
2= satisfied	0,013	1,001	0,000	1	0,989	1,014
3= not satisfied	-1,365	1,142	1,429	1	0,232	0,255
Farm typology			5,248	2	0,073*	
2= Mixed (conventional and organic)	1,599	0,739	4,685	1	0,030**	4,950
3= Conventional	0,842	0,697	1,460	1	0,227	2,321
OA is only a fashion	-0,354	0,200	3,134	1	0,077*	0,702
Motivations linked to farm's characteristics	0,414	0,218	3,619	1	0,057*	1,513
Problems related to the certification system	-0,498	0,203	6,014	1	0,014**	0,607

Logistic regression. Dependant variable: Intention to convert to organic farming (1) vs. no intention (0). The sub-sample is composed by conventional, mixed and formerly organic farmers. ***p-value ≤ 0,01;**p-value ≤ 0,05; *p-value ≤ 0,10.

In the second regression (we omit the data for the sake of brevity), we focus specifically on conventional farmers, farmers who adopt a mixed strategy (organic and non-organic), or who used organic practices in the past. In this sub-sample, the management skills of farmers and in particular their attitude towards innovation influence adoption or rejection of organic methods and they are limited by the bureaucratic procedures concerning the certification system. Social pressures (opinion leaders and family opinions) could also play a role in inducing the conversion towards organic practices.

In the third regression, we find that low education methods are relevant in explaining future farmers' behaviours of organic farmers intended to leave organic practices and to adopt conventional practices.Finally, if we focus on the variables expressing local origins we find a set of interesting results. The variable representing ethnocentrism is not significant in all the three regressions. The variables representing the necessity to create a local origin label for organic products and a generic appropriateness of origin territory to organise organic methods of production are significant in the first and in the second regression.

Conclusions

In our paper we investigate by discrete choice models the role of a wide set of factors on the behaviours and intentions of farmers towards agricultural methods of production. We find that a set of variables referring to the social and economic condition, which the past literature identified as relevant, are significant in our study. However, the specific contribution of our paper is that we investigate the role of local origin issues as driving force for the adoption of agricultural practices. In particular, we investigate the impact of ethnocentrism and origin labels. We find that ethnocentrism is not relevant in explaining organic farming adoption, but one of the reason for which farmers do not convert to organic farming is that they feel that laws and appropriate labels do not protect the local origin of organic products. We deem this is an important policy implication. The local origin issue is not important to stimulate organic farming if we consider subjective and personal beliefs, but is important in terms of rules and at institutional level. The interesting policy insight is that policy makers should produce the appropriate laws in order to valorise local origin of food. Strategies aimed at implementing opportune origin labels together with organic labels could represent the right policy tool.

Acknowledgements

The authors acknowledge the support of the RISBIO project, funded by the Italian Ministry of Agricultural, Food, and Forestry Policies.

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An integrated approach project for the revaluation of a traditional sourdough bread production chain

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Key words: wheat, sourdough bread, organic farming, old and new varieties, sensory evaluation.

Abstract

The influence of organic and conventional farming systems on the performance of a panel of old and modern Italian bread wheat varieties has been evaluated, with the aim to individuate an agronomic protocol suitable for the production of a sourdough bread traditionally prepared in a hill zone of Emilia-Romagna. The agronomic and technological characterisation of the wheat samples obtained in organic and conventional farming conditions has been done and the sensorial qualities of the sourdough bread obtained have been evaluated.

Introduction

Several types of traditional Italian bread, that have in common a long-time, sourdough fermentation step, are now re-discovered due to their peculiar nutritional and qualitative traits in comparison with bakery products obtained with breadmaking protocols based on the use of selected yeast and shorter fermentation step. Sourdough fermentation has in fact several documented effects on aroma improvement, delayed firmness and staling, increasing mineral bioavailability and vitamin content and lowering the glycemic response. Moreover, it is well known that a wide spectrum of variability for breadmaking properties exists not only at cereal species level, but even at variety level. The influence of cultivars on technological properties, sensory profile and staling rate has been investigated for durum wheat, einkorn, bread wheat. The bread production is also influenced by growth location, by type of soil and climate and by year of harvest. Moreover, quality for a foodstuff is defined by Peri (2006) as “fitness for consumption”, a complex system of both material and immaterial products requirements that collects safety, nutritional, sensory, guarantee and ethical requirements.

Starting from these remarks, in our project a panel of old and modern Italian bread wheat varieties have been evaluated, through a multi-disciplinary approach, for the production of a sourdough bread traditionally prepared in a hill zone of Emilia-Romagna. The aim of the project has therefore been directed to the revaluation of a low-input cereal production system for this zone, in which several organic farms are active.

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Materials and methods

Starting from previous evaluation work on agronomic, technological and sensorial characteristics of a panel of old and modern bread wheat varieties, the three old varieties Autonomia B, Risciola and Terminillo, together with the modern variety Soissons, has been selected for further studies directed to the individuation of a fertilization protocol suitable for the hill zone of Pellegrino Parmense (Emilia-Romagna, Italy). The bread wheat varieties were sown in a two-years trial, in organic and conventional farms. Two different levels of nitrogen fertilization and a not-fertilized control have been compared (Table 1). Agronomic traits and resistance to biotic and abiotic stress were evaluated for all the samples. The deoxynivalenol content of all bread wheat samples was determined by a commercially available enzyme immunoassay (RIDASCREEN TM FAST DON, R-Biopharm GmbH, Germany).The technological properties of all the samples were evaluated determining protein content and alveographic indices. The sensory evaluation of the sourdough bread prepared from the different samples was done by two independent groups of assessors. The sensory variables taken into account are referred to visual characteristics (outside and inside colours, rusticity, size, crust), aroma, taste, flavour and texture (both of bread and crumbs) attributes.

Tab. 1: Agronomic and qualitative characteristics of the four varieties evaluated in a two years trial.

	ORGANIC FARM					CONVENZIONAL FARM					
	2006			2007		2006				2007	
Preceeding crop	alfa alfa			alfa alfa		sorghum				alfa alfa	
	Barlanda (DPI= 46 Kg/ha of N)			Barlanda (DPI= 41 Kg/ha of N)		Ammonium nitrate (DPI= 167 Kg/ha of N)				Ammonium nitrate (DPI= 50 Kg/ha of N)	
DRESSING	Production (13% of m.)	W per hectolitre	Fusarium head blight	Production (13% of m.)	W per hectolitre	Production (13% of m.)	W per hectolitre	Powdery mildew	Leaf rust	Production (13% of m.)	W per hectolitre
	t/ha	kg/hl	heads/m²	t/ha	kg/hl	t/ha	kg/hl	(0-9)	(0-9)	t/ha	kg/hl
Test	3.90	79.75	0.65	2.40	74.63	3.40 C	80.37	0.00	0.00	3.35	73.53
DPI	3.83	79.47	0.43	2.83	74.06	4.75 A	79.15	0.29	0.21	3.50	73.36
50% DPI	4.48	80.65	0.67	2.55	75.44	4.24 B	79.81	0.08	0.13	3.37	73.62
Significance	n.s.	n.s.	n.s.	n.s.	n.s.	***	n.s.			n.s.	n.s.
CULTIVAR											
Soissons	4.29 B	77.24 C	0.64 A	3.13 A	73.55	4.45 A	80.14 A	0.00	0.11	4.04 A	73.55
Autonomia B	4.11 B	81.72 A	0.42 B	2.26 C	76.75	3.80 B	80.89 A	0.11	0.17		
Risciola	3.26 C	81.40 A	0.57 A	2.30 C	74.03	3.23 C	79.99 A	0.20	0.17	2.41 C	73.53
Terminillo	4.74 A	79.47 B	0.73 A	2.72 B	74.49	3.80 B	77.96 B	0.11	0.00	2.87 B	73.43
Significance	***	**	*	***	n.s.	***	***			***	n.s.
CULTIVAR x DRESSING											
Significance	n.s.	n.s.	n.s.	***	n.s.	***	n.s.			n.s.	n.s.
Means	4.10	79.96	0.59	2.60	74.71	3.82	79.74			3.37	73.50
CV(%)	10.06	2.10	39.31	7.49	4.07	7.90	1.93			11.86	3.13

Results

In table 1 are reported some of the agronomic and qualitative data obtained when the four wheat varieties are grown in different environments with three different level of fertilization during a two years trial. The two years of trial were very different from a meteorological point of view. In fact, during 2006 the autumn was very rainy, during the winter there was snow coverage and during the spring low temperatures were registered. On the contrary, in 2007 the temperatures never fall below 0°C and the rains were limited.

The presence of Fusarium Head Blight and of mycotoxins like deoxynivalenol (DON), that are of great relevance from a safety point of view were investigated in all bread wheat samples. None of the genotypes was found to be heavily affected by Fusarium nor contaminated with DON. Only very few samples have shown symptoms of infection from powdery mildew and leaf rust (Table 1). The yield productions were different, depending from the year, from the treatments and from the genotypes (see Table 1). As expected, the modern variety Soissons gave the best yield results, followed by Terminillo. The weight per hectolitre was very high in 2006 for all the varieties, whereas in 2007 it was probably affected by the climate. In Figure 1 are reported the results obtained after sensory evaluation of sourdough breads prepared from a set of monovarietal flours derived from Autonomia B, Terminillo, Soisson and Risciola varieties grown in organic and conventional farming. For this experiment, it was taken into consideration the varieties grown in 2006 both in conventional (fertilization with ammonium nitrate, 167 Kg/he of N) and organic (fertilization with borlande, 46 Kg/he of N) farming. The bread samples were evaluated for the ten characteristics reported in Materials and Methods, giving to the samples one point for each trait exceeding the mean of all samples.

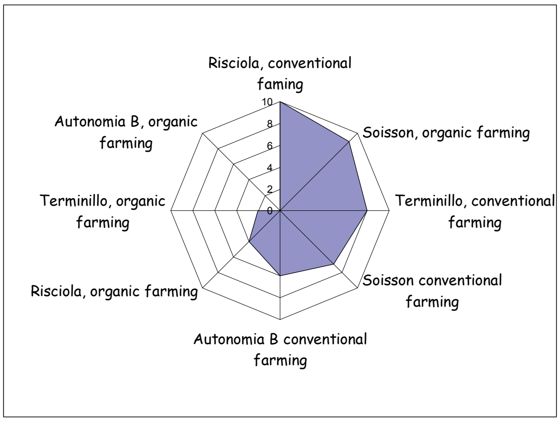

Figure 1: Scores obtained by the sourdough bread samples prepared from flours of the four wheat varieties grown under organic and conventional farming.

Discussion and conclusions

In our project, a multidisciplinary approach has been applied with the aim to revaluate a traditional sourdough bread preparation chain. Moreover, because organic farming system in comparison with conventional one has been found to have significant effect on sensory quality of yeast fermented bread (Kihlberg et al. 2004; Kihlberg et al. 2006; Annett et al., 2007), we have evaluated the farming effect and the different level of fertilization on agronomic and technological characteristics of old and modern bread wheat varieties. We have found significant effects of year, of genotype, of the preceeding crop and of farming system on agronomic performance of the wheat varieties and on their technological traits. Preliminary results obtained after sensory evaluation of monovarietal sourdough breads prepared from wheat samples grown under organic and farming conditions, indicate the old variety Risciola and the modern one Soisson as the most appreciated. As final results, this project, taking into account several genetic, farming and technological aspects, can help in delineating a sustainable production chain for a traditional italian food.

Acknowledgments

This work was financially supported by Emilia-Romagna project "VALORIZZAZIONE FILIERA PANE DI MONTAGNA"

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The impact of mycorrhizal symbiosis on tomato fruit quality

Salvioli, A.[1], Novero M.[1], Lacourt, I.[2] & Bonfante, P.[1]

Key words: Tomato, AM fungi, Mycorrhizas, fruit productivity, real-time RT-PCR

Abstract

The project investigates the potential impact of mycorrhizal fungi, which have been acknowledged as a new class of bio-fertilizers, on the quality of vegetables. To verify such a hypothesis, we selected tomato (Solanum lycopersicum) as a model plant to examine whether the beneficial effects of mycorrhizal fungi on plant development may be extended to some qualitative fruit features. As a second step, five genes related to carotenoid biosynthesis and volatile compounds were selected. Their expression was investigated through a real-time RT-PCR comparison of mycorrhized and non-mycorrhized plants.

Introduction

Arbuscular mycorrhizal fungi (AMF) represent a key-component of the rhizosphere, since they form a mutualistic association with the roots of 90% of land plants. They are known to carry out many ecosystem functions such as improvement of plant establishment and growth, enhancement of nutrient uptake and plant protection against biotic and abiotic stresses (Smith & Read, 1997). For these reasons, they are considered to play a fundamental role in natural as well as agricultural ecosystems together with other soil microorganisms, opening new employment perspectives in the frame of a low-input agriculture.

In order to check the hypothesis that in addition to an improved mineral nutrition AM fungi also benefit their host plants by influencing fruit traits, we selected tomato (*Solanum lycopersicum*) as a model. We first evaluated plant growth parameters and mineral content in order to verify whether tomato responds to AM fungi by stimulating its vegetative growth, phosphate and nitrogen accumulation and fruit productivity. Then the potential impact of AM fungi on fruit quality was assessed by considering carotenoid biosynthesis, a process which is strictly regulated during fruit development and ripening. As a second qualitative trait, the complex mixture of volatile and non volatile compounds that contribute to the overall aroma and taste of the fruit was considered. Real-time RT-PCR analysis was used to compare the expression of five genes related to carotenoids biosynthesis and volatile compounds in tomato fruit investigating mycorrhized versus non-mycorrhized plants.

Materials and methods

Germinating seedlings of *S. lycopersicum* cv. Pearson were inoculated with the AM fungus *Glomus mosseae* BEG12 purchased from Biorize (Dijon, France). The growth experiment consisted of 14 pots filled with sterilized quartz sand mixed with the *G. mosseae* inoculum (30% w/w) for the myc condition plants (seven pots). The plants

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were placed in a growth chamber and fertilized once a week with a modified Long-Ashton nutrient solution. After 90 days the roots were sampled and the growth parameters were evaluated as well as the P and N content. The shoots were frozen and ground to a fine powder which was sent to Floramo (Rocca de' Baldi CN) for the chemical analysis. The N content was expressed in concentration %P/P while the P content was expressed as mg of P for each Kg of biomass. In a second experiment, 20 *S. lycopersicum* cv Micro-Tom plants were brought to fruit production.

For the expression analysis, samples of fruit pericarps from myc and non myc tomato plants were ground to a fine powder in liquid N. Total RNA extraction was performed with a modified C-tab method.

For conventional and real-time RT-PCR, the selected genes were targeted with primers newly designed, except for primers LeF1/LeR2 (Botella-Pavia *et al*., 2004). The following genes were selected for expression analysis: deoxyxylulose 5-phosphate synthase gene (DXS), hydroxymethylbutenyl diphosphate reductase gene (HDR), phytoene synthase gene (PSY1), the carotenoid cleavage dioxygenase gene LeCDD1B and the lypoxygenase gene loxC.

First single-strand cDNA was obtained with the SuperscriptII reverse transcriptase kit (Invitrogen). Real-time RT-PCR reactions were performed with specific oligonucleotide primers (0.3 µM each), according to the conditions described by Siciliano *et al.* (2007).

Results

Impact of AM fungi on plant development

To verify the impact of the AM fungus on growth performance, mycorrhized and control plants were harvested and the fresh weight of shoot and root was evaluated. Mycorrhized plants displayed higher shoots and a wider root apparatus (Fig 1).

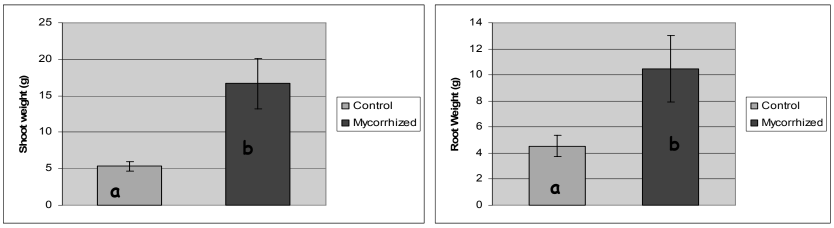

Figure 1: Shoot and root weight evaluation. Different letters indicate significantly different values according to the Krukall–Wallis test of variance (P < 0.05).

To evaluate whether the increase in biomass was also coupled to a higher accumulation of mineral elements, the P and N content was evaluated. These elements are crucial for AM symbiosis, which is characterized by a nutrient exchange between the symbiotic partners.

No significant differences were found in N content, while a significant variation was detected when P was evaluated: the mycorrhized plants had the highest amount of P in their tissues.

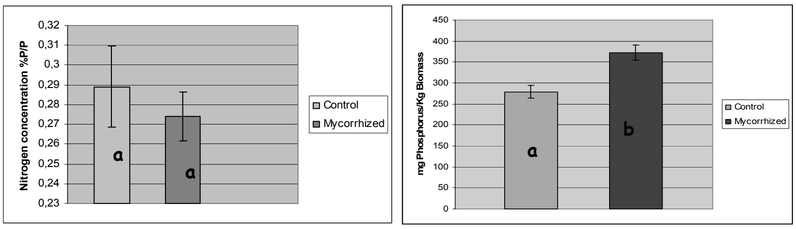

Figure 2: Nitrogen and Phosphorus content. Different letters indicate significantly different values according to the Krukall–Wallis test of variance ($P < 0.05$).

Productivity of tomato plants

The first fruit was obtained for the myc condition 76 days after the sowing, while in the control condition, the first fruit was obtained 10 days later. The fruit was harvested from all the 10 inoculated plants, with an average productivity of 5.5 pieces of fruit per plant, while 9 out of 10 non mycorrhizal plants were productive, with an average of 2.2 fruit per plant. The inoculated plants produced fruit for a longer period (80 days of productivity, compared to 35 days for the control plants). Six months after seeding, 10 myc plants and 2 control plants were still viable.

Real-time RT-PCR assays

Real-time RT-PCR experiments were performed using cDNA from three independent biological replicates for each condition. The five genes were targeted in individual real-time assays. In all the cases a good amplification signal was detected, with threshold cycles (Cts) ranging from 16 to 21. The PCR efficiencies were comparable, and ranged from 98.1% to 105.6%. The Cts values obtained for the investigated genes were normalized by comparing them with the Cts obtained for the calibration genes (actin1 and 18S rDNA), according to the 'comparative threshold cycle' method. In all cases no significant differential expression was detected between the inoculated and control condition, with a maximal standard deviation of 0,3 on the mean values.

Discussion and perspectives

Here, we have shown that *G. mosseae* positively affects the growth development of tomato plants, the P content and fruit production. Inoculated tomato plants produced more fruit and their productive period was remarkably longer. This new finding can be explained thanks to the improved mineral nutrition, which is shown by the higher P content. However, a direct effect of mycorrhizal status on fruit development cannot be ruled out.

A number of plant carotenoids and derived compounds have an important nutritional value according to their activity as pro-vitamin A and their ability to act as antioxidants that help to prevent some types of human cancer and degenerative diseases (Fraser and Bramley, 2004). We monitored the expression in tomato fruit of two key genes of the MEP pathway, DXS and HDR, whose activity has been shown to be limiting for carotenoid biosynthesis during tomato fruit ripening (Lois *et al*., 2000; Botella-Pavia *et al*., 2004). At the same time, we analyzed the expression of the phytoene synthase gene (PSY1), which represents the first committed step of carotenoid biosynthesis in the strict sense (Fraser and Bramley, 2004). A significant accumulation of the PSY1 transcript was observed in ripening fruit, reaching the highest level at the orange stage (Lois *et al*., 2000). Given that fruit aroma and taste is considered an important feature for good tomato quality (Baldwin *et al*., 2000), we targeted two genes involved in tomato aroma composition: the first one (loxC) is involved in the generation of fatty acid-derived C6 compounds (Chen *et al.*, 2004), while the second is involved in the formation of volatile terpenoids from carotenoids (Simkin *et al*., 2004).

We harvested the tomato fruit as the colour turned from yellow to orange, according to Gillaspy and colleagues (1993), who reported that carotenoid accumulation is concomitant with the fist visible colour change in fruit. Under our experimental conditions, all the target genes were well expressed in the considered developmental stage, confirming published data. However, the five genes considered did not reveal a differential expression between the mycorrhized and control conditions. Two reasons can be given to explain the result: the selected genes do not represent a target of the mycorrhizal impact, or such an effect is not evident at the analyzed developmental stage. Alternatively, mycorrhizal symbiosis does not influence the metabolic pathways here considered.

Acknowledgments

The fellowship of A.S. and a part of the investigation were supported by The Proteinn project (for information: http://www.corep.it/innovazione/proteinn.htm), managed by the COREP consortium (http://www.corep.it/index.html).

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New approaches in consumer research

Information Acquisition Behaviour of Fair-Trade Coffee Consumers – a Survey by Means of an Information Display Matrix

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Key words: Market research, marketing, information acquisition behaviour

Abstract

Fair-trade has grown into a noteworthy market segment. As a result, an increasing number of market players have emerged, each trying to communicate their own focal point in criteria and standards. However, the relative relevance of different criteria for the consumer remains unclear. This study explores the assessment of criteria in the choice of the most important fair-trade product, coffee, by tracing the information acquisition behaviour using an Information Display Matrix method. Special focus is given to organic production. Results serve as recommendations for those involved in the development of the organic fair-trade market.

Introduction

Embedded in a broader trend of demands for additional characteristics of products, there is a trend toward so-called 'ethical consumerism' (Carrigan et al. 2004, p. 401ff.). 'Fair' (see EFTA 2006 for a definition) and 'organic' principles of production are increasingly used jointly on this account, as reflected by the fact, for example, that. 64% of the products labelled 'Transfair', the leading seal for fair-trade products in Germany, already also bear the organic seal (TransFair e.V./Rugmark 2006, p. 7). A deeper understanding of the fair-trade market and its consumers is therefore of importance for organic market players. Since the beginning of the fair-trade movement, many fair-trade initiatives have been established, and in their wake a high number of criteria and standards have been formulated concerning the production of goods. Each market player has a different focal point and chooses a different way of communicating and phrasing the product-related information. Thus, the search for information and the purchasing decision are complicated for the consumer (Lübke and Abel, 2005, p. 562f.). The relative relevance of different criteria in the eyes of the consumer, and the phrasing they prefer, have not yet been sufficiently examined. This study aims at resolving these questions with regard to fair-trade coffee by means of the Information Display Matrix method (IDM).

Materials and methods

The IDM is a tool for research in consumer information and decision-making behaviour that is used to identify the cognitive processes underlying search, judgement, and choice. The method enables the detailed analysis of the kind, sequence, and amount of information sought, as well as the duration and structure of the information acquisition phase. Relevant product-related criteria and their relative importance for the purchase decision can be identified. This is done based on the scientifically

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substantiated assumption that earlier and more frequently acquired information is more important for the choice than information acquired at a later stage and less frequently (Mühlbacher and Kirchler 2003, p. 147ff.). The IDM method came into use in the 1980s but since then its value and opportunities have been greatly enhanced by personal computers (Jacoby et al. 1987). Previous studies of fair-trade consumers mostly used standardised questionnaires with choice proportions and ratings or Conjoint Analysis (Ottowitz 1997; De Pelsmacker et al. 2005). The advantage of an IDM is that the test subjects do not immediately realise the objective of the survey and that they interact just with the computer. In this sense the answers are less biased by social desirability or an interviewer effect.

In an IDM, the information is presented in the form of a matrix with the product attributes given on the vertical axes and the alternative product stimuli on the horizontal axis. The varying attributes corresponding to the respective product stimuli are hidden in blank fields. If the person clicks on a field, the information appears in a pop-up. Only one field at a time can be opened. As the test person explores the matrix, s/he obtains the information needed for her/his purchase decision in order to decide on one of the alternative product stimuli. The computer programme records every step of the information acquisition phase and the choice itself. This is linked with the data gathered by a subsequent questionnaire and stored under a randomly assigned number for each individual.

For our study, 150 consumers were interviewed in two German cities. The sample consisted of 90 supermarket customers and 60 customers of so-called 'one-world' shops, interviewed at the point of sale. The alternative product stimuli were standardised in package size and type and continent of origin. All 500 g packages of Latin-American coffee were fair-traded. The stimuli varied in six attributes, which are: 'product price', 'production system' (conventional/organic), 'environmental standards' in the coffee production, 'price premium' as a benefit to the coffee producers (the 'fair component of price'), 'origin' of the product (with regard to geographical region or kind of producer organisation), and 'child protection' in the coffee production stage. The order of the alternative product stimuli and attributes was randomised to avoid sequence effects. In addition to the computerised IDM, the test subjects took part in a short face-to-face interview. The interview helps in understanding the results of the information acquisition behaviour and choice against each individual's background.

Results

Three measures were used to explain the information acquisition behaviour of consumers and their product choice. In the following, main results of the survey are presented. The number of * indicates the level significance ($^p = p \leq 0.1$; * = $p \leq 0.05$; ** = $p \leq 0.01$; *** = $p \leq 0.001$).

The '**importance**' of an attribute is operationalised through three indicating variables: 1) first accession incident being a field showing details about this attribute; 2) total number of accession incidents per attribute; and 3) number of repeated accession incidents per attribute. All three variables indicate that persons in the total sample expressed a significantly different importance for the attributes (Cochran Q 22.4***, χ^2 121.9*** and χ^2 50.1***, respectively). The ranking in relative importance of the attributes differs slightly, but the comparison in table 1 shows that the attributes 'production system' and 'price premium' are most important, 'child protection' and 'product price' less so, and 'environmental standards' and 'origin' least important for both the supermarket consumers and those in the one-world shop.

Tab. 1: Importance of attributes for consumers in supermarkets versus one-world-shops expressed through three indicators

Attribute	Supermarket			One-world shop		
	First accession (%)	Mean accession		First accession (%)	Mean accession	
		total	repeated		total	repeated
Production system	25.5%	5.2	1.8	33.3%	6.0	2.6
Price premium	16.7%	5.2	2.2	25.0%	6.4	3.7
Child protection	20.0%	4.2	1.4	10.0%	4.9	2.3
Product price	18.9%	4.6	1.7	6.7%	5.0	2.2
Environmental standards	10.0%	3	0.7	5.0%	4.3	1.8
Origin	8.9%	2.8	0.8	20.0%	3.8	1.5
All attributes	100%	24.9	8.7	100%	30.3	14.0

Analysing the differences in importance between the two groups in table 1, as revealed by the indicator first accession, 'origin' is more important for one-world-shop consumers (χ^2 3.8*). The attributes 'child protection' and 'product price' are more important for supermarket consumers (χ^2 2.7^p and 4.5* respectively). Additionally, the total sample was split into the groups of buyers and non-buyers of an organic stimulus. Unsurprisingly, 'production system' was significantly more often accessed as a first attribute by those who chose organic (χ^2 6.4*). Persons choosing conventional products accessed 'product price' significantly more often as a first attribute (χ^2 8.0*).

The '**preference**' for an attribute is operationalised by share of choice decisions for a product with this criterion specification contrasted with the expected probability share. As 80% of the participants chose an organic product out of the six product stimuli, it is not surprising that the preference for organic products is highly significant (χ^2 54***). Organic products were preferred, even though the organic products had a higher price. Meanwhile, a preference for a more precise or tangible phrasing, as had been hypothesised, is not significant for any of the remaining attributes. The precise or tangible phrasing used for the attribute 'environmental standards' was, for example, 'shade-grown coffee cultivated in mixed cropping in order to preserve biological diversity', while the inexact phrasing was 'cultivation following fixed environmental standards'.

'**Extensiveness**' is measured by 1) duration of the information acquisition phase in minutes; 2) absolute number of accession incidents in total; and 3) percentage of the so-called submatrix (i.e. number of attributes accessed at least once, multiplied by the number of product stimuli accessed at least once) with regard to the matrix. Customers of one-world shops tended to conduct a more extensive information search, as they spent more time than customers of supermarkets (Mann-Whitney-U 2191*). The two groups, however, showed no significant differences with regard to the other two indicators. Results with regard to the average of all three measures are as follows: 3) 2.58 (2.95) minutes, 2) 24.9 (30.3) and 3) 84% (87%) for supermarkets (one-world shops). Slight differences in the time spent acquiring information may be due to the fact that the duration is longer when the one-world-shop customer is female and that the one-world-shop customers were mainly women. Apart from that, the two groups did not differ with regard to the remaining sociodemographic characteristics (age, presence of children in the household, household size, and income).

In order to contrast the two methodological approaches, the ranking of relative importance as derived from the IDM (mean total number of accession) was compared to the order of importance as derived from the questionnaire (mean rank given). It is noteworthy that while all other attributes remain in the same order, the position of 'product price' is third in importance in the computerised IDM but only fifth in the face-to-face interview. Thus, the rating of the attribute 'price' in the interview was most likely distorted by answers expressing social desirability.

Discussion and Conclusion

The IDM has proven to be an adequate method for measuring the information acquisition behaviour of consumers for goods that are not self-explanatory, such as fair-trade products. Compared with simple face-to-face interviews, the results of the IDM seem to be more realistic, especially with regard to the price. The study has also shown that the combination of the attributes 'organic' and 'fair' is greatly preferred by fair-trade consumers, therefore backing the recent trend. Only a smaller segment of consumers seems to remain who favour fair-trade without the additional organic benefit. The findings indicate that consumers in one-world shops differ from supermarket consumers in their information acquisition behaviour, therefore suggesting the usefulness of a separate communication strategy. Unlike what was expected, a more precise and tangible phrasing of attributes was not preferred, although the criticism that the phrasings on fair-trade products are too complicated is often discussed. Further research should investigate the reasons for these findings.

Acknowledgments

We are grateful to Mrs. Nina Berner for conducting the empirical survey.

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Evaluating trust in organic quality marks: a network approach using laddering data

Gambelli, D.[1] & Naspetti, S.[2]

Key words: trust-building, laddering, network analysis, consumer behaviour

Abstract

A low level of information affects trust in organic quality in Italy. Since organic brands and labels credibility, depends on trust relationships that consumers perceive, it is crucial to understand which kind of relations are more relevant and which of them could have a positive or negative effect in the long-term. The purpose of this study is to examine trust relationship related to buying organic products, to better understand the consumer decision-making process and trust-builders inside the organic channel, using an innovative network approach based on laddering analysis.

Introduction

Marks as forms of quality signals to consumers – previously analysed using Means-end chain theory and laddering data (Naspetti and Zanoli, 2005), are investigated using a Means End Chain (MEC) approach. The study examines over 2124 sentences, structured into 56 codes, or variables, and attempts to determine how trust is built and how it affects other relationship outcomes (Zanoli et al., 2004). The relationships among consumers concepts are analysed using a social network approach (SNA) (Wassermann and Faust, 1994, and Bagozzi et al., 1996, for a SNA application to MEC), aiming to individuate sets of closely related concepts and to assess their relative importance in the consumers' trust cognitive process. Switching from a qualitative study to a quantitative one improved the comprehension of means-end relations and shed a light on the antecedents and/or consequences of trust in organic quality signs.

Materials and methods

The objective of MEC theory is to understand what makes products personally relevant to consumers by modelling the perceived relationships between a product (defined as a bundle of attributes) and the consumer herself (regarded as holder of values). Naspetti and Zanoli, (2005) extend the notion of means-end chain structures of consumers' product knowledge to symbolic signs such as quality marks. They used the soft-laddering technique, which is used to construct MEC, in order to identify relations between consumers and products mediated by the benefits offered from any hypothetical organic quality mark. This methodology has been developed as a tool to discover what personally motivates consumers to have trust in organic products. Approximately 104 in-depth interviews have been carried out in Italy as part of a larger EU-funded project (OMIARD). In order to identify their cognitive structures, consumers

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were asked to imagine a quality sign, that would give them confidence in the organic origin of the product and to link these motivations to product attributes (A) and their consequences (C) in order to reveal their underlying beliefs, feelings and desired ends (Values – V). MecAnalyst+ package was used to code consumers interviews, to derive the implication matrices and the relevant Hierarchical Value Maps (HVMs). The implication matrix – a square matrix with a size reflecting the number of elements mentioned by the respondents (56) – which reports the frequency of the direct connections between single categories (A, C, V, referred to as nodes in what follows), was used as an adjaciency matrix, which is the basis for the social network approach. In particular the laddering outcome matrix may be interpreted as a set of relational data. Relations are not the properties of nodes but of system of nodes; these relations connect pairs of nodes into larger relational system. The qualitative information raised by the laddering technique may be analysed via quantitative and statistical counts of relations. The adjacency matrix out-coming from the laddering is a valued and not symmetric one, the values being the absolute frequencies of relations occurring between each pair of nodes. The main interests for the purpose of data interpretation are: a)the individuation of the nodes that show the highest "importance" within the network, and b) the individuation of significant set of nodes that may eventually be considered as a structured subset of nodes within the general network of connection between A, C, and V. Concerning the first aspect, standard network **centrality measures** have been used: degree centrality, betweenness centrality and closeness centrality. The degree of a node is the number of nodes to which a node is directly connected. Degree centrality is a measure of "local centrality" as is a measure of how well a node is connected within its local environment. Beside degree centrality, betweenness centrality provides information about the extent to which a particular node lies between other nodes: in fact nodes with low degree centrality may however play a crucial role in connecting different subsets of nodes, hence playing an important "bridging" and role within the network. Betweenness centrality requires however the network to be symmetric, hence considers only the presence of a connection between two nodes regardless the direction of relations. The issue of laddering data symmetrisation is a delicate one and has been considered in (see Geiskens et al., 1998). For our purposes (i.e. individuate the "role position" of nodes arising from laddering analysis) indicators hinging upon the assumption of relational symmetry may provide useful information as well, integrating the results based on original directed data. Finally closeness centrality is an indicator of how close a node is with respect to all other nodes; it is therefore a measure of "global centrality", and a node can be considered as central if it lies within short distance from many other points, the distance being defined as the length of the shortest path connecting nodes. In this paper is used to check for the actual hierarchic structure of the network. Concerning the second aspect, we have investigated the network using cliques analysis. Weak cliques analysis (i.e. a clique analysis ignoring the direction of links among nodes, have been used to individuate subset of nodes where every possible pair of nodes is directly connected, and such that these subset are not contained by any other clique. The concept of clique considers therefore group of nodes very strictly interconnected within the wider network. The network of laddering relationships has proved to be quite an interconnected one, and we decided to consider only cliques formed by at least 6 elements (quite a restrictive condition). All nodes indicated in table 1 are included in one or more cliques, hence confirming their active role in the choice process for organic products. We have tried to aggregate the cliques according to the nature of the nodes, and have accordingly defined labels that summarise their characteristics.

Results

SNA computation have been obtained with UCINET 6. Results for centrality measures are indicated in Tab. 1; in particular the node “have trust” assumes absolutely the most relevant position within the network of relations investigated. Results from closeness centrality analysis, not included in Tab 1 for space purposes, have shown that out degree closeness centrality is higher for attributes and lower for consequences and values, and vice versa for in degree closeness, hence confirming the actual vertical integration of the network in terms of attributes, consequences and values. Such a result can be partially confirmed by the proportionally higher scores of out-degree centrality for attributes, and in degree centrality for values.

Tab. 1: Centrality measures: nodes with higher scores

		Degree centrality		Between centrality
		out	in	
strict controls	A	√	√	
Info about place of origin	A	√		
info about label/control/standards	A	√		√
Info about product			√	√
Have trust	C	√	√	√
feel relaxed	C	√		
avoid worries/feel safe	C		√	
own health	V		√	

In Tab. 2 a summary of results from clique analysis is indicated, showing five main clusters of attributes, consequences and values variously organised as a clique of at least 6 components, and labelled according to their characteristics: the clique group labelled “Reassurance” is the one including the higher number of nodes. In other words concepts linked with the Reassurance issue are those more strictly interrelated within the more general network, hence forming a much cohesive subsystem and showing that a wide amount of the trust building process organic quality signs is much connected with such an aspect. This is particularly relevant as the number of nodes that could be classified as belonging to the “Reassurance” concept is not over-represented in our database. Again, the clique clusters confirm the hierarchic structure of the network, with an increase of abstractness of concept attributed from clique group 1 to 5.

Discussion

The results from SNA, substantially confirm the goodness of the qualitative MEC study hereby analysed, particularly the coding procedure, and the “vertical” structure of the model. The centrality of the “have trust” node was not unexpected (Tab.1). Firstly, because the cognitive study (MEC analyses) on quality signs shows the same unique nodal point (have trust), secondly, and more relevantly, because when deciding whether or not to buy organic products consumers usually mention the trust issue. The presence of a lot of aspect connected with the types of information to be placed on the label (tab.2) was also confirmed by the previous MEC study (Naspetti and Zanoli, 2005).

Tab. 2: Cliques clusters and node aggregation by clique membership

Clique group label	n. of cliques	Total n. of nodes included for each group label
Organic label	2	12
Look for health	3	18
Reassurance	8	48
Serenity	6	36
Feel good	1	6

The clique analysis has been particularly helpful in the individuation of subgroups of strictly connected nodes; furthermore these are organised in homogeneous groups according to the nature of the nodes they include. The resulting classification helps from one side to understand more clearly the essential factors affecting the trust building process, and may be a basis for a re-definition of more focussed analysis.

Conclusions

Network analysis can provide valuable support in interpreting and integrating information arising from laddering techniques, particularly in measuring in a consistent mathematic approach actual importance and role of different aspects (nodes) included in the laddering analysis. SNA may be considered as an useful diagnostic tool for standard MEC analysis and the integration between the two approaches shows a potential for further in depth analysis in the cognitive aspects of consumers behaviour. Since SNA emphasise the network nature of the cognitive structure and the role of single nodes and different types of relations between nodes, it is a valuable tool for implementing benefit-based market segmentation.

Acknowledgment

The authors kindly acknowledge funding from the EU - Commission within the project "Organic Market Initiatives and Rural Development"(OMIaRD). The paper is the sole responsibility of the authors and do not necessarily reflect the EU - Commission view.

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Identifying the gap between stated and actual buying behaviour on organic products based on consumer panel data

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Key words: Marketing research, consumer panel, consumer buying behaviour

Abstract

Evaluating the German demand for organic food in the majority of cases has been done by interviews, which are restricted by massive overestimation of consumers themselves. By using consumer panels, it is possible to survey actual consumer behaviour in combination with consumer attitudes and socio-demographic data and also by additionally requested consumers' stated buying behaviour. Such methodology enables exposure and quantification of the gap between stated and actual buying frequency. Also the dimension of conventional products bought by mistake, while intending to get organics, can be identified. These results may give considerations for prospective survey design and adjustment of marketing policy.

Introduction

Over the last few years the organic market in Germany has shown remarkable growth. Nearly all big supermarket chains and many conventional food processors offer organic products and competition between them increases. Thus, a professional marketing policy is necessary to survive in the market. However, market success also relies on information on relevant consumers' buying behaviour to adjust marketing efforts towards consumer demand. Researchers in consumers' behaviour usually face the problem that consumers tend to greatly overestimate their spending for organic food when approached in an interview survey (Fricke 1996, Michels et al. 2004).

Based on data of a special consumer panel for organic products in Germany, the objective of this contribution is to analyse and quantify the gap between stated and actual buying behaviour in the case of organic food including the problem of consumers' buying conventional food for organic by mistake. The results may give important information for designing prospective surveys and developing or adapting marketing strategies within the organic sector.

Material and Methods

The research is based on data of a household panel from the year 2003 in Germany. This panel run by the market research company Gesellschaft für Konsumforschung (GfK), was specially designed to collect data of private households' purchases of organic food and financed by Zentrale Markt- und Preisberichtstelle (ZMP) in Germany. Every three months, 5,000 representative German households took part in screenings. Selection criteria for participation in the panel were the declaration that the

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household used to buy organic food at least once a month and had bought a minimum of one organic product in the current or past month. Thus it was secured that only (stated) organic buyers took part in the panel and not persons who bought organic products without knowing or intending to. In context of the screening, panel households had to declare how often they normally buy organic products and what type of retail outlets in particular they use. The participating households alternated monthly within the panel. Hence, bias caused by extremely high purchases of a household was avoided. It could be achieved that more than 200 relevant households filled in a specially prepared diary on a monthly basis, listing all purchased organic products including brand, organic label, type of retail outlets, volume, price, certification number etc. Many plausibility checks were done to assure that the listed purchases were really done for organic products. So it was possible to evaluate the "organic buying behaviour", combined with the stated buying behaviour before participation on the panel and the households' socio-demographic data.

This paper focuses on two parts of a larger research project. The first part is to verify general differences between stated and actual buying frequency on organic products. In the second part we analyse the problem that consumers may have bought conventional products instead of the intended organic products but did not realise their mistake. As households had stated their buying frequency on retail outlets' level, we want to show the mix up of buying conventional instead of organic quality exemplarily in the case of direct marketing (farmers' markets and farm shops).

Results

To compare stated and actual buying frequencies, the latter were classified according to the stated classification within the screening questionnaire, as shown in Tab. 1. Observing the classified frequencies in a cross tabulation, the percentages of households' stated and actual buying frequencies are comparable.

Tab. 1: Comparison of stated and actual buying frequency (% of households)

	Self estimated buying frequency of households				
	"How often do you buy organic products?"				
Actual buying frequency	Once a month	Several times a month	Once a week	Several times a week	Actual overall
None	60	50	41	23	46
Once a month	15	12	9	4	11
Several times a month	15	19	19	12	17
Once a week	5	6	10	9	7
Several times a week	5	13	22	52	18
Total	100	100	100	100	100
Stated overall	19	42	28	11	100

Example for reading: 60% of participants who estimated that they bought organics once a month did not buy at all (actual buying frequency = none). But only **15**% of all households that stated they bought organics once a month really did. Of all organic-buyers **19**% stated that they bought organics once a month, but only **11**% really bought organics once a month (arrow).

Source: Own calculation

The percentage of non-buyers is shown in the first line of Tab. 1. A total of 46% of households did not buy organic products within a month although they stated doing so. The less the stated frequency in this group, the higher the percentage is of non-buyers, going up to 60% of the stated "once a month buyers". The inside columns of Tab. 1 show the actual buying frequencies as percentages of the stated ones. The highest consistency between stated and actual frequencies is identified within the "several times a week buyers"; 52% of households of this group estimated their buying frequency accurately. Comparing overall values of stated and actual frequencies (bottom line and right column), the stated percentages are considerably higher than the actual ones. An exception is the "several times a week group"; only 11% of households estimated that frequency, but 18% really did so. On the other hand however it is very astonishing that 23% of this group did not really buy organics once a month at all.

We want to widen the above presented results with respect to the problem of buying conventional food instead of organic by mistake. To get preferably differentiated outcomes, producers' marketing as a type of retail outlet was divided into farmers' markets and farm shops. Tab. 2 shows percentages of stated and real organic buying frequencies, also considering the part of non-organic purchases, differentiated into four frequency-groups. The stated behaviour with respect to farmers' markets is three times higher than it is really. Overall, nearly 46% stated but only 15% really bought at farmers' markets, whereas 6% bought conventional qualities assuming they were organic. At farm shops the gap between stated and actual behaviour is not that high. The overall part of conventional products however is very similar to organic products (both nearly 9%).

Tab. 2: Comparison of stated and actual buying frequency at farmers' weekly markets and shops including mistaken buying acts of non-organic products (%)

"How often do you buy organic products at **farmers' markets**?"				
Buying frequency in % of panel households	Stated	Actual		
		Total	Organic	Non-Organic
Once a month	9.3	6.6	4.4	2.8
Several times a month	14.4	5.8	3.6	2.2
Once a week	18.9	1.6	0.9	0.7
Several times a week	2.0	0.9	0.5	0.4
Households overall	45.5	15.0	9.4	6.1
"How often do you buy organic products in **farm shops**?"				
Once a month	6.6	6.8	3.6	3.4
Several times a month	8.0	6.0	2.8	3.2
Once a week	7.9	2.6	1.4	1.1
Several times a week	1.6	1.8	0.7	1.1
Households overall	24.1	17.1	8.5	8.9

Source: Own calculation

The problem of purchasing conventional products by mistake, whilst intending to get organic products at producers' direct marketing channels, has also been analysed on product-level and considering socio-demographic parameters. The highest rates have been located with eggs (66%) and beef (54%), but also potatoes (45%), bread (35%)

and milk (29%) have been mixed up by high percentages. With all retail outlets and households this averages by 12%, whereas in producers' direct marketing by 34%. Especially households of older consumers without children mixed up conventional with organic products.

Discussion and Conclusions

The analysis of consumer panel data points out a big gap between stated and actual buying behaviour in the case of organic food. The results challenge the validity of the mass of interview-based surveys on the organic market. Whether social desirability or personal ignorance (Bryman 2004) about organic products are responsible for the gap between survey results and reality, is not to be answered by our study. However this would be worth attempting in further research studies and requires methodological enhancements in combining panel research and qualitative approaches to ascertain consumers' insights whilst measuring their buying behaviour. The results should be regarded when interpreting and designing consumer surveys on buying organic products. They lead us to emphasise the importance of panel research combined on household level with interview surveys to highlight the background of consumer behaviour in the case of organic food.

A gap between stated and actual buying frequencies and the high percentage of mixing up buying conventional instead of organic quality is one part of discovering discrepancy between statement and behaviour. Also the expressed willingness to pay diverges from the actual spending, as results of a Danish consumer panel show (Millock et al. 2002). To survey actual buying behaviour in the case of organic food, methods of panel research seem to be irreplaceable. The results provide the possibility to "calibrate" and enhance interview-based surveys and methods, which are necessary, as panel surveys are very costly. However methodical approaches to improve and further develop interview design (Groves and Heeringa 2006) should be considered to solve the problem of discrepancies between stated and actual buying behaviour regarding organic food.

Acknowledgements

We are indebted to the Bundesanstalt für Landwirtschaft und Ernährung which financed this research within the Bundesprogramm Ökologischer Landbau.

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Organic Certification and Livelihood

Impact of the adoption of participatory guarantee systems (PGS) for organic certification for small farmers in developing countries: the case of Rede Ecovida in Brasil

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Key words: organic certification, transaction costs, participatory guarantee systems, developing countries, local markets

Abstract

Different types of organic certification have been developed to overcome the problem of its relatively high cost for small organic farmers in developing countries. Among these the participatory guarantee systems (PGS) for organic certification, which does not involve a third party certification body. Providing a theoretical framework able to define the characteristics of PGS influencing its role in promoting local market development and communities social cohesion, as well as the access to export markets, is the aim of this paper. The level of formalism in the relationship among the stakeholders involved in the PGS, its interaction with the flexibility and the scope of their relationship, social control as a substitute for a third party certification body, are considered as influencing factors. A case study is provided: a survey among organic farmers involved in the participatory certification, members of the Rede Ecovida (Brasil), has been carried out, as well as interviews to the different stakeholders. The positive effect of the participatory approach on local organic market development and its still very low chances to access the export market emerged. An interesting finding regards the role of the farmers network (Rede Ecovida) in promoting trust on PGS certified organic products beyond the boundaries of the local communities.

Introduction

Organic production in developing countries contributes to their environmental as well as social and economic sustainability (Halweil 2007), Juma 2007). It also supports the local culture in rural areas. The costs associated to a third party organic certification following the standards defined by different national and international organisms[3] are relatively high; they reduce the potential for growth in developing countries, both of production and consumption of organic products, and their access to international markets. In the PGS all the stakeholders involved in the organic production and consumption take part in the certification process, sharing responsibility (Dos Santos L.C.R., 2005) they cannot be considered third party certification bodies[4]. PGS certifications thus apply to domestic organic markets. The application of PGS by the

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[4] The organisations involved in PGS still do not conform to the ISO 65 norms and other norms defining them as Third party certification bodies (IFOAM, 2006); consequently the products cannot be traded internationally, unless integrated by a third party certification according to the exporting market norms.

Rede Ecovida[1] in Brazil has been recently studied (Ruzzi et al. 2006). Social control, trust, collaboration, third party role, showed an influence in the adoption of this certification in different market areas (local national, international). These factors are also taken into account by the institutional economics approach (Farrell 2005). It describes the interaction between the level of formality of the companies contractual agreements and the level of mutual trust and collaboration in influencing the size of the market area and the scope of the relationship. Formal institutions rely upon detailed written rules and are able to enforce them through a third party body and an efficient legal system. Informal institutions are based mainly on unwritten rules, often quite flexible, broad in their scope and not precisely defined. The rules are enforced through bilateral relationships and/or social control. As a consequence, if the adoption of a PGS for organic certification conforms to the characteristics of an informal institutional agreement, the market areas size should be local, in order to allow for an effective social control. Social control, in turn, can be effective if social cohesion and shared objectives are in place. The goal of this paper is to evaluate the relevance of this analytical framework in explaining the influence of the PGS for organic certification on the accessibility to different market areas (local, regional, national and international) in particular the interaction of PGS procedures with local community social cohesion and its consequences on the development of local markets.

Materials and methods

Information have been collected through the analysis of the literature, interviews to the Rede Ecovida management and a survey based on a sample of 20 farmers adopting PGS for organic certification, from the municipality of Ipè, Rio Grande Do Sul. The statistical approach is descriptive and a mixed qualitative/quantitative set of variables has been used[2]. In particular:

for the analysis of the PGS compliance to an informal relationship: a) scope and flexibility of the relationship between farmers and the stakeholders involved in the certification; b) rules enforcement procedures based on social control;

for the variables influencing the cohesion necessary to an effective social control for PGS: a) frequency of participation to local community meetings for PGS implementation and problems related to participation; b)role of the local institution in promoting a PGS for organic certification (reputation of local institutions);

for the role of PGS in supporting organic smallholders development of local markets: a) motivations for entering a PGS related to market accessibility; b) market channels shares for the Rede Ecovida products and geographical distribution of their market areas.

Results

Although clearly structured, well organized and managed, the Rede Ecovida participatory certification approach shows the characteristics of an informal institution.

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[1] Rede ecovida is a network among 2432 farmers organised in 270 groups, 30 ONGs, 24 Regional kernels, 32 organisations of consumers, processors and traders , 133 local markets;is located in the Rio Grande do Sul, Paranà and Santa Caterina States. Its principles are: respect for the environment ,local cultures, human beings and life, solidarity and cooperation. This vision is defined as "*agroecologia*". Organic production is part of their vision.

[2] The sources for the different variables (survey, literature and interviews) are reported in the results.

The stakeholders interviews and literature analysed show that a wider range of issues and flexible agreements are included in the participative process when compared to third party certification; they involve the whole of the technical and economical aspects of the general and organic farm management which are discussed during the audits.
The enforcement of the certification rules is granted by bilateral and social control: different single stakeholders (consumers, other producers) and formal local and regional control groups from Rede Ecovida are involved in auditing organic farmers. The PGS influence on the community cohesion and trust is positive; a study on the Rede Ecovida (L.C.R. Dos Santos, 2005) reports that 61% of the meetings involving farmers and local community of stakeholders, take place more than five times per year; only 10% of the respondents indicated the lack of interest as a factor influencing their meetings attendance. The role of social cohesion and trust in influencing the increase in the PGS adoption among farmers emerged: local institutions or personal relationships (farmers and farmers organisations) played a major role (Tab.4).

Tab. 3: Why you choose a participatory organic certification (multiple choice answers)

Farmers answers	Share
Cheaper than third party organic certification	76,5%
More chances to access local markets	52.9%
We can use non certified inputs	5.9%

Source: our interviews to farmers

Tab. 4: Who encouraged the adoption of an organic participatory certification?

Organisations	Share
Other farmers an local farmers associations	76%
Rede Ecovida representatives	18%
Other non specified	6%
Total	100%

Source: our interviews to farmers

The positive role of PGS in encouraging local organic markets development is confirmed by a share of 52.9% of the farmers indicating the easier chance to access local markets as a factor encouraging the adopting of the PGS (Tab.3). The market channels structure shows a share of organic products sold at local markets of 27% of the overall Rede Ecovida products (organic and conventional) (tab.5); this value increases quite substantially if related just to the organic products; the overall share of land dedicated to organic products within the Rede Ecovida is in fact around 68% (L.C.R. Dos Santos, 2005)[1].

The network between organic farmers and other stakeholders reduced the gap between rural marginal areas and the “modern” sectors of society allowing the access to supermarkets and catering. The interviews to representatives of Rede Ecovida showed that organic products certified by Rede Ecovida are sold in other regions and states (Santa Caterina and Paranà) as they are accepted by other consumers already familiar with Rede Ecovida products. The export is still relying on third party certification, integrating the PGS.

Discussion

Broad and flexible relationships, within the PGS process, strengthened the ties among stakeholders, helped farmers understanding not only the importance of organic farming but also how to start a community based local organic market.

[1] The quantity of organic production is not available.

Tab. 5: Marketing channels, values and shares of organic products sold by farmers belonging to Rede Ecovida de Agroecologia - year 2003.

Marketing channels	Value R$	%
1. Local organic markets (Feiras Ecológicas) (***)	8.946.682	26,89
2. Export (*) (**)	6.975.796	20,97
3. Catering	5.854.783	17,60
4. Supermarket chains (*) (**)	2.238.804	6,73
5. Food industry(*) (**)	1.434.371	4,31
6. Wholesalers	1.123.408,	3,38
7. Specialised retailers	1.111.225	3,34
8. Others	5.584.714	10,05
TOTAL	**33.269.783**	**100,00**

Source: Rede Ecovida. (*) organic and non organic; (**) Third party organic certification included; (***) only PGS organic certification. For other channels the products certification is not specified.

Trustworthy institution (Rede Ecovida) and social cohesion helped expanding PGS among farmers; this apply also to consumers, accepting products coming from areas not directly under the local social control. These results, coming from a small area and from a relatively small sample of respondent, adopting a descriptive approach, cannot be generalised. The approach provided a useful tool to analyse the PGS role in the promotion of organic production and the market development in rural communities. The focus on social cohesion, trust, rules enforcement within an informal network, seems particularly relevant to this end. Further studies should investigate the PGS based organic certification in different contexts to identify possible strategies for introducing the principle of agroecologia and participatory certification in other developing countries.

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Participatory Guarantee Systems: New Approaches to Organic Certification - The Case of Mexico

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Key words: organic certification, participation, local food systems, Mexico

Abstract

In an effort to address some of the problems associated with mainstream organic certification (such as high costs, extensive bureaucracy, inflexible processes, and a lack of community development focus), groups around the world have begun to develop alternative systems commonly referred to as participatory guarantee systems (PGS). These systems are based on the standards of mainstream certification agencies, but differ in that they adapt them to suit local conditions, employ simple verification procedures, minimize bureaucracy and costs, and incorporate an element of environmental and social education for both producers and consumers. This paper presents the experience of PGS in Mexico, with a focus on the case study of the Tianguis Orgánico Chapingo (Chapingo Local Organic Market). It is based on participant observation and informal interviews conducted by the authors during the course of their work as scholar-activists developing and promoting PGS as a certification option for Chapingo, as well as for an additional 16 markets that form the Mexican Network of Local Organic Markets.

Introduction: An Overview of the Mexican Organic Sector

Since 1996 the amount of Mexican land devoted to organic crops has grown on average by 33% annually, employment in the sector by 23%, and income generated by 26%. By 2007 over 126 000 Mexican producers were cultivating more than 450 000 hectares organically and generating more than 430 million U.S. dollars in income (Schwentesius et al., 2007). 98% of the country's organic producers are small scale, meaning they farm 30 hectares or less. The average size of these farms is just 3.3 hectares; however, it is this group that accounts for 84% of the organic land cultivated and generates 69% of the organic sector's earnings (Gómez Cruz et al., 2006).

For these small scale producers, many of whom are indigenous, the costs and bureaucracy associated with mainstream organic certification can be overwhelming. In order to address this problem, many have formed cooperatives and established internal systems of control so that the costs of certification can be shared. In addition, some farmers receive assistance from NGOs (or, in the case of Chiapas, from the state government) that can help them pay for certification (Gómez Cruz et al., 2006). However, in spite of these efforts, the high price and extensive documentation required for certification from Certimex, IMO Control, Naturland, or other agencies

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active in the country, leaves this option out of reach for many Mexican producers. As a result, approximately one quarter of the organic land in Mexico mentioned in the above statistics is not certified.

While the issue of organic certification has always been essential in terms of accessing the lucrative export market for organic products, with the passing of a new law governing the Mexican organic sector in 2006, certification will now be a legal requirement for using the organic label both for export and for sale within the country. This new regulation could have been potentially devastating for small scale organic producers who do not certify but still want to differentiate their product in the marketplace; however, thanks to heavy lobbying by the Mexican Network of Organic Markets (one of the primary promoters of small scale, local organic production and consumption in Mexico), article 24 of the new law recognizes PGS as a viable option, provided it is used for local sale only. Although the details of the new law have yet to be refined, the inclusion of PGS was seen as a major victory for the local organic movement in Mexico.

PGS in Action: The Case of Chapingo's Local Organic Market

In Chapingo, one of the markets that makes up the Mexican Network of Local Organic Markets uses PGS to maintain its organic integrity. With no certification cost charged to producers, the basis for this system is a committee consisting of approximately 14 volunteer members - producers, professors and students from the local university, and consumers. The first step for a producer wishing to achieve certification and enter the market is to fill out an initial questionnaire outlining past and present production practices. This can be obtained by visiting the market or by contacting the market coordinators. Upon completion, the questionnaire is reviewed in a meeting of the certification committee. If no obvious barriers to certification are evident, a farm map, daily activity log, and sales log are requested, and a visit to the farm or processing site is scheduled.

The leaders of the Chapingo certification committee were adamant in expaining that this visit is not viewed as an inspection per se, but rather as an interactive experience designed to be educational for all those involved. The visits are conducted by members of the committee and normally last approximately 2 hours. In most cases 5-7 people attend the visits; however, all members of the committee are always welcome to participate. It is important to note that those conducting the visits have varying degrees of knowledge regarding organic standards and production practices; however, everyone is encouraged to actively participate in the visits with the understanding that they will gradually develop their abilities. There is currently a tendency to rely on the expertise of one committee member who is a trained organic inspector, but all members (including the inspector) expressed a distinct desire to gradually decrease dependence on this person, so that the committee will be strengthened as a whole. As part of the effort to build the capacity of all members, the committee organizes continual training workshops; however, the organizers of these workshops stressed that active participation during PGS farm visits is one of the most effective ways to develop certification skills.

During the farm visits, each committee member consults a checklist that includes basic data about the farm operation (e.g. size of territory, number of crops, etc.) as well as basic organic control points, including: source of seeds; source of water for irrigation; soil management practices; pest and disease management practices; post-harvest management of crops, including storage and cleaning; and the potential for contamination from neighbouring farms. All committee members emphasized that these visits are not merely designed to decide whether or not a producer immediately qualifies for organic status, but also to provide advice and support for those producers wishing to improve their operations and move closer towards the organic ideal. As such, unlike in mainstream certification, in all visits conducted for the Chapingo market PGS committee members offer comments, suggestions, and constructive criticism with regards to how producers could optimize their management practices.

Generally within a week of the visit the Chapingo PGS committee meets to review the case and make a decision about certification. These meetings usually last approximately 2 hours and the case is discussed until a consensus is reached with regards to whether or not a producer can be certified to sell in the market. The members use the standards of agencies like Certimex and OCIA as a guideline for what is acceptable organic practice. If a producer meets the standards and has completed a 36 month transition period away from conventional production they are granted organic status within the market and certified without condition. For most producers however, certification is contingent on agreement to meet a number of conditions. Two of the most common of these conditions are the development of natural barriers on the borders with neighbouring conventional farms and the composting of manure before application. One of the leaders of the PGS group in Chapingo, who is also a producer at the Chapingo market, stresses that the committee tries as far as possible to work with willing farmers to help them meet these kinds of conditions, or to connect them with extension and education resources that could be of assistance. During this time, provided that they meet the basic requirements of organic production, producers will be allowed to sell in the market under the ‘natural’ as opposed to ‘organic’ label. If follow up visits demonstrate compliance with the conditions, a producer may eventually be moved to the organic section of the market. In the case that a producer is denied certification, clear reasons are outlined and the committee offers to maintain a relationship with the producer and help them make the transition to organic production. In the majority of cases that have come before the Chapingo PGS committee, regardless of the outcome, producers are provided with a list of recommendations for improvement that are not necessarily conditions for certification, but are designed to help the producer optimize their production practices.

Because transparency and community involvement are integral aspects of PGS, the results of all questionnaires and committee decisions are available to the public, and the Chapingo market coordinator made clear that anyone who wishes to join the certification committee is more than welcome to do so. In addition, consumers are encouraged to interact with producers at the Chapingo market (for example through participation in free educational workshops) and this interaction has led to the development of strong relationships of trust, and in some cases friendship, between the buyers and sellers of organic products. These relationships are an important means of supporting the process of PGS, as they can provide the consumer with an extra sense of security.

One of the biggest challenges for implementing PGS in Chapingo is that the certification committee relies almost entirely on volunteer labour. Thus, members’ time is limited by work, family responsibilities, and other commitments, making it difficult to schedule visits and meetings and work on capacity building within the committee. Organizers noted that these challenges have made it difficult to keep up with the demand for certifying new producers who wish to enter the market, and also to consistently monitor the farms of existing market members. In addition, due to lack of time on the part of its members, the Chapingo group has yet to publish a document clearly outlining the organic standards it uses as well as the way in which the system functions – something that ECOVIDA (2004) notes is essential to the successful functioning of PGS endeavours. Because participatory certification systems are so context specific, the standards and procedures of other groups can be used as a basis, but they cannot simply be replicated. As a result, groups like the one in Chapingo find themselves learning through trial and error and gradually developing functioning systems.

Another problem for PGS is that, although the bureaucracy is minimal compared to mainstream certification, producers in Chapingo still sometimes reported that it was difficult to provide the required maps and production activity logs. Market organizers noted that this is primarily because there is no cultural tradition of maintaining such records. One final prominent challenge is that the PGS ideals of equal participation, horizontality, cooperation and consensus building can be difficult to effectively put into practice, and conflicts of interest within the certification committee were sometimes apparent. For example, non-producer committee members noted that, in some cases, producers could be very easy on their peers in the hopes of receiving an easy evaluation themselves. In other cases, non-producers felt that some producers were overly critical of their peers, possibly because of feelings of competitiveness or a desire to achieve high standing within the group.

Conclusions

In their manual on participatory certification, ECOVIDA (2004) quotes Paulo Freire: “The thinking subject cannot think alone; he or she cannot think without the co-participation of other subjects in the act of thinking about the object. There is no ‘I think’, there is ‘we think’…” This notion of thinking and acting as a community can be challenging to put into practice, especially in today’s individualistic society; however, it is at the heart of the participatory organic certification movement. Indeed, PGS is not merely designed to ensure consumer confidence in organic products, although that is certainly one important goal. Rather, it is meant to be a tool for holistic sustainable community development with a triple focus on environmental protection, community building, and local economic development. It is meant to help support producers in the shift to organic production, to make organic products accessible to a wide variety of consumers, and to help the organic movement return to the philosophical roots of its early pioneers. Although it is still a nascent movement, experiences such as that of the Chapingo Local Organic Market demonstrate that participatory certification, although not without its limitations, can be implemented effectively, and can be a rewarding, if at times challenging, experience for all those involved.

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The Circular Economy of a Local Organic Food Chain: Xiedao in Beijing

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Key words: Local and organic food chain, Circular Economy, Leisure Agriculture

Abstract

The local organic food market in China is growing and socalled leisure agriculture has been widely accepted and advocated in urban areas as a positive means of relaxation. This paper presents an analysis of a local organic food chain based on leisure agriculture and seeks to explain development of organic food in Urban China using the theoretical frame of the Circular Economy. The study uses a local organic food chain involving Xiedao as a case. In conclusion, the paper provides an estimate of the energy use efficiency of the chain.

Introduction

China has reached an export value of 0.35 billion USD annually exporting organic agricultural products and has become the 3rd largest country of organic production in the world (Zhang, 2007). However, globalisation and trade liberalisation cause food to be transported over ever longer distances between producers and consumers exacerbating environmental pollution and increasing resource use (Friends of the Earth, 2002).

Circular economy (CE) may interlink manufacturing and service businesses seeking to enhance economy-environment performance through collaboration in management environmental and resource issues. The thrust of the CE concept is the exchange of materials where one facility's waste, energy, water, materials, and information into another facility's input (NDRC, 2006). When the triple-R (i.e. reduce, reuse and recycle) principle of circular economy is applied to the field of agricultural sustainable development, it consists basically with the philosophy of organic farming. China has focused her endeavours on circular economy, integrating cleaner production and industrial ecology in a broader system to support resource optimization (Wang, 2006). This paper analysis the material and energy recycling in one case of local organic food chain, which is the Xiedao Ecological Holiday Village (abbreviated as "Xiedao"). Meanwhile, an estimate of energy use efficiency of the chain is provided.

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Materials and methods

First author conducted an empirical study of local organic food production in the Xiedao, Beijing, China. The data collected focused on the organic food chain, and material and energy recycle of the case. Data were collected by the following methods:

1) Administration of questionnaire, including section for background data on the case.

2) Two interviewee groups were visited with different objectives: one group includes the manager of organic production, farmers, and visitors in Xiedao, with regards of local organic food chain based on leisure agriculture; another group is composed of directors in charge of different sectors in organic food chain, focusing on circulation of energy, matter and resources.

3) Direct observation: the first author visited the case spot---Xiedao.

Results and Discussion

Local organic food chain based on leisure agriculture

The total land area of Xiedao is about 200 hectare, of which 90% is in use for organic production, including planting and farming, the rest 10% is used for tourism. However, 70% of the income of Xiedao is coming from non-farming related activities, covering restaurant, sightseeing, entertainment based on organic products. Respondents believed agricultural pattern in Xiedao is the emergence and growth of leisure agriculture and food production activity, which brings together production and consumption activities, increase the added-value of agricultural products and reduce ecological footprints. It not only meets consumer demands for fresh, safe, and locally produced food but create job, encourage entrepreneurship, strengthen community identity and break the conventional agricultural food marketing system, which means that food is produced in the farm, but marketed and consumed in urban area. During the whole year of 2004, the total number of visitors reached about 1 million.

In addition to strengthening the local economy and reducing environmental pressure, Xiedao is also a community-building initiative. Local organic food chains are built up between farmers and consumers, and consumers gain a sense of connection to the land and agricultural products through picking and consuming organic products. The Xiedao organic market stall is decorated with leaflets and posters advertising a range of organic foods.

Circulation in Xiedao organic food chain

Material circulation in Xiedao is mainly composed of three flows (see Fig.1), covering flow of organic products and appendant, flow of processed water, and flow of biogas and biogas residue.

The organic agricultural system in Xiedao involves planting, animal husbandry, and aquaculture. Organic products such as soybean, rice, vegetable from planting, and meat, crab and fish from animal husbandry and aquaculture, are consumed and bought by tourists. In planting system, parts of the produced rice bran and straw are transferred to animal production and aquaculture as fodder, to resolve the waste in planting. In addition, the pattern of rice and crab together has been developed according to the principle of mutualism: rice provides shelters for crab, and weed, float, insect in paddy field are the food for crab; at the same time, crab has the ability to loosen the soil, and increase the production of rice.

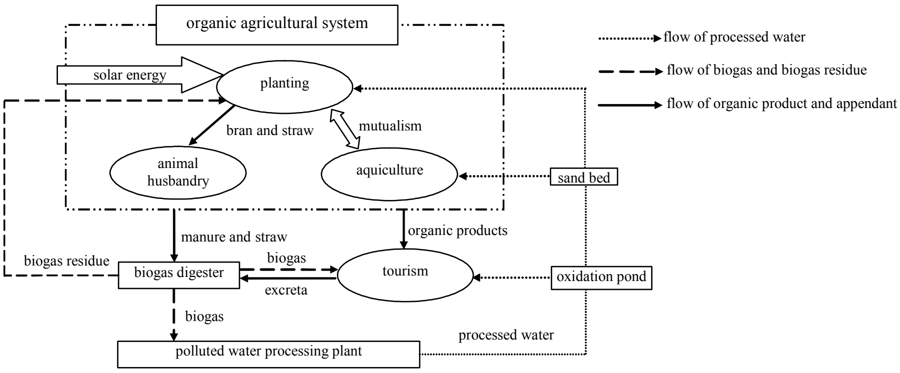

Figure 1: Circulation in Xiedao organic food chain

Manure from the animal husbandry system, and excreta from tourism system are fermented in 300 m^3 high temperature fermentation biogas digester to be biogas and biogas residue. Biogas is mostly used as renewable fuel in tourism and electrical power in the polluted water processing plant. Biogas residue, as fertilizer transferred to planting system, accounts for 88.4% of total input in planting system, and with zero input of chemical fertilizer and pesticide, which equals to 600, 000 Yuan reduction input per year. The recycling or renewable energy in Xiedao include biogas, terrestrial heat, and solar energy, substituting coal and petroleum to meet the demand of fuel in tourism. 73,000 m^3 of biogas is produced per year, equal to about 1 million Yuan. Solar energy (photovoltaics) has been developed to power road lights and irrigation in agriculture.

The energy equivalents of input and output in organic agriculture system in Xiedao include direct and indirect forms of energy. Energy input-output analysis has been used to evaluate the efficiency and environmental impacts of organic production system, and the ratio of energy input-output in Xiedao organic agricultural system is 2.2, compared with 0.1 in American agriculture and 0.25 in Japanese agriculture (Bian Y., et al., 1995).

The average amount of polluted water produced in Xiedao is about 1000 m^3 (800-1200 m^3 per day). A polluted water processing plant was built in 2002. The water from the plant flows and cleans biologically in oxidation pond as the second cleaning. The recycled water is used to irrigate the farmland, and breed fish and crab, and other animals, after sand bed.

Conclusions

Organic agriculture in China is mainly oriented towards rapid growth of external markets. However, local markets for organic products bring both market and non-market benefits, the latter of which may be summarized in terms of local sustainability and rural development. The case study of Xiedao demonstrates that a local and sub-urban organic food chain involving tourism may help “break” traditional agricultural development patterns, and enables a “circular economy” kind of organic agricultural and food (marketing) system. An energy ratio of 2.2 indicates that the Xiedao organic food chain do well also in terms of energy efficiency.

Acknowledgments

A sponsorship to the first author by the China Scholarship Council, additional support by the GlobalOrg project, and the collaboration with the participating key-informants in Xiedao, are gratefully acknowledged. Thanks to Mr. Cai Xinyan and Ms. Xu Hailing for giving up their valuable time and sharing their views and opinions regarding local organic food chains.

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Organic Agriculture: A New Field of International Development Policy

Egelyng, H., Høgh-Jensen, H., Kledal, P.R. & Halberg, N.[1]

Key words: Organic Agriculture, Development Policy. WDR ´08. OECD DAC ´06.

Abstract

This paper reviews strategically selected global policy documents and development literature and analyse perspectives on the role of organic agriculture (OA) as a possible vehicle for sustainable development in developing countries. It shows that not only has compliance assessed organics made entry in terms of projects and programmes in many LICs. OA is also gaining position in formal policies and strategies of international donor agencies and organisations. If agriculture is generally "back" in development business, organic farming has certainly "arrived".

Introduction

Focusing on agriculture as a vehicle for pro-poor development, the OECD Development Assistance Committee (DAC), last year included an organic route on its map. In May 2007 the FAO hosted an international conference on the role of OA in food security, marking a new and improved understanding of OA in resource poor and low input contexts. Finally, the World Development Report 2008 came "back" (re)focusing on agriculture, after a quarter of a century being *anderswo engagiert*. Along with increasing agricultural portfolio donor investments, the above are indications that not only do agriculture climb up development policy agendas worldwide, so does OA. A point in scholarly analysis of the rationale of this new focus is that while development studies long understood agriculture as an engine for development with forward and backward linkages and multiplier effects, most donor communities had lost interest in agriculture. Some scholars argue agriculture is back because agriculture connects the poor to growth. We favour a complementary explanation: power over agricultural policies has shifted from sector ministries and into a broader political realm matching a new economic paradigm (environmental and ecological economics) and a contemporary understanding of agricultures multifunctional roles. The supermarket revolution and global value chain organisation along with a global consumer movement and internet helped shift the game. While none of these developments brought sudden consensus regarding limitations and possibilities for OA to help rural development in low income countries (LIC), OA is both globalizing and glocalising. Certified sales are now reported passing USD 40 billions and low income countries (LICs) enter the market with comparative advantage and major de-facto or "non-market organic" areas rather ready for certification.

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Materials and methods

The materials of development studies are often existing data and literature, analysed from a novel analytical or theoretical perspective. In this paper the materials analysed are policy documents: the *WDR 2008* and the 2006 OECD DAC Agriculture *Policy Guidance for Donors* and a strategic sample of recent and further "grey" development literature dealing with organic farming and development. A literature search was done for articles on the developmental role of organic farming in international journals. The method then consisted of analyses of the texts of the policy documents and reviews of the additional literature, from a perspective of development studies, ecological economics, and political ecology.

Results

The World Development Report 2008 notes that organic products, along with exports of horticulture, livestock, fish, and cut flowers, now makes up 47 percent of all developing country agricultural export value (!) The report does not specify the organic contribution to those forty-seven percent, but elsewhere it does quote global organic 2006-sales at USD 23,9 billion compared to certified fair trade 2005-sales at 1.4 billion. It further notes that markets for "premium quality goods such as coffee, organics, and Fair Trade products" grew and that producers of these have "considerable scope for expanding exports" (World Bank 2007; 60, 61). Referring to "organic foods" to illustrate how public standards can help "ensure fair competition [and] reduce information costs to consumers", the very institutional mechanism that allows markets to recognise and reward organic producers, namely certification (schemes) has also caught the eye of the bank for its relevance in new areas: perhaps such certification could help reduce environmental impacts of biofuels! The WDR 2008 stress that while offering high prices, specialty markets – a category including "organic, gourmet", and "Fair Trade" perhaps along with geographic indications and Rainforest Alliance–certified products – are small, but elaborates organics with cases of regional experience (World Bank 2007; 71, 123, 130, 132, 137, and 189)".

The WDR does speak of "food miles", "environmental footprints" and of how the triple production challenge create needs to reduce the environmental footprint of intensive crop and livestock systems. In particular, reducing the same footprint caused by "agrochemical and animal waste pollution, is a priority" (68, 181, 199, 237). The World Bank would not be the World Bank, if "getting the incentives right" was not "the first step towards sustainability" (199). Yet, eco-efficiency, ecotaxes or pesticide tax has not found its way to the WDR 2008. The WDR does not seem to see the rise of alternative – including organic – markets as a result of any global social movement of frustrated citizens providing "institutional responses" to deficiencies in regulation regimes at global, regional and national levels of governance. The WDR, it seems, prefers a narrow interpretation of demands for certified organics as one of a market mechanism satisfying a consumer demand. This is unfortunate, because it could mislead policy-makers to believe LIC farmers should be left relying on (market) price premiums only and thus to forget the other side of the coin: the obligations and role of the state in creating a broad institutional environment far more conducive to sustainable including low carbon farming methods. It is noteworthy nevertheless that "agriculture is back" on the World Bank agenda, to an extent where acronyms such as EPOPA and IFOAM as well as environmental footprint, environmental services and food miles has entered the vocabulary of the WDR. Similarly noteworthy is that OA, now according to an OECD DAC report, is one of the pathways poor people may pursue out of poverty: a sustainable trajectory out of poverty and pro-poor growth will rely on “diversification of outputs” which will again involve a change to “capture more value added”. The report identifies “a wide range of technological options” among which it includes “organic farming” [] “to supply global supermarket chains”. It stresses that “well resourced producers can more easily meet demands for volume, quality and timeliness of deliveries, while “others” are “likely to need finance and extensive institutional support” (CBTF 2006).

The above reports published 2006 - 2007 “stand” on a recent (new millennium) history or foundation of an increasing number of bilateral and multilateral donor agencies and organisations - a subsection of FAO first among them - pioneering OA as a developmental pathway for LICs (Egelyng and Høgh Jensen 2006). The latest in a series of FAO initiatives to serve LICs seeking policy advice unfolded in May 2007 in a conference aiming to identify OA’s potential and limits in addressing the food security challenge. The conference culminated in urging the FAO Committee on World Food Security to consider promoting OA as a strategy, by including it into national and regional programs. Among the recommendations from the same conference was a suggestion on creation of a Consultative Group for Organic Agricultural research (International Conference on OA and Food Security Rome, 03 - 05 May 2007, see http://www.fao.org/organicag/ofs/docs_en.htm). All this happen while African countries in particular continue facing strategic choices on their future agricultural development. Views remain split between one continuing to draw on the Asian Green Revolution along with proprietary technologies and a different one focusing on the absence in Africa of the kinds of economic, geographical, infrastructural, institutional and geopolitical conditions that characterized Asia at the time of the Green Revolution. This has implications for anyone promoting OA in an African context. For instance: huge transaction costs are involved with diversification of production in Africa, implying that any potential for agricultural growth there, will hardly be rooted in green revolution style technological transformation among millions of small-scale, poor and diversified African farmers (Sumberg, Gilbert and Blackie. 2004; 131-146). International development agencies no longer face any shortage of advice on how to help development of OA in the South. They can, for instance follow the example of the Swedish development agency and assist African farmers to go certified organic and thus enhance their capacities to compete in global markets and they can generally reform institutional environments, policies and programs to be more conducive to sustainable agricultural methods (Egelyng and Høgh-Jensen 2006). They can chose among no less than 50 (fifty) more concrete recommendations compiled by UNEP, UNCTAD and the Capacity Building Task for on Trade, Environment and Development, all aimed at giving recognition and encouragement to the organic sector – and to remove obstacles and biases against OA (CBTF 2006). One challenge common to farmers and the agricultural innovation system (R4D) is the globally increasing demand for organic products and the perceived need of scaling up – or out perhaps. A host of scientific and technical research demands arise from the expansion of certified OA, providing a major opportunity for any “Organic” CGIAR like initiative – such as the one proposed by the May 2007 FAO conference - to support the OA sector. Organic farming with its stringent rules on external input use has to be even more innovative than common agriculture, to solve production and processing problems. Projected increases in certified OA raise additional opportunities for any such institute to contribute to development goals, through helping to develop, maintain or optimize agricultural productivity and soil nutrient levels whilst controlling costs, improving labor efficiencies and harvesting synergies from crop rotations, crop-livestock systems and all the other ecologically based principles characterizing OA.

The recognition of multiple positive externalities of OA led the European Commission to realize that opportunities existed and exist for harvesting "dividends" of public policy through a greener CAP. LICs are often in a completely different situation with no dividends (no, few or small damaging subsidies) to harvest and no significant volumes of non-renewable resources use and pollution (from fossil fuel - carbon and pesticides) to tax. On top, significant constraints for LICs to profitable production, processing and marketing of organic products for export does exist. Yet, their low wages and tropical geographies, may add comparative and potentially competitive advantage in many organic foods. Of course, the current organic price premiums may decline in the long term, as supply catch up with demand and as larger producers and retailers enter the market. A lower price premium will then make OA less economic for many small producers in LICs with poor rural infrastructure and services. Still, organic practices in low external input systems can increase combined market and non-market gains significantly for organic methods to remain preferable.

Conclusions

For a long time, the international development community had a limited or stereotypic understanding of the productivity, if not development potential of OA in resource-poor areas. Perhaps discussions were really based on imagined counterfactuals or data from temperate countries and a context of energy intensive agricultural systems. The international development research literature is yet to pay significant attention to certified organics in the context of development in LIC. Generally, however, the broader development related literature has noted certified OA as increasingly involving LICs, within a global food & fibre system with increasing sales and steadily rising areas of certified land - and potential to contribute to socially, economically and ecologically sustainable development. In the absence of dramatic change in donor investment patterns, the majority of de-facto smallholder farmers in agriculture-based societies may have to continue looking in vain for better post-structural adjustment conditions. The new globalised food system challenges them with exclusion from modern value chains. In the near-absence of domestic markets for organics (Africa) or weaker ditto (China, India), this challenge is no less for farmers wishing to certify as organic producers for the world market. OA is nevertheless posed to play an important role in the trend towards drawing further development policy consequences of the multi-functionality of agriculture.

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The institutionalization of Participatory Guarantee Systems (PGS) in Brazil: organic and fair trade initiatives

Fonseca, M.F. de A.C.[1], Wilkinson, J.[2], Egelyng, H.[3] & Mascarenhas, G.C.C.[4]

Keywords: standards and regulations, conformity assessment mechanisms, organic agriculture and fair trade, economy of conventions, social network analysis

Abstract

Since the nineties the Brazilian organic movements have been looking for alternatives to certification. They have argued that in and of itself or alone certification of family farms and small enterprise is not enough to promote either the learning processes associated with organic production or stimulate development of the local market. The discussion on a Brazilian System for Fair Trade began in 2004, and PGS were considered helpful for organizing farmers, providing guarantees and improving the market. In 2007, a draft of PGS regulation for use in organic was elaborated. The same actors who helped build the Organic System are also discussing Fair Trade System. With the help of public resources, NGOs and family farmers have established systems that provide credibility to consumers with regard to organic qualities and fair trade criteria. The use of PGS is a trend for family farmers trying to access quality markets and also helps participatory research. To some, one perceived challenge is to integrate the two policies (organic and fair trade) since the target publics are similar and the international cooperation agencies give support to both. However, current international initiatives for regulating PGS do not take into account the position of local movements. In the nineties a strategy blind to such a weakness split the organic movements in Latin America and it is unlikely that a similar strategy will promote harmonization or equivalence in the future.

Introduction

When the first Brazilian organic regulation was established in 1999, the perspective for using other conformity assessment mechanisms in addition to certification was institutionalized. Officially recognised organic agriculture (OA) in Brazil which represents around 19 thousand projects includes big enterprises but is mainly comprised of family farmers (around 80%). In 2003, when the Law 10.831 for OA was published after being discussed by public and private organizations, PGS became recognised in the regulations. The first Brazilian initiatives on Fair Trade (FT) were for export (coffee, cacao, orange juice). After 2001, the discussions on the development of FT began at local level. The target public of this initiative is the solidarity economy movement organized by groups or associations. Again PGS was considered as a possible mechanism for consolidating credibility in the local market. Research suggests that consumers tend to associate organic and fair trade principles when purchasing food and non-food (Wilkinson, 2006).

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Material and methods

This paper is based on a social network analysis and it depicts the actors within PGS regulation in Brazil, examining the motives and the methods involved in developing these systems. It identifies the conventions underlying the negotiations on the criteria for conformity assessment carried out by public and private sectors. The profile, principles, criteria, challenges and limitations of the organic and fair trade experiences where investigated to capture the institutionalization of those two local markets and identify their convergence. In addition to theses on OA (Fonseca, 2005) and FT (Mascarenhas, 2006), and academic publications (Wilkinson, 2006; 2007), information on OA was primarily based on two PGS workshops held in 2007.In these meetings, representatives from the organic and fair trade movements, involved mainly with family farmers and local development, but also with international trade, got together to elaborate a proposal for a PGS norm to be presented for approval at the Organic Agriculture Sector Chamber of the Agriculture Ministry. Information on Fair Trade was also gathered during the meetings of the Working Group (WG) for the Brazilian System of Fair Trade at the Ministry of Work and Employment, in addition to the database of the Solidarity Economy published in 2005 (Brasil, 2006).

Results

In 2002, a pilot project was implemented in Brazil by the ISEAL Alliance to promote the development of conformity assessment criteria, exploring the opportunities and challenges for family farmers involved in organic and fair trade markets. Two inspections (organic and fair trade) can imply double costs, more bureaucracy and greater time spending for family farmers. At this time, the idea of a clearing-house for harmonisation/mutual recognition was discussed. Those issues were also aired at the ITF FAO/UNCTAD/IFOAM for harmonisation and equivalence on organic standards (Wynen, 2004). PGS for organic guarantee systems has been discussed since the nineties and as from 2002 it has been explored in relation to the Fair and Solidarity Trade System. Since then public audiences have discussed the principles and criteria and a WG was created in 2006 to elaborate the framework of the system.

Shared Networks and Values – the Organic and Fair Trade movements have based their standards on international references but have made adaptations to local contexts based on agro ecological and solidarity economy criteria. Officially recognised organic projects (around 19 thousand) and fair trade initiatives (around 15 thousand) have been developed mostly by family farmers. The database of the solidarity economy undertakings (Brasil, 2006) capture the characteristics of the actors: area of action – 50% from rural,17% active both in rural and urban sectors; products distribution by type of activity – agriculture, fishing and wild harvesting (42%), food and drinks (18%) and handcraft products (13%). A project elaborated collectively by WG CPR GAO (Organic Agriculture Group) was approved to draft PGS regulation for organic conformity assessment systems, and included visits to two functioning PGS experiences: ECOVIDA in the Southern Region, and the ACS in the Northern region of Brazil in 2007. These visits provided the opportunity for exploring a range of question: principles, definitions, performance, criteria for inclusion and exclusion, training, technical support, costs, dynamic, information to consumers, and distribution channels. The central question was: how does this system provide guarantees to consumers? In addition to these two experiences, nine other networks from the North, the Centre West, the Northeast and the Southeast regions presented their experiences, describing the functioning of their guarantee system. The conformity assessment systems have very different backgrounds and function in very diverse conditions, but share many common features. Most use national regulations adapted to their local socio-ecological conditions, small-scale production, and local market (short distribution circuits). Most produce for the organic market but also for the FT and solidarity economy. The procedures are simple and there is minimal bureaucracy to maintain costs low to farmers and limit time spent filling-in forms. These experiences have technical advisors for helping with the registers, but also with the correction of non-conformities. Most rely on an educational process and social control involving many actors of the production chain focusing on consumer participation to uphold their organic quality system. Transparency is maintained through stimulating active and collaborative participation within the networks but also registers. About the effectiveness of both systems, Minister of Agriculture has registered products as organic from PGS since 2007, and products submitted to PGS mechanisms are in internal market but also for export besides they need to be certified to accomplish with regulations in external markets.

PGS Principles and Characteristics – In addition to the basic elements elaborated by the PGS WG1 (IFOAM, 2005), Brazil defined others. The PGS include different methods of creating credibility adapted to different social, cultural, political, territorial, institutional, organizational and economic realities. The main features of PGS are: social control, participation and solidarity accountability. The social control is established by the direct collaborative participation of the PGS members. These actors define and promote collective actions of conformity assessment from the suppliers to the standard reference. Participation and solidarity accountability are complementary features that make possible social control and shared power, and, govern the evaluations and decisions related to product conformity.

Discussions

At national and international level, the PGS experiences have increased around the world since the first workshop held in 2004 (Lernoud & Fonseca, 2004). They are being used for OA taking into account international and national organic standards and regulations. Eight countries in Latin America and Caribbean (LAC) have the possibility of using PGS for OA (draft regulations or regulations not fully implemented). In Table 1 we compare the basic characteristics of PGS and certification, seeing that they use different mechanisms but have common regulatory objectives: to give guarantee about specific qualities of the product, process and services. For organic and fair trade initiatives domestic and civil conventions are negotiated, and face the same problems: a) little knowledge of the possibilities of different commercial chains and existence of few specialized channels; b) low awareness by clients and consumers of the concepts and principles of organic and fair trade; c) low levels of organisation and capacity for marketing by family farmers and solidarity economy undertakings; d) excessive bureaucracy for accessing public policies.

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1 After the Workshop held in 2004, a PGS WG was created with the mission to develop, facilitate and encourage PGS around the world.

Tab. 1: Basic characteristics of certification and PGS

PGS	Certification
- Participation Shared Power (concertation of interests)	Impartiality
- Public and private partnership Solidarity accountability (mutual)	Independency
- Continuous correction of non conformities by peer reviews and technical advisors (constructing agro ecological knowledge and empowerment)	Competence

Conclusions

The PGS normative text for OA quality system is a real demonstration of how regulations can be more inclusive when governments discuss criteria with civil society. Certification or other conformity assessment mechanism such as PGS provides consumers with the organic qualities and fair trade principles that they are looking for. The implementation of a control system without prior discussion with the movements is likely to provoke tensions. Such tensions were apparent during the LAC PGS Workshop held in October 2007, when organic movements were made aware of the draft PGS IFOAM Manual as since the creation of the international PGS WG there has been little contact with local movements. Based on this analysis we conclude that in Brazil a strong civil society has acted to draw legislation beyond a simple matter of trade and business standards and rather far into a (rural) development mechanism seeing controlled organic agriculture and fair trade as core/integrated par of a sustainable (consumption, production and) future for both urban and rural people.

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Challenges for standards and certification

The Differentiation Process in Organic Agriculture (OA) – between Capitalistic Market System and IFOAM Principles

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Key words: conventionalisation, differentiation, IFOAM-principles, organic agriculture, ethical values

Abstract

The organic food chain is in a differentiation process, in between of external (society and conventional agriculture) and internal driving forces (IFOAM principles). Seven external tension fields were identified, which affected the differentiation process. One of the most important internal driving forces was the development out of the four IFOAM principles. It is recommended to address all stakeholders in the organic movement and to identify possibilities for transferring aspects of the IFOAM principles into standards/ guidelines. Furthermore, it is necessary to intensify the network with key societal players.

The fact of differentiation processes in the organic movement

Worldwide, the whole agriculture and food industry, agricultural practice and research are undergoing changes in terms of economy, trade, labour, environmental conditions, and consumer attitudes. Agricultural practice, and especially traditional and ecological oriented concepts are under pressure because of different societal developments and institutions, where offshore agriculture and food industry as well as consumer decisions increasingly influence production. The organic food chain, which is a sub-system of the whole food chain system, is in an intensive process of differentiation into different subsystems worldwide (see Schimank 2000). Organic Agriculture holds the pole position in the sustainable debate on agriculture and human nutrition, but it is in danger of losing this pivotal position as a guiding moral model concerning sustainability as well as the actual right for premium prices or environmental subsidies. With the following reflections, I try to offer some insights on selected external and internal driving forces, which could explain the differentiation process of the organic agriculture in general and the conventionalisation process specifically:

- *External driving forces:* agricultural and societal development processes, in which the organic movement is embedded.
- *Internal driving forces:* the debate and role of the four IFOAM principles.

The conclusions integrate the findings and especially what the organic movement is able to influence by himself to ensure the outstanding position and quality of OA.

Background of the differentiation process

(1) External driving forces

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OA increased rapidly in the last 20 years. To date we can find many different agricultural practices and interpretations of organic agriculture, which have their general roots in geographic and climatic conditions, as well as traditions, habits, convictions, understanding of nature, religions, philosophies, local and global politics and economic interests. As a result of this differentiation process, we can identify three main communities of OA: A conventionalisation (or rather simplification), B practice following strictly standards and regulations, C organic PLUS (additional sustainable activities). This internal broad interpretation of OA is on the one hand in acertain sense a result of climatic and cultural backgrounds, but on the other hand also undermining the whole organic movement, where the organic food chain is becoming more and more similar to the conventional approach.

The specific focus of this article is to understand the background mainly of the extreme A. The conventionalisation trends of the whole organic system has different roots. To explain the process of conventionalisation, we have to analyse the environment of this development, which we can describe with seven tension fields:

Standards / regulations: Different stakeholders i.e., producers, processors, traders and industries alike, try to influence the standards / regulations in their own interest (towards conventionalisation): (1) Those who wish to participate in the organic food chain and don't want to change substantially their production and processing or trade concepts. (2) Those who want to sell fertilizers, pesticides and other agriculture inputs. (3) Those who wish to reduce the distance between organic and their own agricultural practice in order to be able to use a similar label as the organic producers, but without substantially adapting organic concepts.

Ethic values: Conflicts with ethical values are where the use of wheat is not accepted for energy production in OA, while the situation is not the same in conventional farming. Nevertheless, green energy has a positive image. Another example is the dependence of OA on certain private food and agriculture industries such as breeding companies producing genetically modified plants, what is not in line with the OA approach. In both cases OA is neither free of expectations from society nor dependencies from private organisations with different or contrary value systems.

Economic rules: To be realistic, the amount of organic farms e.g. in Europe and the share of turnover in supermarkets is less than 5%: But at least, they are part of an economic system and in this capitalistic system (characterised by private goods, regulation of economy by the market; maximising of the profit (Hösle 1992: 113)), there is an endeavour to make the best price with the lowest inputs. In organic production, it might be a general problem to behave in opposition to this capitalistic system (Hösle 1992: 113). Nevertheless, OA has made heavy use of these open markets opportunities to get good offers. Therefore, it is not surprising that the processing / trade sector with organic products follows more and more the conventional economic systems (see also De Wit & Verhoog 2007).

Habits, traditions and social dimensions: Stakeholder (producers, processors or traders) who convert from conventional to organic have their own predetermined ideas based on traditional practices and the social contexts. Therefore, it becomes difficult for every stakeholder to change habits, following the completely different organic agricultural, processing or trade paradigm, whereas at the same moment, the conventional agricultural and societal mainstream is developing in contrary direction.

Research, training and education: Research for OA is also limited to some research divisions; their budget is far less than that of conventional agriculture. The same budgetary restraint applies to education sector, training, and advisory services. The question arise, if OA is able to hold and deepen their specific quality?

Media: Communication is key to the expansion of life styles into the society. Media policy is influencing the behaviour and values of a society. The dominance of conventional and the very cool information on their conflict potential for a sustainable development on one side, and the more and more critical media reports on organic products on the other side lead to a high pressure on OA.

Policy and private sector: Several decisions at EU policy sector are a result of the high economic interests of multinational companies and their influence on the agriculture policy decision making process in the region. The latest example is the blockade of the 50% reduction of pesticide use by 2015. Further more, the private industrial sector is arguing that OA is not able to feed the world.

The above tension fields affect societal, economic and ecological values of the organic food chain and the discourse on the future development. In brief and to demonstrate with two other examples, if the organic movement does not open their system for the green gene-technology but also biomass-based energy production or conventional consume patterns like the unlimited availability of non-seasonal food, they risk being branded as anti-progress and being marginalized in the public debate. To find a way out of this paralysing situation, the organic movement has to develop new strategies.

(2) Internal driving forces:

The organic food chain is regulated by guidelines and has developed its own principles (Luttikholt 2007), which are termed as normative ethical guidelines:

- The principle of health: OA should sustain and enhance the health of soil, plant, animal, human and planet as one and indivisible unit.
- The principle of ecology: OA should be based on living ecological systems and cycles, work with them, emulate them, and help sustain them.
- The principle of fairness: OA should build on relationships that ensure fairness with regard to the common environment and life opportunities.
- The principle of care: OA should be managed in a precautionary and responsible manner to protect the health and well-being of current and future generations and the environment.

These principles occupy an outstanding position in the debate on sustainable agriculture. Nevertheless, there are some weak points, which can explain that the conventionalisation process is also home-made by the organic movement themselves:

- Which is the focus of the four principles itself? They are addressing OA. But only some insiders imply that the principles focus the whole organic food chain, which includes also processing, trade and consumption whereas the majority assumes that these principles are mainly developed for the producers.

- How obliging are the principles? The principles tell us what we should do. They are not the same as standards / regulations, which have the function to tell us what is allowed / forbidden. They have a guiding but not a binding function.

- Are the principles translated into standards and regulations? A systematic translation of the principles into regulative instructions is open, except those aspects, which focus on the “dealing with the nature (agricultural practice)” and a catalogue of standards and regulations for processing and trade, which comprises technical schedules.

To conclude these observations, the principles have to address clearly each customer of the food chain and should be obliging. Further more, it is to reflect, how certain aspects of principles could be part of standards and regulations. Even if there was a broad discussion on the development of the principles in many countries, this discussion was limited to outstanding persons and does not affect the organic farming movement as a whole. If moral norms are established in a top-down approach, we cannot assume that customers will follow automatically. This process is always full of conflicts and often not successful. For instance consumers are free in their decision to make any choice for any product no matter whether it is organic or not, local or international, local/seasonal or not, high meat consumption or not. At least consumers are able to foil the idea, which is presented with the IFOAM principles. Nevertheless, we are living in a free society, where a private consumer has a freedom of choice.

Conclusions

The internal development of OA is tremendously influenced by the societal environment. To protect the outstanding organic quality it is necessary to built up networks to get more political, scientific and societal support. The four IFOAM principles are not really transferred into daily practice. In retrospect we can say, that the IFOAM principles were developed in a worldwide process, but they did not affect the majority. From a practical point of view, there was no alternative to this approach. But more and more the national activities e.g. Bioaustria in Austria started an own debate on values (e.g. fairness, healthy products / dignity of animals / ecology). It is recommended to establish those grass root processes in all IFOAM member countries with a permanent roundtable on organic principles and especially what and if, and how to transfer them into practice (standards / regulations) for the whole organic food chain. This participatory oriented approach is following the concept of discourse ethics (Eser & Potthast 1999: 43).[1] This discourse ethics has it's practical limitations, comprises some risks, and has to find pragmatic solutions, but is an entry point to put new life into the debate.

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[1] Consideration of all persons concerned, all arguments, fair dialog (free of hierarchy, constraints); rationality of argumentation (Habermas 1983: 101; see also the principle of Universality (131))

Dropping organic certification - effects on organic farming in Norway

Koesling, M.[1], Løes, A.K.[2], Flaten, O.[3] & Lien, G.[4]

Key words: organic farming standards, opting out, motivations for organic farming

Abstract

From 2002 to 06, the annual dropout rate of certified organic farmers averaged 7.3%. A project was started in 2007 to explore farmer's reasons for opting out of certified organic production. Important factors seem to be public regulations including standards for organic farming, agronomy, economy, and farm exit. While many organic farmers with relatively small holdings have opted out, farmers with more land and larger herds tend to convert to organic agriculture. The trend towards larger-scale farms in organic than in conventional agriculture, encouraged by the design of the organic farming payments, challenges the organic principles of diversity and fairness. Means should be considered to ensure that small organic enterprises are also economically viable.

Introduction

Numerous studies have examined organic farmers' characteristics, motives, attitudes and barriers related to the conversion from conventional to organic farming. Recent studies have also discussed the perceived problems and reasons stated by organic farmers for opting out of certified production. In Norway, farmers' reasons for opting out of certified organic farming have so far just been explored on a regional level or limited to one production; most such analyses have not been published internationally. E.g., it has not been explored if the farmers in question return to conventional practices or exit farming altogether. It is also possible that some who opt out of certified production in fact maintain a farming practice close to the organic principles. In this paper we present the number of farmers entering and opting out of organic farming in recent years; their reasons for opting out; and some characteristics of such farmers.

Materials and methods

This paper is based on results from various previous Norwegian studies, agricultural statistics, and preliminary results from a research project with a combined quantitative and qualitative approach. Interviews were conducted to better understand the complex phenomena of converting to organic agriculture and to opt out. A list of farmers was prepared, including farm data of those who opted out in the period from 2002 to

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autumn 07. Experienced advisers for organic farming helped to pre-select farmers. The interview results presented are based on two interviews with advisers and four with farmers with grain, vegetable, sheep and dairy milk production.

Results and discussion

On average, 179 farmers per year resigned from certified production between 2002 and 2006. This represents 7.3% of the average number of Debio[1] certified organic holdings in this period. About 4% of these farmers were 67 years or older, (retirement age), which is close to the normal figure for farmers in general. Even so, the total number of organic farms[2] increased from 2303 holdings in 2002 to 2500 holdings in 2006. In the same period, the area of organically certified farmland and land in conversion increased from 32,546 ha to 44,563 ha. This rate of growth is far too low to achieve the national goal of 15% organic food production within 2015. The increase in organic farmland per farm has, however, been quite impressive. The average organic area per Debio registered farm increased by 42%, from 11.0 to 15.5 ha from 2002 to 06, while the average total agricultural area on these farms increased by 25% from 19.7 to 24.7 ha[3].

In the period 2002-05, organic farms had on average about 17% more agricultural area than farmers opting out, and also 17% more land than the overall Norwegian average (Table 1). This illustrates the tendency that farmers with access to more farmland consider organic management as more attractive than those with less land. Note also that 72% of the farmland on organic farms was certified[2] during 2002-05, while only 41% was certified on the farms opting out. One reason for this difference may be that the farmers gradually opted out of certified organic production over a period of several years. Alternatively, some of the farmers opting out may only have converted some farmland as a test area.

While there was little difference between all Norwegian farms and organic farms with regard to herd sizes (Table 1), much fewer organic farms had milking cows than in Norwegian farming as a whole. There were also fewer dairy farms in the group of farmers who opted out, and the average herd size was also slightly smaller in that group. From 1995 to 2006, 360 farms supplied organic milk to the TINE dairy cooperative (Lutnæs 2006), which is by far the largest dairy company in Norway. Since 1995, 62 of the 360 farms stopped supplying organic milk to TINE. Of these 62 farms, 40 ceased dairy farming and sold their milk quota. Another 9 stopped producing milk without selling the quota, and 13 started joint operations with other organic dairy farms. Since 1996, TINE has paid a premium price for organic milk; mainly to farmers delivering to an organic milk processing dairy. The price premium prevents organic dairy farmers from opting out: 30 of the 62 farmers did not receive a premium price (Lutnæs 2006). However, 22 of the 62 farmers did receive a premium price, so a high payment is not always enough to stay in business. The claim that farmers had to be localised close to a dairy processing organic milk to receive a premium price has

[1] Debio is the Norwegian inspection and certification body for organic agricultural production. Debio also certifies farmland for the receipt of government payments for organic farming.

[2] In this paper farmers with certified organic area or area in conversion are named organic farmers.

[3] In Norway parallel production of organic and conventional farming is allowed if there is a clear partition between both production systems, so not all farm area on organic farms has to be certified for organic production or in conversion. As soon as a farm has some certified organic production; the farm is registered in statistics as an “organic farm”.

hampered conventional dairy farmers from converting. Over time, the regions where premium prices are paid have increased in size, and the demand for organic milk is now so high that new strategies are probably considered to increase the production of organic milk.

Tab. 1: Key characteristics of farms in Norway

	Farms opted out				Organic farms	All farms
Year	2002	2003	2004	2005	2005	2005
Farms	199	210	182	153	2496	51069
Agricultural area; ha/farm	17.4	15.9	15.6	24.9	23.9	20.1
Organic and in-conversion area; % of agricultural area	28.7%	47.2%	48.7%	39.4%	72.1%	4.2%
Dairy cows; cows/dairy farm	14.3	12.6	17.1	15.5	17.7	16.8
% of farms with dairy cows	11.4%	16.9%	15.7%	11.9%	22.1%	31.8%
Sheep, over 1 year; sheep/sheep farm	36.5	43.9	41.8	47.0	59.0	64.0
% of farms with sheep	40.0%	40.2%	39.9%	32.6%	32.3%	33.4%

Sources: Debio, annual statistics (www.debio.no) and Statistics Norway (www.ssb.no).

From 2002 to 04, relatively many sheep farmers opted out (Table 1); these tended to have smaller herds than both the organic farmers and the Norwegian average. Sheep farmers with small herds probably experienced the new organic regulations, e.g., required solid floor lying areas for all animals, as a too expensive investment. Preliminary results from interviews with experienced farm advisers and farmers who opted out confirm the trends described above. Farmers mention that the organic standards changed frequently and unexpectedly, and became stricter with time. For some changes, the farmers complained about a lack of scientific evidence. New regulations for buildings often required considerable long-term investments, which are considered as especially risky since agricultural policy is regarded as being not very predictable (Koesling et al. 2004). At the same time, low unemployment rates and high salaries tempt farmers to seek off–farm employment. Organic crop farmers mentioned problems linked to weed control and plant nutrient supply. Especially for organic vegetables it was challenging to find local buyers and to get a premium price. For the organic animal husbandry farms, the access to straw for bedding material is a challenge because many regions in Norway are not suited for grain production. Thus, the housing of sheep on slats or expanded metal floors is common practice. In addition, it is difficult to be self-supported with concentrates. The requirement of solid-floor resting areas and 100% organic fodder led many farmers to quit organic sheep farming. For organic dairy farmers not receiving a premium price, the demand for 100% organic fodder and loose-housing barns in 2011 have probably caused them to opt out. The Norwegian results are in line with an Austrian study (Schmid 2005), where the most important reasons for farmers to revert from organic farming were high costs or a shortage of organic concentrates or feed grain, lack of price premiums for organic products, and too frequent changes in regulations.

Most of the government payments for Norwegian agriculture are differentiated in relation to farm size and region, with lower rates for larger farms (agricultural area and herd size) and farms in the most favourable regions. Contrary to this, in general the subsidies for organic farming are very little differentiated according to farm size or region[1]. The system for organic price premiums is comparable. Such a system encourages the conversion of farms with much farmland and/or large herds. In addition, these farms may also utilize economies of scale, especially when marketing their products, buying inputs and special equipment, adapting their buildings to new regulations, or building new ones. Our results show that there is a clear trend in this direction in the structure of the Norwegian organic agriculture. As was found in our study and Austria, also in Denmark, farmers reverting to conventional production were primarily motivated by economic reasons. However, a recent study shows that reverting farmers in the Northern part of Norway were still interested in organic principles. 47% of these farmers in fact were considering to re-register for certified organic production, and 38% answered that they still were farming in line with the organic principles but without being inspected and certified. This indicates that a notable group of farmers who have opted out may still be interested in organic farming.

Conclusions

As in other countries, there are different reasons for farmers to opt out of certified organic production in Norway. Important factors were regulations, agronomy, economy, and farm exit. But there was no indication that more organic farmers quit farming than farmers in general. To achieve the ambitious goal of 15% organic production and food consumption by 2015, it seems that fewer farmers would opt out if the regulations would be more stable and foreseeable. Especially where investments are needed, long-term agricultural policy, government payments and organic price premiums could give farmers more long-term reliable conditions for their decisions. Furthermore it should be considered if regulations and policies promote farms with more farmland and/or more animals and if this is intended.

Acknowledgments

Financial support from the Research Council of Norway is gratefully acknowledged.

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[1] Support is differentiated between crops, and animals in the Northern part of the country receive some more support.

Analysis of differences between EU Regulation (EEC) 2092/91 in relation to other national and international standards

Schmid, O.[1], Huber, B.[1], Ziegler, K.[1], Jespersen, L.M.[2] & Plakolm, G.[3]

Key words: standards, organic agriculture, regulatory framework, standards database

Abstract

Differences between the EU Regulation (EEC) 2092/91 and selected private as well as governmental organic standards were analysed as part of an EU-funded research project on the revision of this regulation. Most of the differences were found in the following areas: conversion, fertilising, animal feeding, veterinary treatment and animal husbandry. Many differences have specific justifications, influenced by specific national or regional circumstances or policy framework. The variations between the EU Regulation, governmental and private-sector standards do not concern basic requirements; i.e. there is a general agreement on the main general principles of organic agriculture within the EU. A certain regional flexibility can be justified.

Introduction

Although the Regulation (EEC) 2092/91 for Organic Agriculture exists since 15 years, its implementation in the EU Member States still varies. Private standard-setting organisations and some governments within and outside the EU have long-established organic standards, which in some areas are more detailed and/or more demanding than the EU regulation. The revision process of this EU regulation is an opportunity to reflect the potentials for harmonisation, simplification and regionalisation of the rules; the analysis of different standards can indicate possibilities for change.

Materials and methods

The differences of various standards were analysed based on the Organic Rules database (www.organicrules.org). The source data were submissions from standards experts for most of the relevant private, governmental or international standards in 17 countries. The submissions consist of a brief summary of each standard's requirements, description of the differences and their justifications compared to the EU Regulation (EEC) 2092/91. Each submission was categorized into subject areas. Furthermore the differences were grouped according to the four ethical principles of the International Federation of Organic Agriculture Movements (IFOAM) of health, ecology, fairness and care. The authors then analysed compliance with and differences to Regulation (EEC) 2092/91. Furthermore (but not in this paper) potentials for harmonisation, simplification and regionalisation were outlined in the report as recommendations for the EU Commission (Schmid et al. 2007).

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Results

The analysis of differences between the (EEC) 2092/91 and other international and national organic standards covered 34 standards from 16 European countries and the USA as well as 3 international standards (IFOAM, Codex Alimentarius and Demeter International). In total 714 difference were uploaded in the "Organic Rules" database until December 2006 of which more then 85% were related to Annex I provisions (Rules on production), followed by approximately 10% in relation to Annex II (Permitted substances).

Because Regulation (EEC) 2092/91 is the legal framework for the EU, European national governmental and private standards setters have to follow these rules and cannot be less restrictive. Some national governmental standards, e.g. the Danish, French, and Swiss ones, contain additional requirements based on specific national legislation and policies or due to specific concerns of producers, processors, consumers or the general public. Many national private standards are more detailed than the EU Regulation or the national governmental standards. Many differences (>30) were found in standards from countries that have a long tradition of organic farming such as Austria, Germany, Sweden or the UK. Many standards also include areas not covered by the EU Regulation, such as wine production, aquaculture, care of the environment and non-food production and processing.

The analysis of specific thematic areas followed the structure of the EU Regulation (EEC) 2092/91. It revealed mostly differences of a technical nature described below. In the field of crop production there were 206 in livestock 294 differences submitted. More details see Table 1.

Labelling: Regarding the labelling of food there are little differences compared to the Regulation (EEC) 2092/91. Several standards cover non-food items.

Conversion: Different approaches are identified regarding reducing the period for conversion of land, either by shortening the period itself and/or by facilitating retrospective recognition of the conversion period. Nine European standards (of which one governmental: DK) require conversion of the whole farm; however the transition period can vary from 2-8 years in the case of a step by step conversion.

Plant production: There are differences regarding the implementation of a seeds database and on the criteria for the authorisation of use of non-organic seeds and propagation materials. In the area of fertilization the most often found differences were fertilisation intensity, manure use, crop rotation and restrictions for certain fertilisers and soil conditioners. In Europe all national governmental and private standards must respect the maximum limit of 170 kg N/ha/year for manure application required by the Regulation (EEC) 2092/91. However some standards do not set maximum limits for the total application of nitrogen. Other governmental and private standards set lower maximum amounts than the Regulation (EEC) 2092/91 for the total application of nitrogen. In several standards the source of conventional as well as organically derived nutrients is restricted as well. Some private standards have stricter requirements regarding the treatment of manure-based fertilisers. Several private standards in some countries have more detailed requirements for the crop rotation. Regarding pest and disease control in general, most of the regulations and standards have very few additional requirements. Several European governments have excluded the use of specific substances such as rotenone (DK, FR, UK), neem (DK, FR, UK), copper (DK, NL), because of their national pesticide authorisation.

Tab. 1: Analysis of differences between Regulation (EEC) 2092/91 and private, national governmental and international standards

Main areas *(Articles or annexes in Regulation EEC 2092/91)*	**No of diffe-rences**	**Coun-tries (n=17)**	**Main type***	**Main justification, relevant IFOAM principle(s)**
Labelling *(Main regulation Art 5)*	20	7	P	Consumer
Seeds and seedlings *(Art. 6a)*	12	3	P	Trade, Ecology
Conversion of land *(Annex I A1)*	37	11	P, N	Precaution
Fertilising *(Annex I A2)* *(I A 2 & II B)*	72 31	11	P, N	Ecology principle National legislation
Pest and disease control *(I A3)*	13	7	P, N	Ecology, health, National legislation
Collection of wild plants *(I A4)*	14	7	P, I	Ecology principle
Conversion of animals *(I B2)*	40	11	P, N	Precaution
Origin of animals *(I B3)*	15	6	P	Precaution (BSE)
Animal feeding *(Annex I B4)*	70	12	P, N	Precaution, Animal welfare, Ecology,
Veterinary treatment *(I B5)*	26	7	P, N	Precaution, health
Livestock husbandry *(I B6)*	58	10	P, N, I	Animal welfare
Manure *(I B7), (Annex VII)*	24 (15)	8	P	Ecology
Housing and free range *(Annex I B 8) (Annex VII)*	76 22	12	P, N	Animal health and welfare
Processing *(Annex VI)*	28	10	I, P, N	Care principle
Areas not covered by Regulation 2092/91				
Greenhouse and perennials	54	7	P	Ecology principle
Ecosystem management	9	4	P	Ecology principle
Soil and water conservation	13	8	P	Ecology principle
Biodiversity and landscape	16	6	P	Ecology principle
Contamination	15	8	P, N	Care principle
Aquaculture	12	8	P	Animal welfare

#P= private standard(s), I = International; N = National governmental standard(s)

Animal production: There are significant variation between standards, regarding the proportion of conventional feedstuff, on the proportion of feed to be grown on the same farm holding and on roughage and herbage to be fed to herbivores. In veterinary treatment of animals there are little differences, except the US NOP (after use of antibiotics animal products cannot be sold as certified organic). In animal husbandry management there are several differences in the area of animal breeding and rearing techniques: mutilation and dehorning, livestock housing and behaviour, electrical conditioning, tethering, transport as well as slaughter and traceability. Several governmental rules and private standards have very detailed requirements on supporting the behavioural needs of animals (bedding material, weaning, exclusion of electrical conditioning, etc.). Some private standards are explicitly outlining under which circumstances animals may be tethered but not permanent. Several national private standards have rules, which indirectly reduce the animal stocking density (e.g. nutrient balance for the whole farm, restricted use of feed from external sources).

Several national governmental and private standards have a vast variety of different requirements for animal housing and free range areas.

Processing: Detailed food processing standards for specific product groups have been elaborated only by a few private standards setters and in one national standard (ban on use of some allowed additives in DK).

Areas not covered by the Regulation (EEC) 2092/91: Regulation (EEC) 2092/91 includes only few specific requirements regarding ecosystem management, but some of these aspects are addressed in general EU legislation in various ways. Several national private organic standards have general requirements concerning low energy consumption; few limit the energy consumption in greenhouse production and/or the water use. Biodiversity and landscape requirements are found in several private organic standards; e.g. by requiring a minimum % of the farmland to be dedicated to diversification and habitat management. Prevention of contamination with pesticides, but also other contaminants like GMO, is an area of concern in the US NOP, one national standard and in several private organic standards. Many national standards have rules on aquaculture. However only few standards (4) had social requirements.

Discussion

The variations between the EU Regulation (EEC) 2092/91, governmental and private-sector standards do not concern basic/fundamental requirements; i.e. there is an agreement on most of the general principles of organic agriculture within the EU. Differences are rather in technical aspects at the implementation level or mostly found in private standards of private organisations, which want to differentiate themselves from the EU rules. Generally the differences are very much dependent from different factors: state of development of organic farming, national legislation, consumer perception, regional pedo-climatic factors, etc. This would justify possibilities for more regional flexibility, as foreseen in the new Council regulation (EC) No. 834/2007.

Conclusions

The analysis indicates some areas, where the EU Commission could envisage a harmonisation in the implementing rules under the new regulation (EC) No. 834/2007, mainly where many standards have already introduced comparable rules. However there is also a justification for a certain regional variation and a differentiation of private standards as long as these lead not to trade distortion and consumer distrust.

Acknowledgments

The authors acknowledge the support of the European Commission and the Swiss Government for funding this research work as well as the work of the standards experts, of Jens G. Hansen (technical assistance) and Hugo Alroe from DARCOF DK as well as Susanne Padel, Jo Gilbert and S. Lomann from the University of Wales UK.

Organic operators' satisfaction with their certification body – a survey in Germany

Zorn, A.& Renner, H.[1]

Key words: Organic inspection and certification, organic association, organic processors, satisfaction, Germany

Abstract

Organic certification represents different functions for the stakeholders involved in this process. For a producer of organic food, it is mainly a service provided by a certification body. Hardly any information currently exists on organic operators' satisfaction with this service. In a survey of German organic processors, we examine the satisfaction and other questions connected to the relationship certification body – client and offer insights for certification bodies and organic associations.

The market for organic inspection and certification in Germany

The organic food market in Europe is regulated by Regulation EEC (No.) 2092/91. This regulation does not only determine the organic production process, but also the process of inspection and certification. In the case of organic food, an independent so-called 3rd party inspection is an efficient solution to guarantee organic quality, since the production process results in credence attributes that cannot be easily verified by consumers (Darby/Karni 1973). In Germany, the national legislation authorises private bodies to inspect and certify organic operators. Currently, 22 certification bodies (CBs) are operating and offering their services in Germany.

The operator can select his CB from these 22 registered CBs - a relatively broad range compared to other European countries. An economically rational organic operator would therefore compare the service offered (the CBs' quality) and the required remuneration (certification fee) before choosing a CB. In this competitive environment, the operator is also able to change the CB, if the offered service or price is not satisfactory.

In the case of organic certification, choosing the appropriate service is of particular importance, since the CB is not just a service provider but also the publicly authorised institution that will guarantee the organic integrity (consumer protection), which includes disciplining organic operators, i.e. its own clients. There is potential of conflict in the neutral inspection of one's own clients within the framework of these two roles.

Dissatisfaction as a reason for changing CB can result from insufficient support on the one hand (e.g. slow handling of requests, inspection results not transparent), but also from (perceived) captious inspections.

That is - in short - the legal and economic environment in which German CBs are acting. This study mainly examines the importance of different criteria operators use to

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select their CB, then questions their current satisfaction with their CB and, finally, asks their reasons for changing their former CB.

Materials and methods

In the literature, the reliability of certification systems and potential shortcomings, as well as suggestions for the optimization, are regularly addressed (e.g. Jahn, Schramm, Spiller 2005, GfRS 2003). In contrast to certification systems research, hardly any literature exists on organic operators' satisfaction with the organic certification process and their criteria for selecting a CB.

This study is based on an online survey of organic processors conducted in July and August 2007[1]. The questionnaire was addressed to 1565 companies in Germany. The e-mail addresses of organic operators were gathered from organic associations' homepages (21.5% of the contact data). Furthermore, two certification bodies disseminated the questionnaire to their clients (78.5%). The questionnaire can be structured in 3 parts: questions on a) the company profile, b) the CB selection process and c) the current satisfaction with the CB. In order to attain a higher level of response, the number of questions was limited to 23, some of which were further divided into subcategories. The statistical analysis (comparison of means) is based on 199 questionnaires from German organic operators, resulting in a response rate of 12.7%[2].

Results of the statistical analysis and their discussion

Organic food processing comprises many different branches, with very specific fields of activity. The most prevalent branches (multiple answers) in this survey are wholesale (n=46), packaging (40), baked goods/bakery (40), import (32) and restaurant (including cafeteria) (29). 58 companies are active in two or more (up to 4) branches of food processing.

The majority (56.3%) of the respondents are running a mixed business and produce organic alongside non-organic goods. In these companies, both the average share of organic assortment (28.3%), as well as the average share of organic sales volume (28.6%), is below 30%. In the case of only 20% of the mixed companies, organic processing is more important (> 50 %) than non-organic, in terms of sales and proportion of stock. Amongst the members of an organic association the proportion of operators who exclusively produce organic (58%) is much higher than amongst the non-members, where only every fourth company produces only organic goods.

The share of companies that are members of an organic association is 54.3% (non-members 45.7%). Membership is mainly of the two associations Demeter (63.2% of affiliates) and Bioland (42.5%). 15% of the companies are members of two or more associations. German organic associations play an important role in the national organic sector, which is also reflected in the process of finding a CB; for every third

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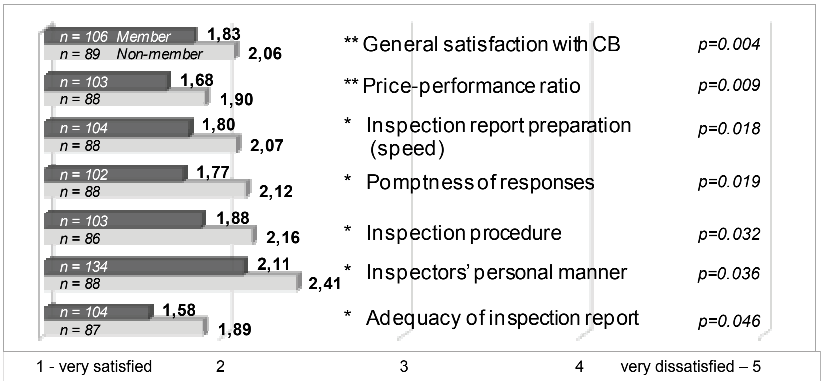
[1] The original survey also included Swiss operators. Since the number of addresses and subsequently the number of responses was limited, the corresponding data was not included in this study.

[2] Questionnaires finished after the first questions were excluded from further explorations. This applies for 11 questionnaires. Reliable information on the response rate of the two sources of contact data (organic associations, CBs) is not available, since the survey was conducted anonymously.

respondent, their initial awareness of the CB can be attributed to an organic association[1]. Of course, this link is more important in case of member operators, but every tenth non-member company also referred to this link, with respect to the search for a CB. In both groups, recommendations or hints from already certified companies are very important; for non-members, this is the most important lead when contacting a CB (25.6% of responses), followed by internet research (24.4%). For member companies, information from organic operators is second in importance (19.6% of responses), after the association's recommendation (56.1%). In this respect, professional consultants, professional associations, CBs' advertising and public administration play minor roles. Overall, information from personal acquaintances is very important, with regard to the choice of a CB. This conclusion is reinforced by the answers to the question for the criteria selecting a CB; the most important criterion is that of having a capable contact in the CB – information that only an insider can provide.

Generally, respondents are satisfied with their CB's work, with 40% considering themselves as very satisfied and 49 % as satisfied, for a total of nearly 90% of the operators[2]. Only 2.5% are slightly dissatisfied, while no respondent is completely dissatisfied with his CB. The itemized question on satisfaction with the CB's service (e.g. inspection procedure, comprehensibility of the inspection report - in total 12 questions) showed that, in 9 out of 12 cases, satisfaction was stated by over 79% of the respondents. In the other three items the number of satisfied operators lies at 46% (information on current legal changes, support in case of residues or suspicion concerning the organic integrity) and 67% (ratio price – performance).

Tab. 1: Comparison of means – members of an organic association versus non-member organic operators and their satisfaction with the respective certification body.



Means between the two groups are different: * significant for p<0.05, ** significant for p<0.01; means are calculated from a 5-point Likert-scale from 1 "very satisfied" to 5 "very dissatisfied".

[1] Historically, some German CBs were part of an organic association (e.g. Bioland). The requirements of ISO 65 led to the separation of CBs and associations. However, an affinity still exists between organic associations and these independent CBs.

[2] The top two ratings on the 5-point Likert scale have been combined as "satisfied operators" in order to give a better indication of the overall satisfaction.

A comparison of means between the satisfaction of operators that are members in an organic association such as Bioland, Demeter or Naturland, and the satisfaction of non-members, shows significant differences. Non-member operators are generally more satisfied with the overall service of their CB than those that are members of an organic association. A detailed analysis of the itemized questions shows that the greater satisfaction in the non-member group results from a significantly higher degree of satisfaction concerning the price-performance ratio, the promptness of the inspection report, the inspection procedure, the personal manner of the inspector, and finally the appropriateness of the inspection report (see Table 1). These findings are not intuitively plausible and require further research. One explanation could be that German organic associations have higher standards than the EU regulation, i.e. higher potential not to fulfil the certification requirements. This might lead to additional work for operators to meet the standard. Furthermore, the certification procedure for an association certification is twofold, hence more complex and more costly. This may lead to lower satisfaction rates in the items of Table 1.

Severe dissatisfaction, along with economic and also formal reasons can lead operators to change their CB, something 11.9% of the respondents had done in the past. 18 of the 23 operators that changed CB gave concrete reasons: 22% changed for economic reasons, such as high prices or synergy effects; 22% were forced to change, e.g. because their CB had closed; the remaining 56% switched due to dissatisfaction with the CB itself, e.g. because of poor cooperation or discord with the CB, poor availability or inspectors'/CBs' "arrogance".

Conclusions

The overall satisfaction with the organic certification bodies considered in this study can be regarded as very good. Significant differences between the groups of member and non-member operators with regard to their satisfaction with the certification process became apparent, but could not be further explained by the existing data; here further research seems pertinent. When choosing a CB, operators take personal acquaintance and links, e.g. of other companies or organic associations, into particular consideration.

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CERTCOST – Economic Analysis of Certification Systems for Organic Food and Farming at EU level

Dabbert, S. [1], Lippert, C., Schulz, T. & Zorn, A.

Key words: Organic inspection and certification, transaction costs, organic regulation

Abstract

With the ongoing growth of the organic sector and the spread of organic production across the EU, the field of organic certification has become a maze of competing labels and logos. This diversity reflects the specific conditions in different regions and countries, but can also lead to confusion for producers and consumers, as well as create a variety of costs. It is imperative to conduct a comprehensive economic analysis of the variety of existing certification systems and their impact on the internal European market for organic goods. This project proposes to combine the experience and knowledge of both researchers and SMEs to analyse the implementation of organic certification systems and to estimate all relevant expenditures or transaction costs for different certification systems along the organic food supply chain. Benefits of certification will also be analysed, using data on consumers' recognition and willingness to pay for different organic logos and trademarks. Finally, recommendations will be drawn for the EU Commission, national competent authorities and private actors in organic food and farming on how to increase effectiveness and efficiency of organic certification.

Project Overview and Objectives

Certification is a key element of organic farming systems today, because only certified organic products may be labelled as such, thereby gaining access to the organic market and earning premium prices. Conceptually, the main benefit of organic certification systems is to assure everyone within the organic supply chain, and particularly the consumer, of the integrity of organic products. This is necessary because 'organic' is defined by the process of its production rather than characteristics of the end product alone (e.g. residue levels) and the supply chain of organic food is subject to imperfect information and opportunistic behaviour (such as fraud).

Moreover, organic certification systems involve costs. A proportion of the higher cost of organic products may result from the costs of certification along the supply chain, through inspection of the farmers, the processors, the wholesalers, the importers and, in cases where products are repacked, also the retailers. Currently, some of these costs may be due to inefficient design of organic certification systems and lack of mutual recognition among certifiers. In any case, it can be assumed that the total cost of the organic certification system in Europe is substantial; however, no reliable estimates exist. In general, very little information on this sector is publicly available and a general overview of key aspects and the functioning of the organic certification system is missing. This is particularly problematic in light of the current revision for the

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legal provision for organic production in the EU (European Union) and associated countries.

For this reason, this project has been proposed under the Seventh Framework Programme of the European Commission. It is the aim of the project to evaluate organic food certification systems in Europe, in order to provide research-based recommendations on how to improve these systems in terms of efficiency and transparency. This is also likely to strengthen the competitiveness of the European organic food sector because it will reduce the incidence of non-compliance and thus increase consumer trust.

The project will be divided into the following key objectives:

1. Provide a comprehensive review of organic certification systems and standard setting procedures, including a database on key data, a review of relevant international regulations, an overview on publicly available certification prices, and an estimate of the size of the certification sector.
2. Analyse the implementation of organic certification systems and assess all relevant expenditure and transaction costs for different certification systems along the organic food supply chain.
3. Investigate the main benefits of certification systems, both qualitatively and quantitatively, in terms of consumers' recognition and willingness to pay for different organic logos and trademarks.
4. Improve risk-based certification systems and increase cost effectiveness of certification, through the application of economic models.
5. Develop recommendations for the EU Commission, national competent authorities and private actors in organic food and farming on how to increase the effectiveness and efficiency of organic certification.
6. Include stakeholders' views in the assessment of organic certification systems and share the project results with them and the public.

Proposed Methodology

Since the amount of literature directly referring to organic certification systems is limited, it is helpful to examine more general literature on food quality and other certification processes which goes beyond organic food and farming and thus integrates other aspects into the discussion. A comprehensive overview on the economic literature on food quality assurance and certification systems (both organic and conventional) is given by Burrell et al. (2006). Focusing on methodology, they identify 13 relevant research questions that address, among other issues, what are the benefits and costs of quality assurance/certification schemes, what is the optimal mix of public and private funding for such systems, what are producers' attitudes towards them, and what are consumers' views of various labels and levels of quality? The framework of this project will to some degree mirror these questions, as can be seen in the key objectives mentioned above. The project will be divided into six work packages (WP), of which each will be dedicated to achieving one of these objectives.

Once a baseline has been developed, compiling all available data on the current state of organic certification in the EU (WP 1), the next step will be to identify and analyse the costs of certification (WP 2). The starting point of a thorough cost estimate must be a classification of all kinds of transaction costs resulting from certification at different levels of the supply chain. The concept of transaction cost economics (Coase, 1937; Williamson 1979, 1985) is a widely used approach to analyse the costs incurred when exchanging goods and services. Alternatively, McCann et al. (2005) suggest a comprehensive typology and discuss measurement methodologies for transaction costs in the field of environmental policy. This framework may also be helpful in conducting a transaction cost analysis of the organic sector. In order to assess administrative burdens, the Netherlands introduced a 'Standard Cost Model (SCM)' in 2002. This model is now used to assess the administrative costs of EU legislation (Commission of the European Communities 2005). In this project, the SCM will be applied to the analysis of the costs of organic certification, being itself a direct consequence of EEC Reg. 2092/91.

Benefits of certification will then be examined in relation to consumer recognition and willingness to pay (WP 3). One method for gathering ideas to begin to understand consumers' awareness and perception of different organic standards and the corresponding buying behaviour is to start with a qualitative market research study. This will involve an overview of existing organic labels standing for different standards and certification systems, achieved through a market inventory conducted by small observational study. Focus group discussion will then be used to collect a wide range of consumers' opinions and views. The combined results of the market inventory and focus group discussions will provide the necessary background information to design an appropriate quantitative consumer research study.

In WP 4, data collected from the two previous work packages will be statistically analysed and used to develop novel economic models for inspection systems. Bayesian modelling will be applied to determine how to increase effectiveness and efficiency of inspection, with regard to risk of non-compliance. A heuristic model of organic certification will also be developed that links all relevant factors determining non-compliance related damages, as well as compliance costs and transaction costs of certification.

During the course of the project, results will be discussed with various stakeholders, particularly in terms of their applicability. This input from the stakeholder will be integrated into the compilation and synthesis of all results and the forming of recommendations for the EU Commission and pertinent national authorities (WP 5).

Project Consortium

The project consortium consists of ten partner institutions from seven different European countries. Although eight of the ten project partners focus on scientific research, two SMEs are also part of the consortium and will bring extremely valuable experiences and perspectives to the project.

A basic idea in the consortium formation is that the partners need on the one hand, a common ground in order to work effectively together and, on the other hand, must be diverse in background (science vs. business), scientific and methodological capabilities, regional spread and other factors, in order to form a complementary partnership.

The members of the project consortium are:

- University of Hohenheim (UHOH), Institute of Farm Management, Stuttgart (DE)

- Research Institute of Organic Agriculture (FiBL), Socio-Economics/International Cooperation Department, Frick (CH)
- Polytechnic University of Marche, Dipartimento di Ingegneria Informatica, Gestionale e dell'Automazione (DIIGA), Italy
- University of Kassel, Faculty of Organic Agricultural Sciences, Department of Agricultural and Food Marketing, Germany
- Institute for Marketecology (IMO), Switzerland
- University of Ege, Faculty of Agriculture, Department of Agricultural Economics, Turkey
- Danish Research Centre for Organic Food and Farming - Aarhus University, Denmark
- Czech University of Life Sciences Prague, Faculty of Economics and Management, Czech Republic
- Institute for Ethical and Environmental Certification (ICEA), Italy
- Aberystwyth University, Institute of Rural Studies, United Kingdom

This choice of partners ensures that the project will have the advantage of particular expertise in a wide range of fields relevant to this study, including: previous experience with all aspects of organic certification and policy, comprehensive knowledge of economic modelling and analysis, as well as experience in consumer and market research, participatory methods, dissemination and stakeholder involvement. The results of the project and the subsequent recommendations will not only be shared with the European Commission and national/regional governments for the purposes of policy development, but also disseminated at the stakeholder level through workshops and pertinent newsletters, to the scientific community through scientific publications and congresses, and finally to the general public by means of a freely accessible website.

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IFOAM principles in the light of different ethical concepts

Freyer, B.[1]

Key words: ethics, IFOAM-principles, organic agriculture, values

Abstract

The IFOAM principles of health, ecology, fairness and care are a product of debates on ethical values done by the organic movement from the last years. The paper discusses how the values are embedded and linked with ethical concepts. Furthermore, the question of how to transfer these values into practice is reflected.

Introduction and objectives

There is an increasing trend towards conventionalisation an increasing debate to peg enterprises on ethic values as well as a search for instruments to implement values into practical reality. The organic movement is challenged to (re)define their values and find ways to formulate them into practice. One important result of ethical debates is the four IFOAM principles. A question however remains to be addressed: how are the IFOAM principles embedded or linked with ethic concepts[2], and whether the principles offer a new perspective for the ethical debate in general. To give some insights in this debate I reflect the background of ethics, and how the IFOAM principles are related to different ethic concepts.

Ethics

Socrates (470-399 B.C.) main topic was the reflection on "the right path of life". *Aristotle* (384-322 B.C.) recognized ethics as an independent philosophical discipline. Ethic is a part of practical philosophy, besides economy and policy. Ethic is a science on moral acting, in a sense of good living, fair acting, and an aptitude to make reasonable decisions and judgement. Morality means moral norms, value-based judgement and institutions, and the task of ethics is the philosophical investigation of what is moral (Pieper 1994: 27). Ethics focuses on the theory of explaining norm systems and action rules. Ethic attempts to address such questions as: what values and norms, aims and purposes should humans orient their actions on. Norms and aims vary for individuals and depend on what is acceptable by in his specific society, group and himself (his own moral integrity). The issue of ethics is the effort to prove each moral concept, to argue and approve its valid. Ethics also aim to find a supreme and reasoned principle, which is qualified to assess and rank values, norms and aims and if necessary, to add them into new perspectives; which finally to contribute to an optimisation of humans (and nature) living together in harmony.

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[2] The focus is on occidental ethics

Linkage between ethic and IFOAM principles

The function of ethics is to strengthen the coexistence of humans, and encompasses the well being of the individual and the community. This is also the overall aim of the four IFOAM principles, based on the values of health, ecology, fairness and care have been formulated as normative and ethical guidelines (Luttikholt 2007). The four principles could be described as “moral norms for the behaviour of all stakeholders who are part of the organic food chain system”. The idea is that at least all accept and follow these principles and orient their actions towards them. All human beings who are part of the system are responsible to fulfil these values (care). They should not differentiate between human and nature but should consider all in totality (health; wholeness and integrity of living systems) (IFOAM 2007). The principles are holistic in a sense that they integrate the whole planet (space) as well as secure a future to coming generations (fairness). Nevertheless humans become a specific focus of attention (care). At least the values are concerned with associations of living systems (ecology) and reintegration of any living being. The question is, how do these values relate to ethical concepts?

Ethical concepts and IFOAM principles

The framework of the following reflections is given by the two concepts; anthropocentric ethics and physiocentric ethics, with a selective focus on their specific differentiations. In anthropocentric ethics, humans are on the top of the life pyramid (impressed / res cogitans) in demarcation to the other world (material / res extensa) (*Descartes* 1596-1650). *Kant`s* (1724-1804) Categorical Imperative “Act only according to that maxim whereby you can at the same time will that it should become a universal law”. It is in the tradition of anthropocentric ethics to follow the deontologic ethics where an action is based on guiding principles rather than the consequences of the action. This approach focuses on the rightness or wrongness of actions themselves. Utilitarism excludes interests of plants and animals (Frey 1980) but partial pathocentric ethic includes the interests of animals which are subject to suffering (*Bentham`s* 1748-1832). *Kant`s* approach further includes the human responsibility for animals, but he didn’t attributed to animals any rights or an own value. This position is not in line with the IFOAM principles. In contrary *Kant`s* idea, that ethical rules "bind you to your duty" (Waller 2005: 23) could be a perspective of IFOAM principles. Utilitarianism as one concept of consequentialism follows the idea that any action that produces positive consequences is a morally right action, briefly, the ends justify the means; or rather, the rightness of an action is determined by its consequences (Flew 1979: 73). There is a debate, if utilitarianism follows more a human centred, strong anthropocentric, hedonistic and egoistic approach or more a responsible attitude, also including the well being of society and nature as a whole (see Peet 1999; Daly 1995). Egocentric ethic, based on ego, was developed in the 17th century, and came up with nature-science revolution and the rise of capitalism. The fundamental issue is the individual with his own interests, with the assumption that what is good for the individual is also good for society. This position is mainly in conflict with several interpretations of IFOAM principles, at least, because it follows the competition approach of liberal economy. As a means to get out of this competitiveness, *Hobbes* (1588-1679) recommended a contract of association between parties (Merchant 1991: 135). In this sense, the IFOAM principles are in agreement, as they offer a basis for a contract between all stakeholders involved in the whole movement. Gradually, modifications of anthropocentric ethics has systematically lead to physiocentric ethical concepts (Pfordten 1996: 21). This ethical approach integrates ecosystems. Their living and inanimate components are in the responsibility of human being (biocentrism, holism, ecocentrism, pathocentrism). Biocentrism is a normative ethic which attributes independent moral value to all living beings whereas the ecocentrism includes the entire ecosystem. Moderate biocentrism means that we have to protect the whole living nature and all forms of life are equally valuable and humans are not on the top of the hierarchy of living organisms. *Bentham* represents the pathocentric ethic, where all organisms which are able to suffer, are to be protected in a certain sense. Zoocentrism integrates higher animals, a position often held by animal-rights-activists. Albert Schweitzer *(*1875 - 1965) is the main representative of the radical biocentrism, where every organism has the right to live and is to be protected. The most radical position presents the holistic ethic, which accords the inanimate nature the same rights as living organisms. At least all physiocentric ethics are not free of conflicts, because there are several practical restrictions that limit their implementation into daily practice. However, physiocentric ethics have some similarities with the IFOAM principles, which includes all impacts of human acting on nature and try to respect, protect the integrity of the living things and inanimate nature. Besides these general orientations on ethical concepts, there are several disciplinary oriented ethics:

- Bioethic – sustainable dealing with and use of nature
- Social ethic (SE) – rights and duties of individual for other persons
- Economy ethic (part of SE) –profitability and acting which include more than self-interest
- Science ethic – fairplay, incorruptibility
- Peace ethic – exclusion of all destroying actions

IFOAM principles offer interfaces to all these ethics. The ecologic ethic (holistic enviornmental ethic and other similar concepts) has an outstanding position in the debate of IFOAM principles (see also the holistic environmental ethic; Birnbacher 1991; Jonas 1984; Meyer-Abich 1979). This concept includes the moral responsibility for the whole environment (living and inanimate), the reverence for nature, the categorical imperative to respect and protect higher animals, the minimization of endangering future human existence, the conservation of natural and cultural resources, the integration of future oriented aims of other human beings (subsidiary), and the education to responsible actions. The moral concept of this ecocentric ethic is the cosmos of the individual, human society and the whole environment. Also, religious perspectives are part of this concept since comparable positions can be found in nature religions. These concepts seem to be the main sources for the IFOAM principles and guidelines. Nevertheless, the claim that these are transferable into daily practices, are not without risks for the whole idea.

How to transfer the IFOAM principles into practice?

The task of ethics is not to stress ideologies or to impart any convictions (Pieper 1994). Following the reflections on biogenesis of Piaget, we can only talk about moral understanding and behaviour, if those ethical orientations…"have not the character of a compulsion from outside, but guarantee most of freedom for all members of a community. Only a rule, which fulfil this objective, is a moral rule" (see Pieper 1994: 20). However, those engaged in OA are guided by the following motivations:

- If a farmer is heteronom, he is, as a sense of a duty following the organic standards because he is interested in subsidies, higher prices and higher income (see the ethical background: Pieper 1994: 18, 19)

- Someone could also decide freely to fulfil the guidelines because he stands for the values and realises that they meet his personal convictions and that of nature and society as well

In the first case, to follow organic standards is a means to an end, where the IFOAM principles are not focused, nor important for daily life. Whereas in the second case the principles are the motivation to be an organic farmer. The mission of ethical norms is to give orientation, without obliging, because it is the stakeholders' own initiative to act morally. Without this personal motivation and responsibility, standards and regulations guided by ethical dimensions would not be significant to society. This is the challenge for the organic movement as it searches to translate values into any type of standards and guidelines.

Conclusions

The values presented with the four IFOAM principles have strong relations to physiocentric ethics. Nevertheless, their position is to delineate and integrate anthropocentric ethics and holistic environmental ethics. "Most ethicists agree that no conclusions about general validity can be drawn from the actual existence of standards. This would be a naturalistic fallacy" (Akademie der Wissenschaften, 1992; Ott, 1999, in WBGU, 2001). At least, "ethical judgements refer to the justifiability of moral instructions for action that may vary from individual to individual and from culture to culture" (Ott, 1999). The IFOAM movement has to continue the debate, following the principles of organic agriculture, to develop and modify their values, as a result of open debates in different environmental, traditional cultural and societal context. Finally, efforts in the education and training sector are important as they lead to the practice of ethical values along the whole organic food chain.

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Organic sector relationships

Labour Quality Model for Organic Farming Food Chains

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Key words: Corporate Social Responsibility-concepts, ethic values, labour quality, organic farming

Abstract

The debate on labour quality in science is controversial as well as in the organic agriculture community. Therefore, we reviewed literature on different labour quality models and definitions, and had key informant interviews on labour quality issues with stakeholders in a regional oriented organic agriculture bread food chain. We developed a labour quality model with nine quality categories and discussed linkages to labour satisfaction, ethical values and IFOAM principles.

Background and objectives of the study

Labour quality with regard to the quality of working life (Hardenacke et al. 1975: 32) could be seen as part of the concept of Corporate Social Responsibility (CSR), which describes and measures the sustainability of companies (e.g. Kopfmüller et al. 2001). Labour quality has numerous definitions and is of high diversity (Dunckel 1999: 24). It is part of the IFOAM principle debate (Luttikholt 2007). Oppermann (2003: 78; Fink-Heßler 2004: 11, 14) concluded that from the sociological point of view, less is known on work and professional conditions in (organic) agriculture. Furthermore, the network "Zukunftsfähige Arbeitsforschung (future oriented labour research)" criticised, the traditional research on labour quality pointing out that it focuses mainly on industrial enterprises and their technical working processes. Therefore, our specific interest was to identify indicators for labour quality in general and organic agriculture food chains specifically.

Methods

The diverse but overlapping approaches on labour quality and experiences led to the decision, to study the concepts, criteria, indicators and models, on labour quality based on the review of literature.. At the second level, we conducted group discussions with stakeholders in organic bread food chains in small and medium sized enterprises with total of six participants – two farmers, millers and bakers. At the third level,, we synthesized the different indicators identified in literature and from the group discussions and developed them into a model on labour quality.

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The literature review focused on the general definitions of labour quality, results from the different sectors analysis on labour quality, labour quality indicators of freelance, craftsman, and agriculture labour, mills, and bakeries in general and finally with a specific focus in organic regional oriented food chains and labour quality in psychology context (German spoken literature).

At the beginning of group discussion, we provided an overview of the concept of labour quality within the categories of requirements and resources, according to Fuchs et al. (2006: 29). Following this, we asked them about their perceptions of labour quality, using the following guiding questions:

- What do you understand by labour quality?
- What is positive, what is negative?
- Which pictures do you remember spontaneously?

These questions were discussed in groups based on experiences with labour quality in the own enterprise and within the product chain.

Results and discussion

- Literature review on labour quality

Labour quality research is mainly structured in the analysis, assessment and recommendations for reorganising labour activities and systems (Ulich 2005: 63). There are several psychological methodologies to measure labour quality, which enable the analysis and assessment in different lines of business (Dunckel 1999: 11, 24), related to the research question and the focus (Ulich 2005: 53). Most of these approaches are developed for big companies and therefore their use is limited in SME enterprises or need far-reaching adaptations (Pröll 1998: 20). The "salutogenetic subjective labour analysis" as one of these approaches could be seen as a promising set of indicators. It comprises the characteristics of jobs, the workload, and organisational resources of the enterprise, social resources in the labour sector as well as social support (Udris & Rimann 1999: 407). This also applies to the labour assessment criteria models (Ulich 2005: 144), where we also find different approaches (e.g. V. Rosenstiel 2003: 117; Volpert 1990; Ulich 1984; Hacker & Richter 1980). Weaknesses are the lack of clear measuring rules and that there is no common sense on a basic set of criteria (ibid: 118).

Besides the above mentioned approach, the subjective experience of labour described with labour satisfaction and emotions also comprises different areas and definitions (e.g. Fuchs et al. 2006: 41; Ulich 2005: 138; Neuberger & Allerbeck 1978:12; Kirchler & Hölzl 2005: 139). The concept is criticised because of its subjective assessment (Izard 1994). Nevertheless, it has its legitimacy because criteria such as labour pleasure has a overall potential to describe the quality of labour situation as a whole, and is linked with several actions e.g. creative thinking and solution, or independent and self-responsible acting (Fuchs et al. 2006: 75). Additional to these scientific approaches there are several international and national standards and instruments for the assessment of labour (Kurz-Scherf 2005: 194; Meager & Sinclair 2004: 149; Sengenberg 2004: 147) including universal ideas on labour quality – freedom, justice, security and dignity. But we found also indicators linked with freelance and craftsman labour, which is a characteristic in agriculture (Brüggemann & Riehle 2005: 33; Schriewer 1999: 8). Freelance: independency, freedom from work and time pressure (Bissels et al. 2006: 99; Protsch 2006: 3); craftsman labour: diverse, creative, self interest or one`s own initiative (Ganzert 2005; Ganzert & Wild 2004; Götz 1997: 24; Schwappach 1986: 117).

Finally, we studied labour quality in organic agriculture as well as regional product chains of organic bread. For the whole organic sector, following indicators were found to be of relevance: working place conditions, labour time, self exploitation, carrier potential, societal acceptance or the relevance of agriculture in society respectively, joy of life and others (see Thomas & Groß 2005; Hilbermann et al. 2003: 37; Jahn et al. 2002: 65; Rösch & Heincke 2001: 99). There is also a broad spectrum in the perceptions of a farmer: e.g. living with and in nature, contrary to industrial jobs, working without norms, workplace and family in one place, self-responsibility (Roeckl 2003; Eitmann & Weinheuer 2005: 3; Fink-Keßler & Hahne 2004: 14). Work as a farmer is ingenious, independent and self-determined (Gottwald 2003: 16; Müller 2002: 40). On the contrary Knickel & Schmidt (1994: 195) reported from physical and psychological stress especially in small scale farms, lack of perspectives, uncertain future of the farm while Beste (2005) added the work load as a result of direct marketing activities. Schulz (2006: 27) and Fuchs (2006: 29) underline fair income and distribution of property.

Literature on labour quality in mills is limited. Responsibility and physical stress were mentioned (AMS Österreich 2006). Individuality, creativity, holistic work and contact with customers (development of an emotional relation) are discussed values of regional oriented bakeries (Schmidtlein et al. 2002: 155; Rennenkampff 1999: 268).

- Workshop results

The workshop, where labour quality was described from different perspectives in the food chain, offered several terms on labour quality, partly in line with literature, partly new dimensions. The specific contribution of the participants was, that living in and with nature is one of the most important motivations and driving factors for labour satisfaction which is a category of emotion psychology (V. Rosenstiel 2003: 64). This is an outstanding value, which explains the pleasure, where organic farmers sense, even if other qualities leave much to be desired. High labour satisfaction with its characteristic emotions e.g. happiness and fun (Friedmann 1952: 352, cit. in Ulich 2005: 142) is therefore close to positive fulfilled labour quality categories.

- Model on labour quality

In total 35 papers authors / author teams were analysed. At the first level all relevant terms concerning labour quality were selected. The result was a total of 187 terms, including the workshop results. Based on this selection, we synthesized the terms under nine quality categories, which we title as holistic labour quality model:

- **Psychological quality** - Psychological health / stress reducing labour management
- **Physiological quality** - Physiological health in labour processes
- **Subject matter quality** - Holism and diversity of labour
- **Independency quality** - Space for own decision making and organisational participation
- **Organisational quality** - Joint responsibility and transparency
- **Income quality** - Fair income and distribution of properties

- **Development quality** - Personal learning and development
- **Communication quality** - Relations and social interactions - internal, external
- **Social quality** - Social values in the company / farm

To embed the model in a broader environment we discussed how labour quality could be linked with IFOAM principles and ethical values. We assume that if the nine labour quality categories are fulfilled, ethical values e.g. freedom, equality, justice, autonomy, solidarity or dignity (Schulz 2006: 27; Ulich 2005: 210; Udris & Rimann 1999: 407) are fulfilled in a positive sense as well. Furthermore, we hypothesize, that high level of labour quality contributes to a high fulfilment of the IFOAM principles health, ecology, fairness and care in practise. We conclude that in a certain sense, labour quality categories are operationalised IFOAM principles.

Conclusions

Research on labour quality is conducted for industrial enterprises. Their focus is mainly in technical processes. Different theoretical concepts on labour quality offer a large variety of criteria, as well as our discussions with different members of the bread food chain. Therefore, we synthesised a comprehensive model on labour quality, as a step towards the systematic analysis of labour quality in organic food chains in general. The next step will be to prove and falsify the model with different members of organic food chains. Further discussions in the model are required in context to Corporate Social Responsibility activities in organic farming and the debate on ethical values.

Acknowledgments

We acknowledge all participants of the workshop and the Government of Lower Austria, who financed this research.

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Collaborative relationships in the organic wheat supply chain: a case study on three EU Countries

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Key words: organic supply chain analysis, wheat, food quality, food safety.

Abstract

The study was conducted as a part of a EU-wide survey on organic supply chains, carried on in 8 European Countries. In this paper we report the results of the study regarding the winter wheat supply chain in Italy, France and Hungary. In depth interviews with key-informants were carried on in 2006 to investigate the relationships within the supply chain. Results show a low level of collaboration among various actors especially on cost and benefits sharing.

Introduction

Only few studies describing the structures and performance of organic supply chains were conducted in the past. And no study investigating the effect of supply chains on food quality and safety is available. Nevertheless, according to Bteich and colleagues (2007), there is a very different situation of the level of collaboration inside the winter wheat supply chains throughout Europe. The Hungarian organic market, with an organic market share of 0.07% can not be mentioned as greatly developed (AMC, 2002). Organic wheat farmers in Hungary are usually not associated in marketing initiatives. They sell the wheat to wholesales directly. For lack of storing opportunities they are forced to sell the wheat right after harvesting. Between 90 and 95 % of all the Hungarian wheat goes into export. The wholesalers buy the wheat directly from farmers and ship it to its destination. Only in some cases big farms collect and store the wheat from smaller farmers and sell it with an extra charge to the wholesaler.

In France the communication within the supply chain is relatively slow at a national level because of the divergence and differences of management between regions. Communication is quick at a regional level where it is more organized and effective. Vertical integration between millers and hypermarkets is still rare. Also horizontal alliances are rare, some are registered at the co-operatives level that collect wheat and mill it. In fact, there are many organizations that adhere to the cereals collection.

The level of vertical integration within the Italian cereal supply chain is not very high and mostly it refers to the cooperatives (often characterised by quite high level of integration). The horizontal integration is nevertheless less observed and even if there is a frequent integration between co-operatives of producers and wholesalers, this type of integration does not exists between processors and distributors. In what follows main results are highlighted aiming to contribute to a better understanding of the supply chain performance and the collaboration system of the winter wheat supply chain.

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Materials and methods

To examine supply chain collaboration, the three dimensions mentioned by Simatupang and Sridharan (2004) – Information sharing, Decision synchronisation and Incentive alignment, were explored. The quality of collaboration between the interviewed actors and their buyers and suppliers was investigated asking them how often they used to collaborate with their immediate downstream (upstream) supply chain members (buyers/suppliers) on some specific issues. Performance was also measured by means of a partial value chain analysis (Simatupang and Sridharan, 2004, Roberts and Stimson, 1997). A case study approach, was developed to collect data by semi-structured interviews with key-informants (25), that is supply chain actors involved in the specific supply chain (producers, packers, processors, transporters, traders, retailers). A "snowballing" technique was used to select interviewees. Once selected some core firms along the chain, subsequent key informants were chosen from their main upstream and downstream partners that is those they mentioned along the chain.

Results

The winter wheat organic sector is, as expected, at a very different stage in the three countries investigated. France has the oldest supply chains (1962-1988) and Hungary the newest ones (1991-2004). Both the average share of organic winter wheat turnover over total turnover and the share of organic wheat turnover over total organic turnover of the interviewed companies vary drastically between the countries studied. In Italy and in France, manufacturers/processors operate in both organic and non organic production and also process other products; on the other hand producer groups/community produce exclusively organic winter wheat. In Hungary, the processing of organic winter wheat represents the whole organic processing, while farmers/producers produce not only organic winter wheat but also other cultural varieties both organic and conventional.

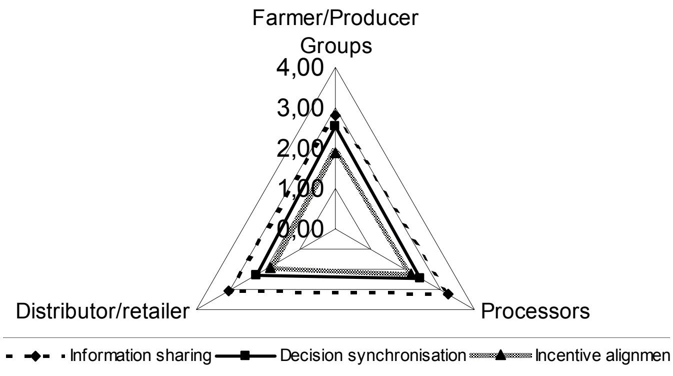

Figure 1. Collaboration indexes in the three countries (France, Hungary and Italy) - indexes contain between 8-12 variables (values range from 1 = never; to 5 = always)

Synthesising the survey results (according to three indexes: information sharing, decision synchronization and incentive alignment) a more homogeneous situation describe the level of collaboration existing among supply chain members in the three countries. Results depict a situation where in general, the level of collaboration for *incentive alignment* with the principle buyer and supplier is the less mentioned aspect while the *information sharing* is the most frequent way of collaboration. In France the collaboration with the supplier is usually much higher than in Italy and Hungary almost for all indexes investigated.

Inside the *information sharing* index the areas in which supply chain members are more available to communicate with their suppliers are: demand forecast, price and price changes, delivery schedules, QMS and traceability procedures. While with the main buyer they prefer to discuss about product quality. In general less collaboration is registered on order state and order tracking.

Concerning the *decision synchronisation* with the supplier, France and Italy seem to indicate more positive connotations than Hungary for almost all the variables especially for joint decision making on origins for raw material. The higher level of willingness to collaborate is evident in certification issues and in product safety and quality as much as price changing and demand forecast. Especially in Hungary decision synchronisation does not seem to be done in collaboration with the principle buyer and figures fluctuate around seldom.

The analysis of *incentives alignment*, mostly referred to cost and benefits sharing, shows a scarce relationship among supply chain members at this indicator level. Referring the analysis to the buyers the highest indices in France are registered on some specific aspects: “delivery guarantee for peak demand”, “allowance for product defects” and “shared logistic costs”. In Hungary the highest index for collaboration at the level of incentives alignment is registered for “allowance for product defects” and “agreement on order change”. In Italy the highest index is for “delivery guaranty for peak demand” too.

Discussion

The low level of collaboration with respect to cost and risk sharing seems to reflect the power of the various actors at each level in the supply chain and the different margins they receive. The chain is dominated by wholesalers and distributors which are expected to put huge margins on the wheat impose their standards to farmers, millers and bakeries. A great dilemma inside the chains is the dependency of the farmers to prices they receive from their wholesalers

In France mills constitute the most powerful centre of the chain that is directly related to the bakeries and other processing units. In France hypermarkets and large distribution are more and more influent and requiring, since they rule and determine the markets demands.

The Hungarian supply chain is dominated by wholesalers which are expected to put huge margins on the wheat. Because of the lack of inland consume the farmers are forced to sell their wheat to traders, which have contact to export markets. The wholesalers are not willing to accept the higher prices of organic production by using organic seeds and having fewer yields. They pay none or only a small extra charge for organic wheat in comparison to the conventional price. Also In Italy among distributors, hypermarkets are considered to be the leader and main actors of the supply chain, and processors, play also a considerable role deciding the quantity to be processed and the type of the final product.

Conclusions

Considering the little data available and according to the results emerging from this study, it is difficult to say whether the collaboration along the supply chain have an impact on quality and safety. In Italy, alike in France, (but less in Hungary), respondents state that they collaborate on these issues. Information sharing on quality and safety, ranked quite high, suggest further improvements in planning collaboration both with the buyer and supplier (Stolze et al. 2007).

Acknowledgments

The Authors kindly acknowledge funding from the European Community financial participation for the Integrated Project 'Improving quality and safety and reduction of cost in the European organic and "low input" food supply chains (QLIF- FP6-FOOD-CT-2003- 506358). The paper is the sole responsibility of the authors and do not necessarily reflect the European Commission view.

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Strategies to Induce Cooperation from Farmers in an Organic Food Supply Chain: the Case of Bio Market, Inc., Japan

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Key words: quality, supply chain, collective reputation, conventionalization, contract

Abstract

Organic food supply chains often face a challenge to receive stronger commitment from farmers necessary to access the mainstream food market. This study measured the farmers' effort level was by using a proxy indicator, and sought factors that affect the level, based on the data obtained from an organic food supply chain in Japan. Four factors were found: (1) the farmers' self-evaluation on their effort level, (2) satisfaction with the terms of contract, (the farmers' self-evaluation on their product quality, and (4) the farmers' dependence on the chain as a source of income; are related to the effort level realized by an individual farmer. Based on the result, the study has concluded that the measures that lower the self-evaluation of farmers' performance can make the farmers more cooperative with the aims of the chain.

Introduction

The Japanese organic food supply chains have historically developed unique rules for the purchase of organic food. The buyers (consumers, wholesalers, etc) are required to pay a fair and fixed price for products, and to purchase the quantity as promised at the beginning of the growing season. Such alternative market system is known as „*teikei*", „joint purchase", or „home delivery services", and has encouraged farmers to join the scheme and boost production. However, the continued growth in production and the increasingly sluggish demand have occasionally created a massive surplus, forcing them to explore buyers outside the existing chain.

The sales expansion to external buyers, however, has not been easy. The mainstream markets, such as supermarkets and restaurant chains, often request good cosmetic quality and stable supply of the products, at the same or lower prices. In the absence of a monetary incentive, it has been difficult for an organic food supply chain to meet the expectation of the buyers in the mainstream channels; the largest problem being the instability of supply (Taniguchi 2003). In addition, many organic food supply chains are reluctant to install a price mechanism as a means to improve farmers' performance. Acknowledging that the national auction house has been a driving force for the capital intensive, large-scale, monoculture production, the stakeholders of the chain believe that the integrity of organic production will be lost if they make the market more competitive. [2]

Theoretically speaking, it is considered that farmers are always tempted to cheat their effort level under the information asymmetry. If they are a part of a supply chain, there is a greater incentive to falsely report the effort level, because they can free-ride on

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[2] Guthman (2004) reports that the organic production is already widely „conventionalized" in California and the associated problems have been observed.

the „collective reputation" of the chain. Tirole (1996) argues that an individual member of the chain decides their effort level based on the value of the collective reputation, which is established by the former and existing members of the umbrella before the individual's entry. In other words, the effort level of an individual member is likely to be affected by the past behaviors of the other members in the umbrella. Gergaud and Livat (2004), in support of Tirole's view, empirically showed that the collective reputation is affected by the individual reputation, and vice versa.

Correspondingly, this study applies the theory of collective reputation to the case of organic food supply chains, and examines if the effort level chosen by an individual farmer is affected by the performance of the other farmers in the chain. Then, based on the results, strategies to increase the farmer's effort level are suggested.

Methodology

This study is based on the case of POFA, an organic food supply chain in Japan led by the wholesaler "Bio Market, Inc.". The analysis consists of: 1) the calculation of the proxy indicator and examination of the room for improvement in farmers' effort level; and 2) the identification of the characteristics held by farmers who have higher effort level. Preliminary interviews with the stakeholders in the chain, including the farmers, the shop owners, and the wholesaler staff, were made prior to conducting the main analysis.

Farmer's "effort level" was measured by "deviation," which is defined herein as the average absolute difference between the weekly „planned" quantity and the „actually supplied" quantity of a product. The "deviation" was then normalized by dividing them by the average weekly „planned" quantity. The „deviation" was calculated for every individual farmer or farmers group in the chain and for a total of 20 major fruits and vegetables, which were supplied in the period between the first week of January 2003 and the last week of 2005. Based on the individual "deviation" level, farmers were then divided into two groups: the "large deviation" group (= low effort group), and the "small deviation" group (= high effort group).

$n = (1, 2, 3, \cdots, N)$: index of week in which products are supplied.
$j = (1, 2, 3, \cdots, J)$: index of farmer.
$i = (1, 2, 3, \cdots, 26)$: index of commodity supplied.

A structured questionnaire was made to grasp characteristics of the farmers in the chain. The questionnaire was mailed on September 15, 2006, to all organic farmers, whether individually or in groups, 87 in total, of which 59 (67%) returned it by the end of the following month. The questionnaire asked farmers to provide self-evaluation on: the level of commitment to the improvement of quality and punctuality of supply (13 questions); and the quality of their own products relative to the average quality level in the chain (1 question). It also asked about the respondent's satisfaction with the terms of the contract with Bio Market (8 questions) and the degree of dependence on the chain as a source of income (1 question). All questions above were evaluated in 5-grades, and each grade was counted as „points earned" for each question, which were summed up for each question category stated above. The difference of the average points between the two groups was statistically tested.

Results

Weekly “deviation” for each commodity was 0.47, on average, which means about half of the quantity planned was not delivered or supplied in excess. Standard deviation of the farmer’s “deviation” for 20 product items was on average 0.34, with the median 0.25. Standard deviation for three items exceeded 0.40, suggesting the existence of large gaps in “deviation” levels among the farmers.

The questionnaire result showed that the majority of respondents have the following characteristics: 1) operate as a family farm, 2) manage small scale of farm land (less than 3 ha), 3) put more than 60% of farm land under organic management, 4) depend more than 70% of household income on farming, 5) be relatively young (less than 55 years old), and 6) work in partnership with Bio Market for more than 15 years. Many respondents sell their products also to consumers (directly) and/ or other outlets including: specialized wholesalers, home deliveries, and natural food stores.

Average points earned for each question category (QC) and the t-statistics of the difference between the two groups are shown in Table 1. As evident in the table, the „small deviation“ group tends to: evaluate their own efforts more moderately (QC 1); be more satisfied with the contract with Bio Market (QC 2); rank their own product quality lower in the chain (QC 3); and depend for their income more heavily on the sales to Bio Market (QC 4); than the „large deviation“ group does.

Tab. 1: Average Points for Each Question Category (QC)

Question Categories	Small deviation	Large deviation	t-value
1) Self-evaluation of effort level for improvements	37.9	42.2	2.47**
2) Satisfaction with contract with Bio Market	29.0	25.6	2.22*
3) Self-evaluation on the quality of his/her own product relative to other products sold in the chain	3.3	4.0	2.93**
4) Dependence on Bio Market as a sales channel	3.5	2.6	3.21**

* significant for P<0.05 ** significant for P<0.01

Note: The points for question categories 1) and 2) are calculated from the sum of the five-grade evaluation, ranging from “not at all (1)” to “strongly yes (5).” Question category 3) is a single question asking for a five-grade evaluation ranging from “very low (1)” to “very high (5).” Question category 4) is also a single question, but is a multiple choice from “Less than 10%,” “10 to 30%,“ ”30 to 50%,” ”50 to 70%,” and “70% or more.”

Contrary to expectation, the results of the QC 1 and QC 2 showed that the farmers who modestly evaluated their own effort level or the quality of their own products tended to deviate less (i.e. make stronger commitment to the chain). One of the possible explanations for this is that the farmers in the “small deviation” group are “unskilled” farmers who feel that it is more costly to leave the chain compared to those in the “large deviation” group. In other words, the “small deviation” group might be more dependent on, and benefit from, the collective reputation of the chain than the other group. Since the perceived cost of switching is higher for the “small deviation” group, the opportunity cost of cheating is likely to be higher, thereby bounding the group stronger to the chain’s policy. The result of the QC 4 complements this assumption; it showed that the “large deviation” group has wider sales channel compared to the “small deviation” group, hinting the “small deviation” group has less bargaining power against Bio Market. Further, the result of the QC 2 is consistent with the analysis above, because the “large deviation” group, if they are more confident and skilled, would feel unsatisfactory or unfair to being treated equally with those in the other group under the contract with Bio Market.

Discussion

The fact that the ranking of the product quality within the chain is related to the effort level is in line with the idea that the farmers take account of the performance of others in the chain when choosing the effort level, as hypothesized earlier. This study contributed to providing another example that exhibited measures in solving free-riding, even in the absence of monetary measures or punishment rules. One might argue that organic farmers are already making the maximum efforts, and there is no more room for improvements. However, in the preliminary interviews, the stakeholders expressed their concern for the existence of free-riding, and the questionnaire conducted in this study revealed that 30 to 40% of farmers admitted some “deviation” was caused by artificially controllable reasons. Nevertheless, the weakness of this study is an attempt to use “deviation” as a proxy for the farmers’ effort level. Since there are numerous factors that are not captured clearly but may affect the “deviation” level, including unusual weather, and plague of bugs/ diseases, etc, the indicator needs more careful examination and/ or sophistication.

Conclusions

This study has found that the effort level realized by an individual farmer is affected by the effort level by the other members, and supports the view that non-monetary incentive for the greater level of cooperation does exist. The farmers who made more efforts were “modest” in their own performance, which suggests that the effort level of a specific farmer might increase if the chain adopts strategies that can shift the perceived collective reputation upwards, and thereby lower their subjective ranking within the chain. Possible strategies include: organizing tours to model farms, new contract with highly skilled farmers, and the use of promotional materials.

Acknowledgments

Many thanks to farmers, shop owners and wholesale staffs in POFA network including: Yasuo Sakai, Nobuo Yukawa, Kiyomi Yukawa, Hirokazu Seki, Yoshiaki Maruyama, Hisashi Yamada, Yoko Ito, and Daisuke Mitsuoka, for kindly sparing time for the interviews, and to Dr. Juliette Rouchier of CRNS, for her helpful advice.

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Price Premiums for Organic Food from Australia and China

Paull, J.[1]

Keywords: Country of Origin Labelling (CoOL), eco-labels, certified organic, eco, natural, adjunctive labelling, food labels, provenance.

Abstract

Australian consumers (N=221) were surveyed to establish their valuations of food, based on provenance, organic status and eco-labelling. For Chinese produce Organic *attracted a 6.4% premium, and* Certified Organic *an 11.6% premium. Australian produce attracted a 7.9% premium for* Organic*, and a 16.5% premium for* Certified Organic*. For Chinese produce* Natural *added a 1.7% premium, and* Eco *2.9%, compared to Australian produce which added a 2.6% premium for* Natural*, and 2.8% for* Eco*. Chinese produce was devalued by 20.6%, compared to Australian produce (alternatively Australian produce attracted a premium of 26.0% over Chinese product). Respondents who volunteered comments, indicated they were "dubious of" or lacked "trust" in the labelling of food from China; affordability and buying "local" were also issues mentioned by respondents. Certified Organic offers an opportunity for Chinese producers to improve their return on effort, and raise the status of their produce. Adjunctive labelling can add 14.6% to consumer valuations of Chinese produce.*

Introduction

Chinese agriculture has been described as the world's oldest agriculture (King, 1911). China is now a world leader in organic food production (Paull, 2007). For the Chinese agricultural sector, organic production offers a path to higher returns, lower input costs, environmental benefits, the retention of rural workers in rural areas (Giovanucci, 2005), access to international markets and enhanced prestige.

Labelling is increasingly important for adding value to food. All label elements that are adjuncts to the generic description of the food are candidates for adding consumer value. Adjunctive labelling includes country of origin, organic claims, fair trade claims, regional identification, dietary claims such as *suitable for vegetarians*, health and nutrition claims, and religious conformity claims such as "halal".

Price premiums for organic produce reward farmers for the additional care taken, and contribute to the costs of the certification process, Retail price premiums in Australia for organic food average 80% (Halpin, 2004), without regard to country of origin. Halpin reported the view among retailers that premiums are too high for consumers and that 15% would be more acceptable.

A proliferation of eco-labelling in the market, including "natural" and "organic", causes confusion for consumers according to Wong (2005) who reported that of "organic vegetables" on sale in Hong Kong, only 29% were certified. In some jurisdictions - including Australia – produce can be labeled *Organic* without third party certification.

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Country of Origin Labelling (CoOL) is increasingly important in food retailing. Reported here are the values consumers attributed to food, based on three dimensions of labelling information: country of origin, organic labelling, and other eco-labelling.

Methodology

This study examined three food labelling variables, each at three levels. Using a factorial design, this generates 3x3x3 = 27 treatments or food scenarios. The variables were provenance (*China, Australia, Tasmania*), organic status (*null, Organic, Certified Organic*) and eco-labelling (*null, Natural, Eco*). Each subject valued the 27 generic food scenarios individually, in each case in the range $5.00 to $10.00 (on a 21 point scale, stepped in increments of 25 cents), and answered eight demographic questions, and additionally there was an optional comments box. The instrument was presented on the World Wide Web. Subjects were recruited *via* a press release, issued by the Media Office of the University of Tasmania to Australian media, mostly newspapers, which gave a web address, and invited readers to respond to a "survey about food labelling"; none of the variables under investigation (*Organic, Certified Organic, Eco, Natural, Australia, China*) were mentioned in the press release.

Results

221 respondents completed the survey, and all analysis reported here is based on the full sample. The demographics of the sample are as follows: 75% of respondents were female, 47% were aged 40 or under (Australian population median age is 36 years), 42% reported below average income, 96% were from Australia, 72% completed tertiary education (Australian adult population figure is 58%), 78% were the main food shopper in their household, 3% were affiliated with the organic industry, and 5% reported they never purchased organic food. The average time to complete the survey was 6 minutes. The comments box was used by 81 respondents.

The responses were analysed using ANOVA. The three main effects (Organic, Provenance & Eco) were all significant (Factor-Organic: $F(2,219) = 178.161$, $p < 0.001$; Factor-Provenance: $F(2,219) = 249.720$, $p < 0.001$; Factor-Eco: $F(2,219) = 55.042$, $p < 0.001$). Three of the four interactions were significant: Organic x Provenance $F(4,217) = 21.783$, $p < 0.001$; Provenance x Eco $F(4,217) = 2.983$, $p = 0.021$; Organic x Provenance x Eco: $F(8,213) = 2.484$, $p = 0.013$).

A summary of results for China and Australia are reported here. The mean valuations for the nine China food scenarios and the nine Australia food scenarios are presented in Fig.1. The country of origin (Provenance) factor yielded the largest effect. Respondents attributed to Australia a valuation 26.0% higher than the China valuation. All label elements added value (Fig. 1). *Organic* added 6.4% for China and 7.9% for Australia, *Certified Organic* added 11.6% for China and 16.5% for Australia (Fig. 2). There was a significant interaction ($p < .05$) between provenance and eco-labels (Fig. 3). For China, *Natural* added a 1.7% premium and *Eco* added 2.9%; the corresponding figures for Australia were 2.6% and 2.8% (Fig. 3). All the preceding percentages are based on marginal means. Of the nine China scenarios, the treatment *China, Certified Organic, Natural* attracted the highest premium of 14.6% (Fig. 1). Of the nine Australia scenarios, the treatment *Australia, Certified Organic, Natural* attracted the highest premium of 21.1% (Fig. 1). In the optional comments box, 12 comments referred specifically to food from China, all were negative.

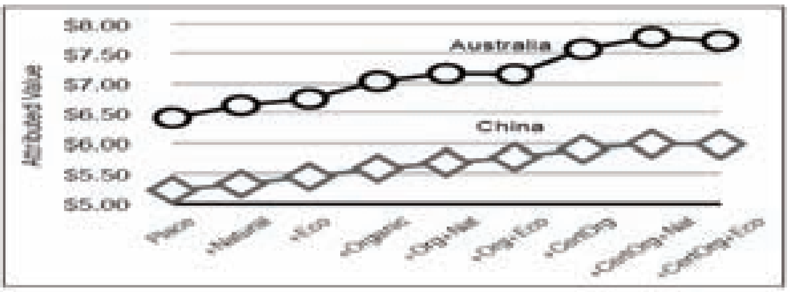

Figure 1: Australia & China: Consumer valuations for nine food labelling scenarios, N=221, cell means.

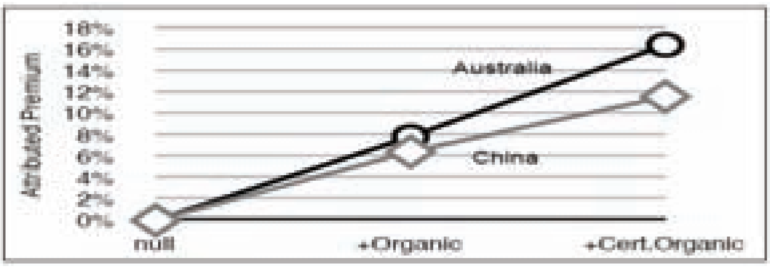

Figure 2: Australia & China: Consumer valuation premiums for *Organic* and *Certified Organic*, N=221, based on marginal means. There is a valuation gap of 4.9% between Australian and Chinese *Certified Organic*.

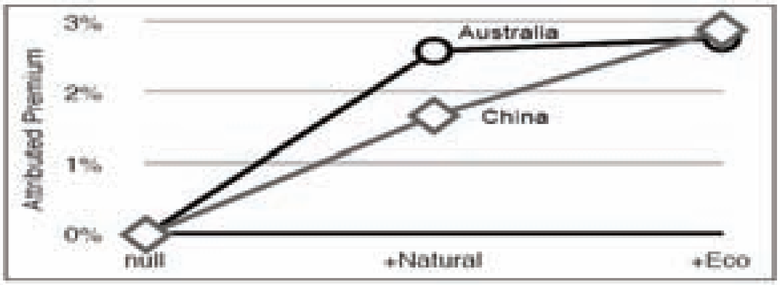

Figure 3: Australia & China: Consumer valuation premiums for *Natural* and *Eco*, N=221, based on marginal means. Eco-labelling adds small but significant value.

Discussion and Conclusions

Halpin (2004) reported that certified organic premiums averaged 80% in Australia, and that consumers are likely to consider this figure too high. The present study confirmed this, and additionally found that the price premium consumers attribute to organic food is a function of the provenance of the food.

Country of origin (CoOL) has a greater impact on consumer valuations than the organic status of the food. Consumers valued up *Certified Organic*, whether from Australia or China. *Certified Organic* attracted twice the premium of *Organic,* indicating that consumers clearly distinguish between these two different claims. *Certified Organic* derives half its premium for "organic" and half from "certified". Adjunctive labelling of produce added value cumulatively for consumers, for example *Certified Organic, Natural* scenarios exceeded the value of *Certified Organic*. The eco-labels *Natural* and *Eco* added statistically significant but monetarily small premiums.

Wai (2006, p. 112) has claimed that Chinese organic standards are "the most stringent in the world", while LeCompte (2007) has reported that "Made in China" attracts more complaints from North American organic consumers than any other single issue. The present study found that Australian consumers devalued Chinese produce, compared to local produce.

Kuhlmann (2007) declared that the opportunity for Chinese organic exports is as ingredients of food processed in first world countries. The issue with this approach is that while manufacturers gain the benefit of cheaper inputs, consumers are likely to remain ignorant of the provenance of the ingredients. In Australia and New Zealand, for example, most processed food now suppresses the origin of the ingredients, by invoking one of the FSANZ (2006) labelling prescriptions, either *"made from local and imported ingredients"* or its inversion *"imported and local"*. This practice advantages Chinese organic ingredient exporters over local producers.

For China, organics offers the opportunity to add value to agricultural produce, to move the focus of Chinese produce from price (cheapest) towards quality (best), to increase rural employment opportunities, to bring wealth and renown to rural regions, to reduce reliance on farm inputs, especially imported inputs, to increase reliance on farmer know-how and skill, and to safeguard the health of rural workers, the environment and consumers. China is already a world leader in organics (Paull, 2007). Because of the vast size of China's agricultural output, there is the opportunity for China to redefine the standards of internationally tradable food as *Certified Organic*. Such a lead from China would reap health and environmental benefits for China and the world.

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Corporate Social Responsibility and Organic Farming – Experiences in Austria

Goessinger, K.[1] & Freyer, B.[2]

Key words: Marketing, Corporate Social Responsibility, Organic farming, Ethical values, Food sector

Abstract

Although the market for organic products has been growing in Austria for a few years, the rising competition of so called regional, natural or sustainable products should be taken seriously. One solution in times of "conventionalisation" of organic farming could be higher ethical standards in organic farming and more effective communication of ethical values, as it has already been practised by a great number of medium-sized and large enterprises under the name of "Corporate Social Responsibility" (CSR). CSR refers to all services that are beyond legal requirements, performed on a voluntary basis. This article discusses the topic CSR and similar approaches in the Austrian organic sector on the basis of 30 interviews with Austrian organic farmers and processors. Its level of familiarity, its institutionalisation and the farmers´ and processors´ attitudes towards the Anglo-American concept are analysed. The article also points out which CSR services could be performed in the organic food chain by giving concrete examples and presents a typology of three different groups of organic farmers and processors concerning their exposure to written marketing of CSR or similar services.

Introduction and objectives

The promotion of regional products and the growing anonymity in the organic supply chain make it more difficult for organic products to keep the status of being something special and unique in the debate on sustainable land use. Therefore, this paper introduces the concept Corporate Social Responsibility, explores its level of familiarity among organic farmers and processors, and their attitudes towards the concept. Besides, the paper describes which CSR services are performed in the organic sector and investigates if these CSR services are also communicated to the consumers in a written form.

We use the neo-institutionalism as our theoretical framework. Therefore, we focus on CSR, IFOAM principles and standards/regulations of organic farming, as well as the actors' perspective. Our hypotheses are:

1) CSR has been an instrument used by large companies so far, not (yet) by small- and medium-sized organic enterprises.
2) In order to stand out in the market, innovative organic initiatives perform services that go beyond the regulations.

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3) The concept CSR is not (yet) viewed as being compatible with the values of organic farming.

In the tradition of qualitative research, we follow a case study approach where we do not have the objective to get representative results.

Methods

This explorative study is based on case studies of 30 small and medium-sized enterprises[1] throughout Austria that produce and/or process organic food products and are also responsible for their own marketing. The enterprises or initiatives must have developed a CSR or similar approach, which means that they perform services that go beyond legal standards: the regulation of organic farming (EC 2092/91) and also beyond regulations of the national organic associations. Their focus has to be on organic domestic products.

Tab. 1: Characterisation of actor sample

Sample Size	Initiative	Head-count	Exlusively organic?
10	Care farms which are partly also processors	< 50	Yes
14	Family farms and small size farmers´ cooperatives	< 50	Yes
3	Small processors	< 50	Yes
3	Medium-sized processors	< 250	No

Whenever available, we analysed written material of the initiatives (e.g. website, leaflet, information on the product, etc.). In addition, phone and face to face interviews were conducted on the basis of a guideline questionnaire with open and closed questions.

Results and Discussion

1. What is CSR and how is it institutionalised in Austria?

The concept of CSR has gained importance in Central Europe in the last years. In the business sector, numerous medium-sized and large companies established CSR to demonstrate and communicate ethical values to improve their corporate image. Meanwhile, also numerous Austrian companies include CSR concepts in their corporate strategy. The European Union defines CSR as "a concept whereby companies integrate social and environmental concerns in their business operations and in their interaction with their stakeholders on a voluntary basis".[2] CSR is closely linked to the concept of sustainable development: companies have to be conscious of their economic, ecological and social impacts. RespACT, the Austrian business council for sustainable development, is the leading platform for Corporate Social Responsibility and Sustainable Development in Austria. Its objective is to enhance the implementation and communication of CSR in Austrian companies.[3]

If we focus on the IFOAM principles which have a model function for the whole organic food chain, the crucial question arises: are they obligatory or voluntary? On the one

[1] According to the EU-definition of SME (2003/361/EC)

[2] COM [2001] 366 final

[3] http://www.respact.at

hand they are partly integrated into the organic standards and inspected during the control process, but on the other hand the principles transport a lot more than the standards. What we know is that organic farmers as well as processors perform several services which go beyond the standards and regulations, especially in rural areas: In addition to agricultural production and ecological services, organic agriculture acts as an essential stimulator for the region as regards employment and infrastructure. Besides, organic agriculture contributes to the conservation of cultural landscapes, supports social interactions and processes, and promotes socio-cultural activities like the preservation of rural customs. We can conclude that organic agriculture provides several services, which are in line with CSR.

2. How familiar are organic farmers and processors with the concept of CSR?

Hardly any of the interviewed organic farmers and processors knew the term CSR. This might be due to the fact that CSR hardly appears in the Austrian agricultural debate. Terms like eco-social responsibility, developed and promoted by the former minister of agriculture Josef Riegler, or sustainability, are on the contrary well-known. In contrast to the first group, the interviewed medium-sized processors were familiar with CSR and argued that CSR or other ethic approaches had been part of their corporate philosophy for many years (e.g. one company has been supporting a development aid project for more than 20 years now). However, the increasing political, economic and medial attention on these topics and the interest of large international corporations in CSR is a recent development. The interviewed organic processors associated the term CSR mainly with a theoretical concept, a temporary fashion, in short – a concept that is difficult to identify with. They stressed that for them the concrete activities or services were more important than the development of a conceptual CSR approach.

3. Which CSR activities are practised in the organic sector and how are they communicated?

In our case studies, we identified CSR or related activities which focus on ecological, social, cultural, economic or animal welfare aspects. Examples are the support of social projects, work and possibilities of integration for disabled people, the preservation of highly sensitive cultural landscapes and biodiversity, specific protection of the environment, etc. The interviewees were asked if they performed additional services going beyond organic standards and if they communicated them as well. Three groups of initiatives were identified concerning written marketing measures of CSR services:

1. Initiatives performing services that go beyond the organic standards but do not communicate them in a written form.
2. Initiatives claiming to do more than organic in their promotions but that are in reality “only” organic without performing any additional services.
3. Initiatives performing services that go beyond organic that also communicate them to the consumers in a written form.

The case studies revealed that generally marketing in the form of leaflets or websites is not practised by a great majority of the interviewed small organic farmers and processors. Reasons for not using written communication are lack of time, lack of know-how in marketing, or no sales problems. Moreover, some initiatives do not communicate their additional services since the owners take what they do for granted. Others do not want to market their values and beliefs in the form of a CSR concept because they view CSR as a tool used by large companies that want to mask their unethical behaviour by "green washing". As regards "care farms" some interesting findings were revealed: They do not want to stress the social aspect of their initiative in their marketing, because for them the most important message they want to deliver to the consumers is the fact that they are producing high quality goods. They do not want to attract consumers who buy their products only because of sympathy for the people working at the "care farms". They believe that as soon as consumers get interested in their products, they can provide them with more information about the background of the farm. Most interviewed medium-sized processors communicated CSR or similar services in a written form.

Conclusions

CSR is a well-known concept for medium-sized and large enterprises in the Austrian food sector, whereas the great majority of organic farmers and small organic processors are not familiar with it. However, the case study analysis in Austria reveals that there is a large amount of organic farmers and processors who perform services that go beyond organic guidelines but do not communicate them effectively to the consumers. These CSR or similar activities could be used to highlight organic products produced under higher ethical conditions. Following a neo-institutional perspective, we conclude that there is a type of organic farmers and processors who neither want to follow a utility- nor a norm-oriented CSR approach. They seem to prefer individual concepts for their CSR activities as well as for their personal communication with the consumers to transport their specific values.

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Factors Affecting Market Outlet Use by U.S. Organic Handlers

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Key words: U.S., organic handlers, market outlets, multinomial logit model.

Abstract

The U.S. organic sector has expanded rapidly over the last decade, resulting in significant changes throughout the supply chain. Intermediaries need to move greater quantities of organic food to a growing numbers of retailers. As organic sales continue to increase, intermediaries marketing to several types of outlets may be better placed to adapt to changing market conditions. Data from a survey of U.S. organic handlers is used to identify which characteristics are associated with the number of marketing outlets handlers serve. The analysis finds that handlers with a greater share of organic sales and those certified organic longer are more likely to sell in more than one market outlet, while those selling products locally and regionally rely on fewer outlets.

Introduction

Retail sales of organic food in the United States have soared over the last decade, from $3.6 billion in 1997 to $15.7 billion in 2006. Growth in the organic sector has provided opportunities for all agents along the supply chain, from organic producers to handlers and retailers. In addition, marketing and retailing of organic foods in the U.S. has shifted dramatically, moving from a focus on direct/local markets and natural products channels to one that is equally divided between natural and conventional channels, with direct markets making up a fraction of sales (Dimitri and Lohr, 2007).

Although nearly all organic commodities pass through the hands of at least one intermediary (also called handlers) on the way from the farmer to the consumer, there is a dearth of literature examining the middle section of the supply chain. Recent research on organic handlers, both in the U.S. and EU, has been based on surveys of limited geographic scope (Austin and Chase, 2004; Banterle and Peri, 2007; Bingen, Osborne, and Reardon, 2007).

Organic handlers play a central role in the industry, packing and shipping, manufacturing and processing, and distributing, wholesaling, and brokering organic products. Their functions are similar to those of their conventional counterparts, with the added requirement that a product's organic integrity must be maintained as it moves along the supply chain, as specified by the U.S. national organic standards.

This paper uses data from a nationwide survey of U.S. organic handlers, undertaken by the U.S. Department of Agriculture's Economic Research Service (ERS), to examine marketing decisions made by U.S. organic handlers.

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Materials and Methods

The organic handler survey was drafted with input from stakeholders, including certifiers, farmers, processors, academics, and representatives from non-profit organizations. The final survey instrument consisted of 59 questions, covering: operational and business practices, basic characteristics of handling facilities (e.g., gross sales and years certified organic) and relationships with both customers (e.g., marketing outlets used, distance to markets) and suppliers, including types of suppliers, and purchase arrangements (contract versus spot market). The survey was mailed to the population of all U.S. certified organic handling facilities in 2004, with 1,393 organic handlers completing the survey, representing a 63 percent return rate.

Much of the economics literature examining organic food marketing focuses on the producer's marketing decision (see for example, Park and Lohr, 2006). In this paper, we take a slightly different approach, modelling the marketing decisions made by organic handlers regarding the number of outlet types used (nine types of marketing outlets were specified in the survey, including retail, intermediaries, and direct sales). We hypothesize that certain factors influence this choice, such as where a firm sells its products, the share of sales that are organic, and the type of product the firm sells.

Tab. 1: Descriptive statistics for variables used in the model

Variable	Description	Mean (SD)
Years certified	Number of years certified organic	4.1 (4.5)
Share organic	Percent of sales that are organic	35.7 (39.7)
Producer-handler	1=also certified organic producer, 0=just organic handler	0.26 (0.44)
Manufacturer	1=at least 50 percent of organic sales under manufacturing function; 0=otherwise	0.51 (0.50)
Wholesaler	1=at least 50 percent of organic sales under wholesaling function; 0=otherwise	0.19 (0.39)
Broker	1=at least 50 percent of organic sales under broking function; 0=otherwise	0.03 (0.17)
Packer/Shipper	1=at least 50 percent of organic sales under packing/shipping function; 0=otherwise	0.11 (0.31)
Sells to retail	Percent of organic sales to retail outlets	25.4 (36.9
Sells to intermediaries	Percent of organic sales to intermediaries	55.6 (44.7)
Sells to direct/ institutions	Percent of organic sales to direct and institutional markets	11.9 (27.3)
Local sales	1=100 percent of organic sales are made locally (within a one hour drive); 0=otherwise	0.10 (0.30)
Regional sales	1=100 percent of organic sales are made regionally (within state/surrounding states); 0=otherwise	0.12 (0.32)
Sells produce	1=one of top 5 products sold is produce; 0=otherwise	0.21 (0.41)
Sells manufactured products	1=one of top 5 products sold is a manufactured product; 0=otherwise	0.40 (0.49)
Sells grains or feed	1=one of top 5 products sold is grains or feed; 0=otherwise	0.06 (0.25)

A three-case multinomial logit model identifying the factors influencing the number of marketing outlets used by organic handlers was estimated. The first (and reference case) is the use of one marketing outlet (such as a natural product retailer, wholesaler, or direct market) for 100 percent of organic sales by an organic handler (N=580). The second is the use of two markets for 100 percent of sales (N=332), and the third case is the use of three or more market outlets for organic sales (N=333). Of the respondent population, 1245 handlers fall into one of these choices.

Explanatory variables include operational characteristics of organic handlers (such as the share of gross sales that are organic and functions) and marketing characteristics (such as products sold and distance to markets) (Tab 1). Geographic variables were excluded as insignificant.

Results and Discussion

In terms of operational characteristics, similar to Park and Lohr (2006), those handlers with a higher share of organic sales (Options 2 and 3) and more experience in the organic sector (Option 3), represented by years certified organic, were more likely to employ more than just one marketing outlet for all organic sales (Tab 2).

Tab. 2: Results of the multinomial regression, marketing outlet use

Explanatory variables	Option 2: Use of two market outlets		Option 3: Use of three or more market outlets	
	Estimated coefficient	z-statistic	Estimated coefficient	z-statistic
Years certified	1.040	1.62	1.078*	2.83
Share organic sales	1.010*	3.58	1.021*	6.48
Producer-handler	1.638*	1.87	0.912	-0.31
Manufacturer	2.043*	2.18	1.647	1.43
Wholesaler	2.967*	2.75	3.732*	3.19
Broker	1.960	1.11	1.299	0.34
Packer/Shipper	2.381	1.92	3.332*	2.52
Sells to retail outlets	1.024*	4.44	1.033*	4.98
Sells to intermediaries	1.001	0.31	0.998	-0.32
Sells to direct/institutions	1.008	1.48	1.020*	3.03
Local sales	0.312*	-2.94	0.215*	-3.41
Regional sales	0.207*	-4.07	0.069*	-4.79
Sells produce	1.248	0.71	1.486	1.14
Sells manufactured products	1.371	1.25	1.596*	1.65
Sells grains or feed	2.217*	2.07	0.349	-1.53

*indicates significance level of 10 percent or better. Log odds are reported. Base case is use of one marketing avenue for 100 percent of sales. Number of obs = 706; $X^2(30) = 342.33$, Prob > chi2 = 0.000; Pseudo R2 = 0.2256.

Not surprising, wholesalers and packers and shippers, as well as those selling manufactured products, are more likely to use more marketing outlets (Option 3). In addition, as the handler’s percentage of organic sales to retail and direct/institutional markets increases, so does the facility’s likelihood of using three or more marketing outlets. Finally, as the percentage of organic sales to local and regional markets increases, the likelihood that the handler uses three or more markets decreases.

Handlers also certified as organic producers and functioning as manufacturers and wholesalers were more likely to market to two marketing outlets than those using just one marketing outlet for all sales. Like those using three markets, those selling through retail outlets were more likely to use two outlets, and those selling organic products locally and regionally were less likely to use two marketing outlets. Handlers doing business in grain and feed products were more likely to use two markets than those facilities using only one market.

Conclusions

Organic handlers play a crucial role in moving organic products along the supply chain, from farm to consumer. Rapid growth in the organic market can have a dramatic impact on individual handlers. Handlers are moving larger quantities of organic food along the supply chain as the types of outlets have shifted from the traditional direct markets to a wider range of outlets. These market changes create marketing risk for companies striving to remain profitable in a more competitive environment. Those utilizing a greater diversity of marketing outlets may be better placed to bear the risk commensurate with rapidly changing markets.

This paper makes use of a new dataset, and is the first effort in understanding the factors that influence the marketing decisions of organic handlers in the United States. The results indicate that experience in the organic sector, the share of organic sales, and functions of the handling facility affect the number of marketing outlets used by organic handlers. In addition, handlers using retail outlets and direct/institutional outlets are more diversified in terms of the number of markets used. Handlers selling to local and regional markets, on the other hand, use fewer outlets. Thus, the analysis suggests that firms marketing beyond the regional area, with a higher share of gross sales in organic products, and with more experience in the organic sector are those best able to, in the face of changing market conditions, supply the rapidly growing organic food market.

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Opportunities for small organic shops despite the rise of organic supermarkets

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Key words: organic shops, specialised supermarkets, marketing

Abstract

Similar to the trend in the German organic food industry as a whole, development on the Berlin organic market is currently very dynamic. As a result, many organic supermarkets and chains are moving to Berlin, creating a major challenge for small Berlin organic shops in particular. We examined the current competitive situation on the natural foods retail market on the basis of a market analysis and interviews with experts. Potential measures for improving the competitive positioning of smaller organic shops were identified. Although to date not many smaller organic shops have been driven from the market, experts and market players expect the structure of the market to change to the detriment of organic shops because organic supermarkets have better competitive advantages in many areas including communication policy, pricing policy, sales floor layout, etc.. However, small organic shops have still not yet totally exploited their full marketing potential, particularly with respect to the sales mix policy and communication policy. For small shops to compete on the market, they need to have a distinct profile, strengthen their function as a local supplier and systematically increase the already high level of customer satisfaction.

Introduction

Berlin is one of the largest organic markets in Europe. Sales of organic products in Berlin have risen consistently over the last few years (Scholl, 2007), a trend that was accompanied by a sharp rise in the number of organic supermarkets in Berlin. The result is that organic shops in Berlin face ever increasing competition from within their own industry. These competitors have competitive advantages which have economic consequences for retailers. This study analyzes the development of the organic retail industry in Berlin, how strongly Berlin shop owners feel that their economic existence is threatened by the organic supermarkets and what options they have for improving their competitive position.

Materials and methods

The market was analysed by counting the businesses listed in the Berlin-Brandenburg organic shopping guide for the years 2004, 2005 and the current address database of the development association for organic agriculture in Berlin-Brandenburg (FÖL).

Guideline based interviews were conducted with experts with the goal of generating the knowledge necessary to explain social change (Meuser and Nagel, 2005) and

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avoid having to carry out time-consuming observation processes (Bogner und Menz, 2005). The experts were 4 owners of organic shops in various districts of Berlin, the managing director of an organic supermarket chain in Berlin, the managing director of a regional wholesaler in Berlin-Brandenburg and the head of an association in Berlin-Brandenburg for promoting organic agriculture. We define organic shops as owner-run shops up to 250 qm in size (Spiller, et. al. 2005) while organic supermarkets are larger than 250 qm, have a modern look and feel and a full range of products with 5,000 to 10,000 individual items (Richter, 2005). The interview guidelines were based on the following hypotheses: 1. The biggest competitor for small shops in Berlin are the organic supermarkets. 2. Small shops have as yet unexploited potential in marketing to improve their competitive position. 3. Regional wholesalers can help smaller shops in Berlin improve their competitive position. The interviews were analyzed in seven sub-steps (Meuser and Nagel, 2005) as follows: a) recording, b) complete transcription without notation based on the actual interviews, c) paraphrasing, d) creation of headings: the text material was consolidated with either more or less detail depending on the hypotheses, e) topic-based comparison: sections from the individual interviews that addressed the same topic were merged f) sociological conceptualization: disengagement from text, abstraction g) theoretical generalization: establishing correlations and identifying standard terms. These detailed and exact processes were chosen to ensure that the results reflected the experts' knowledge and eliminated the influence of the author's personal interpretation of the interviews to the greatest extent possible.

Results

The market analysis showed that the number of organic supermarkets in Berlin increased from 19 to 32 between 2003 and 2007; in contrast, the number of organic shops fell slightly by 10% from 99 to 90 (FÖL, 2006). According to the interviewees, smaller natural food stores are being driven from the Berlin natural foods retail market. This can be attributed to the tougher competitive situation between organic supermarkets and organic shops. Organic supermarkets have a better competitive position over smaller shops primarily in terms of marketing tools, sales mix policy, pricing policy, location policy, communication policy outside of the sales sites, communication policy within the sales sites, sales floor layout, etc. Reasons are economies of scale in advertising, purchasing, distribution and management. According to the experts, however, competition between the organic supermarkets will also continue to increase over the next few years. Some organic supermarkets will open more branches while others will close. The smaller organic shops, however, still have considerable room for improvement in marketing. One key way to enhance customer loyalty is to strengthen the function of the organic shops as local suppliers. In addition, services play an important role in customer loyalty. These services could include, for example, a snack bar, a delivery service, individual orders and advice, business hours in line with customer needs, etc. Experts also said that there are opportunities for smaller organic shops to improve their competitive position by tailoring their selection of products specifically to their customers and distinguishing themselves through specialty products produced in small quantities that the large organic supermarkets cannot offer because of their standardized production processes. Even though several experts thought pursuing a purchasing collective (from regional wholesalers) to improve pricing was a good idea, an in-depth analysis would be necessary to determine how much work and cost would be involved. Other experts were skeptical and didn't feel this would be realistic. However, some experts would welcome more support from regional wholesalers to improve the competitive positioning of smaller shops. A network between the shops is deemed practical for exchanging ideas and investigating possibilities for cooperation. To raise awareness about the problems and stimulate discussion within the industry, the interviewees regard it as necessary to inform the public of the structural change the natural foods retail market is undergoing in Berlin either in the press or through the distribution channels used by organic shops.

Discussion

"The organic shops are facing the same fate as the mom-and-pop stores in the 1970s," was the conclusion Spiller and Gerlach (2006) reached in their study on how dynamic the organic industry is. The experts interviewed also foresaw this trend for the Berlin organic shops even though the analysis of the market structures in Berlin does not as yet indicate a significant structural change in the Berlin natural foods retail market at the expense of the smaller organic shops and only a slight drop in the number of organic shops has been recorded. However, the remaining organic shops have already reported losing revenues and customers to the increasing numbers of organic supermarkets. These results confirm the assessment of Spiller et al. (2005) who considers the organic shops' strongest competitors to be the organic supermarkets because of their competitive advantages in many areas. The experts consider the better prices of the organic supermarkets to be their main strength. This confirms the Hamm and Wild's assessment (2006) that "price will be the primary factor in driving competitors from the natural foods retail market in the future". The shopping atmosphere in organic shops was considered better by the experts than in organic supermarkets. This outcome is consistent with the results of the customer survey in the "Network for natural food stores Munich" project (Pichelbauer, 2007). In addition to the large stores with a full range of products and modern facilities, Braun (2006) gives the small, personal specialty stores the best chances for a successful future. This assessment was shared by the experts for the Berlin market. However, none of the businesses surveyed pursues strategic marketing although this seems advisable particularly for medium-sized, traditional organic shops (Braun, 2006).

The dynamic development in creating new branches of the organic supermarkets and the customer losses associated with this development represents an economic threat for the Berlin organic shops. Strategic marketing could help small organic shops improve their competitive position. Regional wholesalers could give small shops more support here. Thus the hypotheses we set out to examine have been confirmed.

Conclusions

Shop owners should first recognize the value of marketing for the success of their business and undertake the appropriate measures. We recommend further developing core services and competencies with a range of services. An easy way to give the customer additional benefit would be, for example, to sell snacks and hot beverages or open a bistro. Constantly changing the free samples on offer enhance the customer experience and increase revenues. Increasing the percentage of goods certified by German organic associations and communicating to customers the differences in production and processing over other certification guidelines could be another element in creating a distinctive profile. Another option would be to increase the percentage of distributor brands in the range of products. These affordable organic brands for first-time buyers could help win over new customers. Individual, inviting, frequently changing window displays (e.g. large format photos, creative collages of packaging, etc.) and a distinctive corporate design could catch the eye of people walking by. Visible external advertising which clearly shows the organic label are recommended.

With respect to customer relationship marketing, we would recommend that the organic shops get involved in the cultural and social life of the respective neighborhood, e.g. with sponsored playground festivals, informational events on sociopolitical issues in their shops or by supplying sporting events with beverages. Drawing contests for children whose pictures are then displayed in the shop window or events in the district center (nutritional advice, cooking courses) are other suggestions for more intensive customer relationships. Customer loyalty could also be boosted by enhancing the customer experience in the shop through a direct partnership between the shop and agricultural businesses in Brandenburg and photos or short films about current work, successes and difficulties on the farm, etc. so that the customers get an idea of how production works. Another way to market smaller shops is by becoming members of the Fair und Regional Bio Berlin-Brandenburg association for producers, processors and retailers. And, last but not least, a consistent human resources policy that incorporates regular trainings and intercompany discussions and advice, service and sales psychology are indispensable to the success of an organic shop.

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The German organic sector from the perspective of social-ecological research on agriculture and nutrition

Nölting, B.[1]

Key words: social conditions, development of organic agriculture, education-consulting-knowledge transfer, consumer protection, sustainable development.

Abstract

Social-ecological research analyses agriculture and nutrition from the perspective of sustainable development. This interdisciplinary and transdisciplinary approach embeds the organic sector in a broad societal and ecological context, integrating normative aspects into its research methodology. New insights from six German research projects are presented.

Introduction: Social-ecological research on agriculture and nutrition

Far-reaching transformations can be observed in the field of "agriculture and nutrition", but not every developmental path leads toward sustainable development. Undoubtedly, organic agriculture and food industries can contribute toward sustainable development in manifold ways (Halberg et al. 2006). However, not every organic enterprise is necessarily sustainable. The organic sector represents one important option, amongst others, for achieving a more sustainable agriculture and nutrition. This paper deals with questions concerning what role the still relatively small organic sector can and should play in the vast field of "agriculture and nutrition".

This contribution draws on results from the Social-Ecological Research Programme of the German Ministry of Education and Research. Social-ecological research is a type of sustainability research which integrates knowledge derived from different disciplines and practical experiences in order to elaborate feasible solutions for sustainability problems. Six research projects using this approach of social-ecological research analysed the field of "agriculture and nutrition", covering conventional and organic agriculture, food processing, marketing and consumption, and cooperated in a research network (tab. 1).

Tab. 1: Topics of the projects from the social-ecological research network

Projects	Agriculture	Processing	Marketing	Consumption	Policy
Food change			✓	✓	✓
OSSENA	✓ (regional)	✓	✓	✓	
Turnaround in consumption	✓ (organic)	✓	✓	✓	✓
Regional wealth	✓ (organic)	✓	✓		(✓)
AgChange	✓				✓
PartizipA	✓				✓

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The methodological approach of social-ecological research

The conceptual and methodological approach of the network projects[1] has the following three primary characteristics. 1) These research projects referred explicitly to the *normative concept* of sustainability, clarifying which of the rival definitions of sustainable agriculture and nutrition they held and what their position on these conflicts and debates was. 2) The researchers took an *integrative perspective* on sustainability problems combining agricultural and nutritional research with regard to the whole value-added chain and its linkages with nutrition. 3) *Participatory approaches* included practitioners, stakeholders etc. in order to link the analysis closely with real world problems as a basis for developing practical solutions.

In sum, the projects, discussing their results in the research network, did not focus on single, disconnected aspects of organic and conventional agriculture and nutrition, but rather analysed relevant sustainability problems in relation to the framework conditions as well as to their particular context. The integrative approach and an intense relation with practitioners complement one another, thus going beyond disciplinary research.

Some results from social-ecological research projects

Some exemplary results with regard to organic food production and consumption in Germany are presented here (for more information see Nölting/Schäfer 2007 and the project websites). They can be assigned to the three main components of the field of “agriculture and nutrition”: 1) enterprises from food production; 2) consumers and nutrition; and 3) policies and discourses as framework conditions.

From sustainable food to sustainable enterprises: The project “Regional wealth” analysed the contribution of enterprises from the organic food-chain towards quality of life and sustainable development in the Northeast German region of Berlin-Brandenburg. One method was a close stakeholder participation including trans-disciplinary workshops, joint decisions about indicators, and an advisory council of practitioners from the organic sector. Due to this participative approach, the results show that organic companies are not only engaged in environmental protection – even beyond the organic standards – and create jobs and income. Further, the research revealed “invisible” social effects such as a transfer of knowledge and experiences about sustainable agriculture and healthy nutrition to consumers, the participation in regional networks, and the stabilisation of social resources in rural areas (Schäfer 2007). The project “Turnaround in consumption” compared organic farms in two German regions and developed a typology of organic farmers according to region, motivation and economic specialisation. The results reveal that organic farmers are also involved in diverse activities (e.g. tourism, natural protection, marketing) that foster rural development. This typology helps identifying and addressing the “right” farmers for specific projects of rural development (Engel et al. 2006).

Both projects point out that entrepreneurial activities entail more than just employing a sustainable mode of production (e.g. environmentally friendly, fair) and creating

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[1] See www.sozial-oekologische-forschung.org/en/154.php. The projects are: *Food change* (www.ernaehrungswende.de); *OSSENA – Nutritional quality as quality of life* (www.ossena-net.de); *From the turnaround in agrarian policy to a turnaround in consumption patterns?* (www.konsumwende.de); *Regional wealth reconsidered* (www.regionalerwohlstand.de); *PartizipA - Participative modelling, analysis of actors and ecosystems in agro-intensive regions* (www.partizipa. net); *AgChange – conflicts in the new agricultural policy* (www.agchange.de).

sustainable products (e.g. healthy). Additionally, the integrative and participative approaches stress the impact of the enterprises on society beyond the market as well as the importance of the social embeddedness of organic firms. In fact, the social contexts of organic firms and their positions within the market are corresponding factors, e.g. a sustainable profile can be an asset for marketing. In this regard, however, trends in the German food market, such as severe price competition, are a drawback for sustainable food production.

Taking the perspective of consumers seriously: The projects “Food change” and “OSSENA” show that consumers do not orient their nutritional practices solely toward achieving economic cost-benefit-maximisation or comprehensive information. As “competent” consumers, they rather manage their nutrition within the constraints of a complex everyday life and according to deeply rooted nutritional cultures and patterns, which makes changes in nutritional habits very difficult. Adopting a participatory and gender sensitive approach, the project “Food change” focused on the everyday perspectives of consumers other than the perspectives from e.g. marketing, nutrition or health experts. The findings show that consumers need simple solutions for sustainable nutrition that easily fit in their everyday life. Organic food is only one element of combined, easily accessible offers of sustainable nutrition; other elements are fair trade, regional food, less meat, competences in cooking and healthy eating, adequate options of out-of-home-eating etc. (Eberle et al. 2006). These findings are also reflected in the research project “Turnaround in consumption” that developed an integrated model of action that addresses the perceptions, knowledge, motivations and actions of consumers simultaneously, in order to motivate them toward eating more organic food. Such a campaign will only be successful, however, if it addresses the specific experiences of the target group and their everyday life context, instead of inundating them with information and “preaching” the right diet.

Discourses and policies: Necessary changes for sustainable agriculture and nutrition entail re-formulation of policy goals and redistribution of resources and chances. Such alterations arouse conflicts, and there is a fierce struggle going on in Germany over redesigning policy strategies and re-framing public discourses on agriculture and nutrition. Disputes about organic agriculture and genetically modified organisms are at the heart of such conflicts. The projects “PartizipA” and “AgChange” – using participatory methods, such as group model-building or participatory sustainability impact assessment – suggest that conflict does not necessarily obstruct finding solutions, but can rather be a starting point for constructive problem solving. By including debates on normative aspects and valuations in the analysis as well as involving stakeholders, the projects were able to use the diversity of perspectives as well as normative conflicts as a source of knowledge and motivation.

Discussion of the results and conclusions for organic research

The results and recommendations of the network projects point out that sustainability problems cannot be resolved by single measures such as organic food production and consumption. The researchers, often together with practitioners, formulated and experimented with manifold instruments and strategies. Even though practitioners were not always able to directly implement these recommendations, social-ecological research produces knowledge at the interface of society and science. This robust research perspective embeds organic food production and consumption in a broad societal context, examining them in light of sustainable development. Its strength lies in employing an interdisciplinary and transdisciplinary mode of analysis of food production and nutrition which can also provide new insights for specialised organic research. It helps to link the organic sector with the vast field of “agriculture and nutrition” which is dominated by conventional production and faces manifold sustainability problems (health/obesity, environment, biodiversity, market concentration, nutritional culture etc.). Organic food production cannot resolve these problems alone because of its relatively small size and because it addresses only some of these problems. However, the results from social-ecological research suggest that the social context of organic enterprises and consumers, their motivation and valuations, heterogeneous actor networks, conflicts over policies etc. can have a potential for sustainable development even beyond organic agriculture. It points toward topics for further research, such as the following:

1. Having started as a social movement that tried to change society, the organic sector has been familiar with the debate on normative implications and value judgments since its origin. However, these discussions seem to have grown less important during the phase of differentiation and professionalisation over the last years. The organic sector, and those who research it, should again revisit and take up the debate with regard to sustainable development; it has to clarify its normative orientations within the whole value-added chain and the role of organic agriculture in society in general.

2. Sustainable nutrition entails more than organic food. Consumers need room for manoeuvre, competences in nutritional understanding, and management strategies concerning how to handle nutrition in everyday life and in the framework of existing nutritional cultures. Since sustainable nutrition means more than individual choice (at the market), consumers need professional assistance and empowerment. In this respect, it seems worthwhile to explore the potential of organic food consumption further.

3. Political conflicts and controversial discourses about (organic) agriculture and nutrition should inspire societal learning on sustainability. Research should identify the most effective procedures and strategies for societal learning and how they can be made fruitful for further development of the organic sector and increasing its contribution toward sustainable nutrition.

Acknowledgments

Thanks to all participants of the research network and to the German Ministry of Education and Research for funding the Social-Ecological Research Programme.

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The Prospects of Organic Agriculture Development in the Chosen Regions of Poland – Podkarpacie and Kurpie.

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Key words: organic agriculture, development, Kurpie, Podkarpacie, Poland

Abstract

Organic farming is developing dynamically in the European Union. In Poland its growth is dynamic but still not on a wide scale. The area of organic farms has just exceeded 1%. Research shows that the main obstacles of the dynamic development of organic farming are lack of properly educated young farmers, lack of efficient distribution system of organic products in Poland and abroad and a lot of small farms of low productivity.

Introduction

Organic farming not only provides high quality produce, but at the same time is a crucial element of multifunctional development of agricultural areas, in other words sustainable development (Knickel et al. 2006). Organic farming is developing in Poland. According to Main Inspectorate of Market Quality of Agriculture Products and Foodstuffs (GIJHAR-S) there is a constant increase in number of organic farms. (www.ijhar-s.gov.pl). Poland is a country in which historical events and political conditions do not foster a dynamic increase in consumers' organic awareness. Poland is on the fifth place in the world after the USA, Argentina, Italy and Canada in terms of increase of organic land area (Willer and Yussefi, 2007). Even though the organic utilised agricultural area rose up to more than 80 000 in 2004, olthough, it is still a bit below 1% of all UAA. As a result, a supply of organic products on the domestic market has increased; still, the demand keeps its fairly low level (Żakowska – Biemans, 2005).

Organic production is a chance for a number of small, not very specialized farms. Due to difficult climate conditions, poor soils, not good economic and social conditions, regular farming production is very close to organic production which makes it easier to convert into an organic one. However, there is a need for financial, organizational and educational support for organic agriculture production and for improvement of market organization of organic products (Runowski, 1996; Runowski 2003).The Kurpie region is located in the north-eastern part of Poland called "The Green Lungs of Poland". There are a large number of small low income farms and the soils are poor. Lack of big cities and unpolluted environment comprise excellent conditions for organic farming development. This part of Poland is especially suitable for milk production. Nevertheless, it is still underdeveloped in terms of tourism (Bołtromiuk, 2001;Toryfter, 2002). The Podkarpacie region is similar in those respects although it is situated in southern-east Poland. There are a lot of environmentally sensitive areas. Agriculture is based on family ownership and dairy production (Sołtysiak, 2002).

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The aim of the research was to present the possibilities and barriers for development of organic farming in those regions and present the practical outcome of the situation.

Materials and Methods

The paper is a review of the current situation of organic farming in the Kurpie and the Podkarpacie regions among organic and conventional farmers. The research has been conducted in the form of a personal interview – a questionnaire, which included both opened and closed questions. There were two types of questionnaires: respectively for organic and conventional farmers. The results included in the paper come from the research done in 2006 and 2007. In the Kurpie region there were 72 farmers questioned: 35 organic (9 during conversion) and 37 conventional. In the Podkarpacie region there were 96 questionnaires: 63 organic and 33 conventional.

Results

The average age of organic and conventional farmers is similar in the Kurpie region whereas in the Podkarpacie region organic farmers are older than conventional (fig.1). In the group up to the age of 40 there are more conventional farmers in both regions (about 5%) whereas in the group over 60 there are more organic farmers in both regions (about 5%).

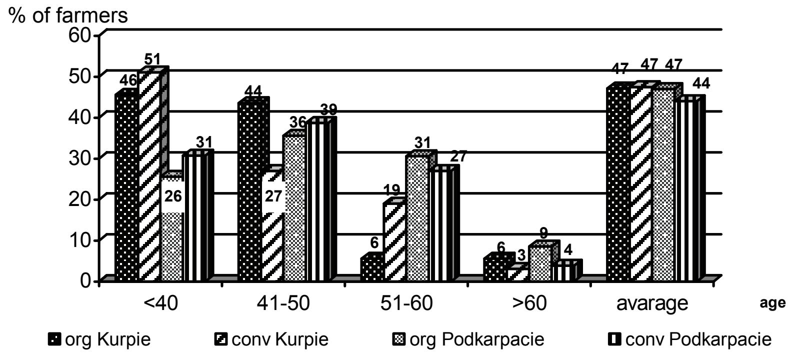

Figure 1: Age of organic and conventional farmers in Kurpie and Podkarpacie 2006/2007

In both regions the majority of organic farms are the small ones, i.e. the size do not exceed 20 ha (fig. 2). However, in the Podkarpacie region there are 66% of farms that belong to the group of 1 – 5 ha. In the Kurpie region 51% of farms have 5 – 10 ha.

Horizontal integration is one of the factors that let farmers improve their situation on the market, e.g. better access to distribution channels. The regions are different in this respect (fig.3). In the Podkarpacie region farmers are better organized, i.e. 88% belongs to seven different kinds of farmers' organizations whereas in the Kurpie region 42% belongs to 2 farmers' groups.

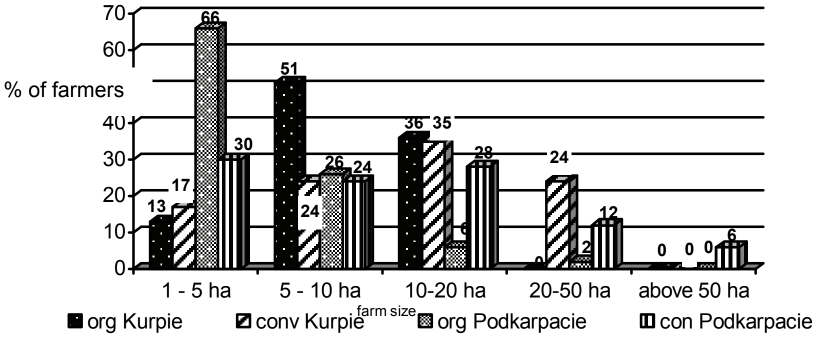

Figure 2: Participation organic farmers in farmers' associations

Selling products on the local market dominates in both cases (fig. 3). However organic farmers seem to use direct sales more often than conventional ones. Moreover, among organic farmers in the Kurpie region box schemes and selling products directly to the different kinds of shops is better developed.

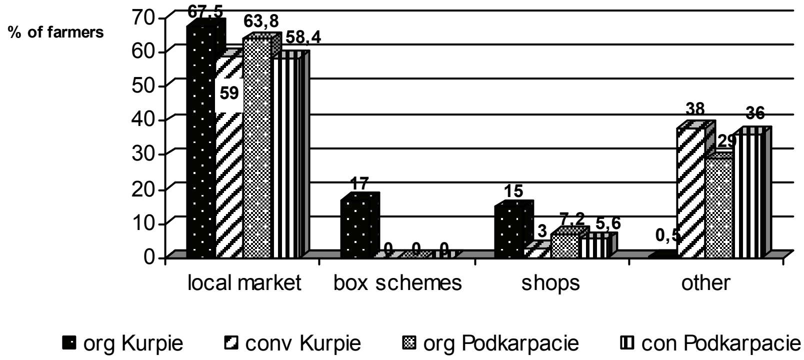

Figure 3: Distribution of organic product

Discussion

As indicated by earlier research, both regions are perfect in terms of environmental conditions for development of organic farming (Sołtysiak et al 2002, Toryfter 2002). One of the main factors stimulating growth of organic farming are young well educated farmers who proved to be more dynamic and ready for changes and improvements (Runowski 1996, 2003). Therefore in the researched regions there is a need to introduce incentives which will influence the lowering of the average age of the farmers, and will encourage the young ones to stay in the country. One of them might be financial support, especially during the conversion period and after for further development and modernization. Presented results prove (Slabe et al, 2006), that well organized market is one of the key conditions for development of organic sector. They also show that the farmers from the small farms, regardless of their association with production groups or other organizations, are not capable to develop the production to the extend allowing them to go beyond the local market. Organic farmers from the Kurpie region, for example, despite the fact that they are worse organized, show better creativity when it comes to sales methods (box schemes). It may be related to the fact that there is a significantly bigger number of the young farmers (below 40) in the Kurpie region in comparison to the population of farmers from the Podkarpacie region. A lot of small low productivity farms, lack of connection between producers and processors and lack of well organized distribution channels for organic products were listed by the farmers in both regions as the main factors which hamper the development of organic farming.

Conclusions

1. Development of organic farming is a chance for sustainable development in the Kurpie and the Podkarpacie regions. Both regions have suitable environmental qualities for the development of organic farming, but they need suitable forms of support in order to encourage them to stay in the country.

2. The main obstacles for organic agriculture development are: small size of organic farms, their low productivity and lack of young well educated farmers.

3. The young age of farmers is a much stronger influence regarding their creativity and looking for new methods of sales than their participation and membership in producers' associations and organizations.

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Agromere: how to integrate urban agriculture in the development of the Dutch city of Almere?

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Key words: Urban agriculture, sustainable cities, stakeholder management

Abstract

Urban agriculture produces green city areas with as an extra dimension providing food, energy, care, education or recreation for the civilians. And thus it can contribute to a more sustainable and liveable cities. The objective of the project Agromere is to create a process which will lead to a new residential quarter where agriculture is fully integrated in city live. Agromere is situated in the fast growing city of Almere, the Netherlands. In a combined stakeholder and design process a township is designed which integrates living (5,000 inhabitants) with urban agriculture on 250 ha. During this process an enthusiastic network of stakeholders has been established which developed innovating and unique ideas on urban farming. The potential for organic farming in the city is high because of its emphasis on animal welfare and consumer relations.

Introduction

Nowadays more than 50% of the world population (3,3 milliard people) is living in cities (Martine, 2007). In the Netherlands this percentage is already more than 75%. In the Dutch urban environment people become estranged of food production, nature and the basic values of rural live, like quietness, darkness and the rhythm of seasons. Is it possible to (re-)introduce agriculture in city development and so contribute to a more sustainable and liveable city? Urban farming is already working in both developing and developed cities worldwide, including the Netherlands (Dekking et al, 2007; Van Veenhuizen, 2006). In most cases urban farming is about local food production and green environment. In addition to this urban agriculture can fulfil more of the city needs, like health care, elderly services, child care and education. Farming could also contribute to the shape and management of the green fringe of the city. Moreover, it can function as energy supplier, water buffer and processor of city waste.

Agromere -an imaginary quarter of the city of Almere (180,00 inhabitants)- is a good example of how urban agriculture can be applied in city design. Almere has to expand because of the growing need of new houses in Western part of the Netherlands and in absence of other places to build. In 2030 with 400,000 inhabitants Almere will be one of the major cities in the Netherlands.

Materials and methods

The objective of the case Agromere is to create a process which will lead eventually to a new residential quarter where agriculture is fully integrated in city live. The assumption is that it is essential when important stakeholders participate in this

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process and fully contribute to the final result. Eventually, the stakeholders have to adapt urban farming as an added value in sustainable city development. In order to guarantee this, we combined the **DEED** framework (Giller, 2005) and the stakeholder approach (Freeman, 1984). Here, the iterative cycle of investigation starts from **D**escription and cycles through **E**xplanatory, **E**xploratory and **D**esign phases. Each of these activities feeds into the negotiation between stakeholders, which forms the core of this approach. These stakeholders represent, the Ministry of agriculture, local farmers, city counsel of Almere and Zeewolde (nearby town), the province of Flevoland, nature conservation organisations and commercial city developers. To explore also the needs of the citizens of Almere, two quantitative surveys were carried out. In the 2005 survey, 342 citizens (ad random selected in two city quarters) were interviewed by telephone to discover the demand for agriculture in Almere (Stobbelaar et al, 2006). In 2007 an internet survey, using the consumer panel of the municipality of Almere (N=562), explored the demands on urban agriculture as it would be part of the neighbourhood (Engelen, 2007).

Results

Description phase: The North east of Almere (app. 2,500 ha) is a polder landscape reclaimed about 50 years ago. Agriculture (most large scale arable farming) is the main land use activity nowadays. In this area the city of Almere needs to expand with 20 to 60,000 houses. At present, agriculture is excluded in the development plans. Explanation phase*:* Agromere started in 2005 with creating a multi stakeholder network in Almere. All of these stakeholders have different claims and interests on the area of north east of Almere: houses, nature, cultural history, industry, water housholding, infrastructure and agriculture. To explain these claims, the major drivers behind these different claims were described and later discussed in a workshop with the stakeholders. Exploration phase: The approach of future scenario's was used to cross these present claims and interests. Future scenario's are based on the assumption that it is important to develop systems or designs which are prepared to deal with future uncertainties, rather than to build on known certainties (Van der Heijden, 2005). All stakeholders were interviewed on possible uncertainties on developing Almere North east and the role of urban farming in this development. The stakeholders defined technology and locality as the most important uncertainties. Based on the extremes of these uncertainties we created in cooperation with the stakeholders four concepts for urban farming: Topspot, Ecocity, Agripel and Farmers village. These four concepts were used as a tool in the process towards joined images on urban agriculture, they were not a goal in itself. Subsequently these four were confronted with the claims and interests of the stakeholders. The stakeholders choose a combination of Ecocity and Farmers village as the most appropriate.

The two surveys are showing that inhabitants have an open mind for agriculture in their direct surrounding. Respondents gave urban farming an important role in maintaining green areas, keeping quietness and open spaces in the city. Food supply, energy production and waste management were mentioned as important functions (fig. 1). One third of the respondents appreciate a distance to the farm of less than 500 m. Animal welfare on the farm is important for two third of the respondents, an organic way of production for one third. Preferred activities at the farm are shopping, walking, visiting a restaurant and having an educational tour.

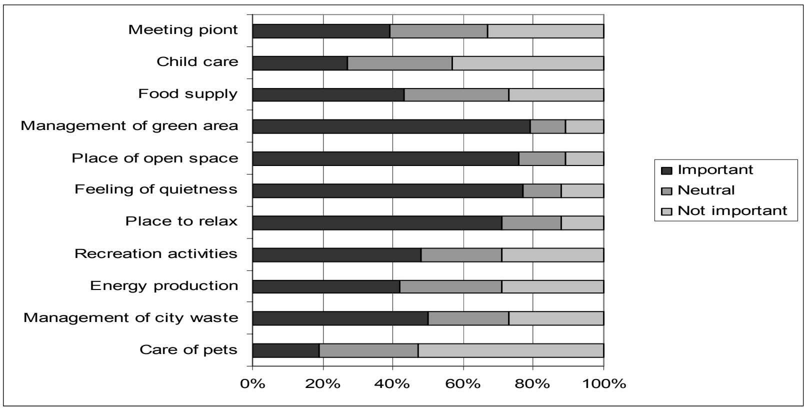

Figure 1: Important functions of urban farming to respondents (N=562) in Almere (NL). Source: Engelen, 2007.

Design phase: In this fourth step we outlined the village of Agromere with app. 5,000 inhabitants (or 2,300 households) on 250 ha of land. For houses and infrastructure 80 ha is used. These are normal figures in current Dutch city planning. On the remaining 170 ha, four urban organic farms are situated: a community supported vegetable farm (CSA), a dairy farm with nature-education, a greenhouse farm, with restaurant and school and an arable farm with health care and village-shop. Each of those four is related to each other by (re) using products, services, raw materials and waste.

Discussion

The Agromere case shows that spatial planning can be done interactively without using too much of the sparse land. In Agromere, the open space normally used for parks, play grounds and ponds, now gets an urban agrarian function. The amount of open space in the village remains still the same. The two surveys confirm that the inhabitants of Almere perceive the added value of (urban) agriculture as city green. The potential for organic farming in city live is high because of its emphasis on animal welfare and consumer relations (Stobbelaar & Van Veluw, 2006). Remarkably was that the enthusiasm of the respondents for urban farming was growing during the questioning indicating that more information on the added value of urban farming is necessary. A comparable survey in 2007 in Amsterdam (N=1062, not published) confirms this assumption.

Successful planning of urban farming requires the involvement of a wide range of actors stakeholders (Dubbeling and Merzthal, 2006). The DEED framework, the two surveys and the Future Scenario approach were helpful in this combined stakeholder and design process. At the start, stakeholders had no idea of urban farming and the way it can fit city planning. During the process an enthusiastic network of stakeholders (together with research) has been created which developed innovating and unique ideas on urban farming. We continue developing the outlines of Agromere in cooperation with the stakeholders because of by the summer of 2008 the municipality of Almere has to launch the developing plans for Almere North east. Urban agriculture is now a serious option in these developing plans.

Conclusions

The outline of Agromere indicates that a participative design process of urban farming is needed to commit stakeholders to this new concept. Without this process urban farming will not be a natural part of the spatial planning and city development of Almere. The Dutch citizens are still aware of the added value of agriculture in their live, but there is a need to inform them further about this added value of urban (organic) agriculture.

Acknowledgments

Special thanks we owe to the students Neeke van Zwol, Anna Veltman, Christel Engelen and Marleen Warnaar for their contribution to the Agromere project.

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The New 'Local': A Global Review of Using Geographical Indications

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Key Words: Geographical Indications, appellations, small farmers, developing countries, standards, tradition, culture, environment.

Introduction

What do Parmigiano cheese, Bordeaux, Idaho potatoes, Basmati rice, and Darjeeling tea have in common? As the concept of 'local' sourcing and marketing becomes more important, these Geographical Indications (GIs) or appellations are a potentially unique form of competitive advantage available even for small farmers and enterprises. A GI legally identifies and formally recognizes a good as originating in a delimited territory, or region where a noted quality, reputation or other characteristic of the good is essentially attributable to its geographical origin and/or the human or natural factors there.

Organic standards, though valuable, may not offer the most appropriate way of safeguarding the actual provenance of local foods and conveying this to consumers in the marketplace. However, in more than a hundred nations, GIs are recognized as a unique expression of local agro-ecological and even cultural characteristics that have come to be valued as signals of high quality and local traditions. In many cases GIs can readily combine with organic certifications and thus provide a unique combination of assurance to consumers.

Description and Methods

A multinational team[2] has reviewed nearly 200 published studies on the experience in the EU, US, and elsewhere as well as assessed, via nine original case studies, what different popular origins have done with their GIs in Guatemala, Jamaica, Mexico, Ethiopia, India, Colombia, Kona, and Mongolia. The goal is to provide an objective 'Guide' to understanding, forming, and using GIs effectively (to be published by the UN's International Trade Center).

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[1] Work undertaken for the UN International Trade Center. The full document will be available in mid 2008. Author contact: D@DGiovannucci.net

[2] In addition to the project leader Daniele Giovannucci, the research team includes:

Catarina Illsley (Head, GEA Grupo de Estudios Ambientales)

Tim Josling (Professor Emeritus Stanford University)

William Kerr (Agricultural Economics chair at University of Saskatchewan and editor of the Journal of International Law and Trade Policy)

Bernard O'Connor (EU Attorney and Professor of Law, author of 'Agriculture in WTO Law' and 'The Law of Geographical Indications').

Dwijen Rangnekar (Senior Fellow at the Centre for the Study of Globalisation and Regionalisation and the School of Law Warwick University)

The literature review documents, among other things, the considerable success of many origins that have formal GIs to confirm and convey their local attributes to the market. This is measured by difference in revenue and employment for formally recognized GIs when compared to similar products in those regions.

In addition to reviewing the practical pros and cons of different approaches to GIs, the review will also explain the costs and benefits and provide information to assess the different instruments available. so that developing country producers, communities, policymakers and technical ministries for agriculture, commerce, intellectual property, etc. face unique challenges and barriers to creating effective GIs. For e.g. to protect their GIs requires an understanding of the application of complex legal issues that differ considerably in different markets. One result of the review is a basic set of guidelines informing stakeholders about what to consider when undertaking the development of a GI.

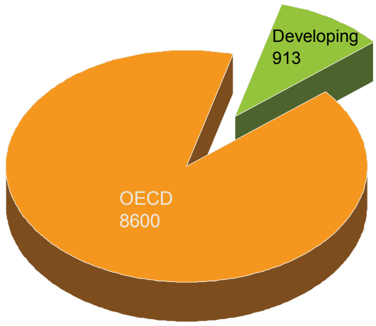
Key Conclusions of the studies

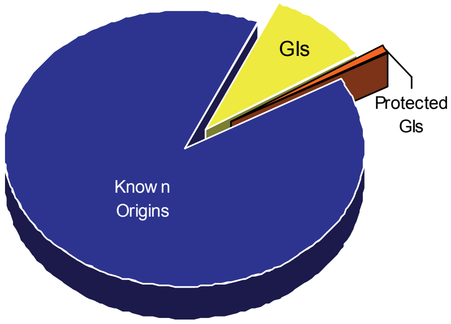
Geographical Indications can prove to be a valuable asset for organic producers and marketers because GIs can complement and are in alignment with the precepts of organic agriculture. They can foster market-based support for local traditions and cultures. They provide an excellent framework for broad-based and equitable rural development at the regional level. Viable GIs are essentially building a legally protected brand and a reputation in the marketplace. They are not easy to achieve nor easy but also not easy to erode because they depend less on common factors of competition in the field of agrifood production such as costs of production.

Developed Nations have many well known GIs including*:* Scotch, Roquefort, Champagne, Parmigiano, Cognac, Feta, Kona, Vidalia, Port, and Bourbon. In contrast, developing nations have relatively few, but their success hass increased the level of interest in them as a way of protecting the concept of local production in a manner that is harmonious with existing international trade regulations such as those of the WTO and particularly the TRIPS Agreement. Among the better known are: Ceylon tea, Pampas beef, Tequila, Basmati, Darjeeling, Blue Mountain, Tellicherry, and Café de Colombia.

Distribution of Geographic Indicators

Although most of the protected GIs exist in developed nations, a far greater number of candidates to become GIs are known in developing nations. Most are neither formally demarcated nor protected by laws. Yet the market already recognizes Cambodian Kampong pepper, Morocco Argan oil, Nicaragua's Chontaleno cheese, and Rooibos from South Africa.





- Nearly 10,000 protected GIs
- Developing countries all together have less than 10% of these
- EU 27 = 5,250 Protected GIs
- US = 950 Protected GIs

Such locally recognized origins offer a number of potential **unexplored opportunities**. There may be considerable benefits available from tapping into evolving consumer preferences for local foods that simultaneously offer a measure of quality assurance – as most GIs meet high standards, including, in some cases, for organic production. One question remains unanswered: will locally-oriented consumers also value the tradition and local cultural aspects of foods that are produced far from their markets?

GIs have **developmental** characteristics. They emphasize the local. They value the cultural aspects and traditional methods that are intrinsic to the production and processing of a product. They also value the land and its particular agro-ecological characteristics that make GI products unique. As such, they are also in accord with organic principles.

GIs are in alignment with **emerging trade demands** for quality, traceability, and food safety. They typically, though not always:

- Apply standards
- Use certification systems that can interface with others such as organics
- Tend to be traceable due to their uniqueness especially with the advent of low-cost DNA tracing

- Often implement appropriate processing technology

In these ways GIs can serve as conceptual frameworks to drive an **integrated** form of rural development. The institutional structures that are part of many successful GIs may be beneficial to local and regional governance as well as to organic certification management.

But, GIs are not easy to achieve.

- Success is often measured in decades and requires patient application and sustained commitment of resources.
- Issues of equitable participation among the producers and enterprises in a GI region are critical to consider, and not easy to accomplish
- Besides organizational and institutional structures to establish and maintain the GI, there may be ongoing operational costs to consider:
    - dissemination
    - marketing
    - monitoring and management (separate legal enforcement)
- Most of the successes from developing countries have come on top of a
- long-standing popular product and via further marketing by strong partners.

The potential long-term value can be extraordinary nonetheless and not only on the economic level (jobs, greater income, ancillary development such as tourism) but also on a cultural and local level in terms of the recognition of customary and value-adding traditions that convey a sense of a people and their relationship to a region.

Organic marketing and organisation in developing countries

Shaded Coffee: A way to Increase Sustainability in Brazilian Organic Coffee plantations

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Key Words: Shaded Coffee, Organic Agriculture, Sustainability, Coffee Quality, Chemical Elemental Composition

Abstract

Consumption of specialty coffee, mainly organic coffee, increases worldwide following the tendency of consuming social and ecological sustainable products. Brazil is the world largest coffee producer, with an average of 2,300,000 tons of green coffee in the last 5 years. Cultivation of organic coffee and shaded coffee are common in Central America, while in Brazil both conventional and organic coffee are cultivated in the full sun system. The full sun system is criticized due to the lack of biodiversity and high demand for inputs. Shaded coffee system has more biodiversity, recycles and fix more chemical elements, such as N, P, K, Ca and C, having a great potential to mitigate the global warming, being consequently more sustainable. In Brazil, shaded coffee system is not well trusted and known as less productive. Seeking for organic coffee sustainability, this work evaluates productivity, coffee quality and chemical composition of coffee beans from two distinct organic coffee systems: shaded and full sun, in the largest arabica coffee producing region of the world, south of Minas Gerais State, Brazil. For productivity and coffee quality there was no statistical difference, although there was a tendency of superiority for the shaded treatment. For coffee beans composition, the shaded system presented higher K values. Considering the results obtained, the shaded system can be suited to increase organic coffee sustainability in this region of Brazil.

Introduction

Concerns of the society with life quality, environmental and social aspects of agricultural production continually increases. The organic agriculture fully attends this need of the society and the demand for its products rises globally generating market opportunities for producers worldwide.

The International Federation of Organic Agriculture Movements (IFOAM, 2007) estimates that the global organic market in 2006 reached 30 billions Euros and that the total area of production was of 31 millions hectares.

Coffee sector worldly represents a market of US$ 70 billion/year, only behind oil (Loureiro & Lotade, 2005). Consumption of specialty coffees, such as organics, gourmets and fair trade is increasing intensively. According to Illy (2005), consumption of conventional coffee increases at a rate of 1,5% a year while specialty increases at a rate of 12% a year.

Although Brazil is the largest world coffee producer its organic coffee production is comparatively small, being the sixth largest producer in 2002 and 2003. In the 2004

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crop the Brazilian organic coffee production has risen significantly reaching around 15,000 tons. (Souza et al., 2005).

Mexico has been the largest world organic coffee producer, with an average of 30,000 ton in 2003 and 2004. Peru has also increased its production and nowadays Mexico and Peru are the two world leading organic coffee producers, being most of their production from shaded systems (Lernoud & Piovano, 2004).

In most producing countries, coffee is cultivated in shaded systems, being Brazil one of the largest exceptions (Bacon, 2005). Researchers, producers and society fear for the sustainability of these production systems ecologically simplified and highly dependent from inputs. Coffee plantations with high vegetal biodiversity are environmentally balanced, with reduced pressure from pests, stable climate conditions, humidity during the dry periods, lower soil erosion and lixiviation, higher rates of nutrients cycling and better coffee quality (Altieri, 1999).

The use of shade coffee trees for C sequestration and reduction of N fertilization has a huge potential for mitigation of the global warming (Montagnini & Nair, 2004). This potential is even greater in Brazil where most of the coffee plantations are in the full sun system.

Therefore it is needed to study the few shaded systems in Brazil, evaluate its potential and establish new techniques and policies to stimulate the increase of biodiversity and the sustainability in Brazilian coffee plantations (Ricci et al., 2002)

Materials and methods

The study was conducted at Jacarandá Organic Coffee Farm, Machado town, south of Minas Gerais state, Brazil. The farm is certified since 1992 by the Instituto Biodinâmico de Desenvolvimento Rural (IBD), an accredited IFOAM member. The experimental field is cultivated with Arabica coffee plants, Mundo Novo variety. Shading is provided by a native leguminous tree *Platycyamus regnellii.* Three blocks were set and the two treatments were: (i) shaded and (ii) full sun. Four repetitions were established, resulting in 24 plots. Each plot was composed by two coffee plants.

The coffee beans were manually harvested and the volume (l) from each plot was quantified on the same day. Coffee from each plot was naturally (with skin and pulp) sun dried. Samples were brought to the Radioisotopes Laboratory (LRi), Piracicaba – CENA/USP where beans were mechanically peeled in a “coffee huler equipment”, oven-dried and then ground. Test portions were irradiated in the nuclear research reactor IEA – R1m of the Instituto de Pesquisas Energéticas e Nucleares, (IPEN/CENEN), São Paulo. The induced radioactivity was measured with detectors after 3, 7, 20 and 28 days of decay time. Determination of chemical elements was carried out by k_0-INAA using the *Quantu* software package (Bacchi and Fernandes, 2003).

The quality coffee determination took place at the Laboratory of Classification and Cupping Quality from the Brazilian Agriculture Ministry (MAPA-Rio de Janeiro). Three quality parameters were evaluated by the coffee experts: (1) Screen size proportion of the beans, (2) Type determination (number of defects) and (3) Cupping of the coffee drink (flavour and aroma).

The data were statistically evaluated through the SAS program. Univariate tests included ANOVA to test the hypothesis of similarity to all the parameters evaluated. Tukey test at 95% was applied for multiple comparison among the averages.

Results

Table 1 below shows the results of the work for productivity, coffee quality and chemical composition of the beans.

Tab. 1: Average results and standard deviations for production (in litters of coffee), cup drinking quality, percentage of screen 14 and up (size of beans), type in points (number of defects) and coffee beans elemental concentration for Ca, Fe, K and Zn ($\mu g\ g^{-1}$) for the shaded and for the full sun treatments.

	Prod. / plot (l)	Cup quality	% Screen 14 and up	Type in points	Ca	Fe	K	Zn
Shaded (n=12)	36.4a	1.83a	84.9a	-84.2a	1140a	24a	16200a	7.2a
SD	20.24	0.8348	4.87	46.8	120	3	900	1.0
Full sun (n=12)	33.9a	1.67a	83.6a	-89.2a	1080a	24a	15100b	7a
SD	18.31	0.77	3.22	56.23	140	2	1200	0.9

Means followed by the same letter are not significantly different ($P<0.05$) by Yukey test

Discussion

The results of production from Table 1 present no statistical difference among the treatments, although the shaded system shows slightly higher volumes than the full sun. Higher production for shaded system was also observed by Ricci et al. (2002). Important to consider that the tree studied in this paper *Platycyamus regnellii* lose its leaves during the winter while in the work carried by Ricci et al. (2002) the trees were pruned in the winter. This reinforces observation from producers that the shade trees have to lose the leaves in the period of short and cold days (winter) in order to obtain a good coffee production.

The higher concentration of K on coffee beans may be a consequence of a higher concentration of K on the soil of the shaded system. As this element is very mobile in the soil and in the plant it was absorbed by the coffee plant in larger quantities in the shaded system. Moreover, this higher concentration of K in the shaded system may also be related to larger volume of coffee roots, resulted of lower soil temperature (Rena et al., 1986). The possible higher concentration of K in the soil may be a result of lower leaching and erosion (Rena et al., 1986). Besides, this system may also count with the recycling of nutrients carried by the shade tree, originated through the absorption of nutrients by the roots and latter falling of its leaves on the soil of (Theodoro, 2001).

As it can be seen in Table 1, no statistical differences were observed among the two systems of production for cupping quality, size of the beans and type. Although, there is a tendency of superiority for the shaded treatment to these parameters. This reinforces the smaller number of defects obtained by Ricci et al. (2002) and the better cupping quality and larger size of the beans obtained by Matiello (2002) and Rena et al. (1996) for the shaded coffee.

A wider interpretation and correlation of the results suggests that the higher values of K obtained for coffee beans from the shaded treatment must have had influence over the productivity and coffee quality. The K element is for long considered the element of the quality in plant nutrition (Malavolta, 1989) and also the most important element for coffee drinking quality (Silva, 2002).

Conclusions

The shaded organic coffee treatment presented the best results for productivity, coffee quality and chemical composition of the beans, therefore, being recommended for this region of Brazil.

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Consumers' Awareness, Demands and Preferences for Organic Vegetables: A Survey Study in Shiraz, Iran

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Key words: organic vegetables, awareness, demand, preference

Abstract

Some Iranian vegetable producers use a lot of chemicals, but not in a safe way or at the optimum level. There are several reports about chemical residues in vegetables that have serious side effects on human health and the environment in that country. On other hand, many Iranian farmers traditionally use organic production practices, but organic cultivation in Iran is not in accordance with international regulations. Since vegetables are the most important category of organic products, and since the future of organic agriculture will largely depend on consumer demand, a survey of 470 respondents was performed in Shiraz regarding their level of awareness about organic vegetables, their tendency to consume of organic vegetables, the effect of proper appearance of vegetables on the tendency to purchase organic vegetables and the importance of the organic label and certification of organic vegetables. Results showed that about half of the respondents have knowledge of organic vegetables and that their tendency to consume organic vegetable is very high. The results also showed that proper appearance does not effect the tendency to purchase organic vegetables, and that almost all consumers prefer to purchase organic vegetables labelled as certfied. It is suggested that organic vegetable production be introduced and supported by the Iranian government.

Introduction

Some Iranian vegetable producers use a lot of chemicals, but not in a safe way or at optimum level. In addition, there are several reports of chemical residues in vegetables. On the other hand, many farmers in Iran have traditionally used organic practices for a long time. Data shows that 113,659 ha of field crops and 125,802 ha of horticultural land in Iran are cultivated organically, but not according to international regulations or guidelines such as those of IFOAM. (Ghorbani et al., 2007).

Burgeoning consumer interest in organically grown foods has opened new market opportunities for producers (Dimitri and Greene., 2002), and in recent years consumer demand for organically grown food has also increased (Soler et al., 2002).

The future of organic agriculture will to a large extent depend on consumer demand. Thus, a consumer-oriented approach to understanding organic food demand is important. (Bonti-Ankomah and Yiridoe., 2006).

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Hartman Survey Group (2002) reported that vegetables are the most important organic product and they are top-selling of organic product in USA. So investigation on organic vegetables and their market is very important.

The purpose of this study was to determine the level of public awareness about organic vegetables and the tendency for their consumption, the effect of proper appearance of vegetables on the tendency to purchase organic vegetables, and eventually, the importance of organic vegetable labelling and certification.

Materials and methods

The data in this study came from 470 surveys in the city of Shiraz in southern Iran. The study was conducted using the random sampling method and data was analyzed by the chi square analysis.

Results

a) Sample description

470 respondents were interviewed by means of a questionnaire. The sample consisted of 300 women (63.83%) and 170 men (36.17%). The average age of the respondents was 30.5 years; 60.6% had a university education.

b) Consumer awareness

To determine awareness level, consumers were asked “Do you know what organic vegetables are?”Table 1 shows that 46.59 percent of respondents answered “Yes”.

Tab. 1: Consumers awareness of organic foods

Do you know what an organic vegetable is?	frequency	Percentage	X^2	
Yes (aware)	219	46.59	2.179	n.s.
No (unaware)	251	53.41		

** indicates statistical significance at the 0.5% level

We examined the results derived from the questionnaires using chi-square analysis. With the probability of 0.995 (α=0.005) and df=470, we cannot reject the H_0 hypothesis. The chi-square analysis showed that there is no significant difference between the responses “Yes” and “No”. In other words, about half of the population is aware of what an organic vegetable is. Therefore we can say that awareness level concerning organic vegetables is in the acceptable range.

c) Consumer tendency for consumption of organic vegetables

Some information was presented to the all respondents, and their resulting tendency was assessed as illustrated in Table 2.

Tab. 2: Consumers tendency for consumption of organic vegetables

Do you have a tendency to consume organic vegetables?	frequency	Percentage	X^2	
Yes	436	92.76	343.8	**
No	34	7.24		

** indicates statistical significance at the 0.5% level

As illustrated in table 2, the chi-square analysis results shows with a probability of 0.995 (α=0.005) and df=470, there is enough evidence to reject the H_0 hypothesis. Hence, there is a significant difference between responses. Results showed that the tendency for organic vegetables is very high, so it seems that the government and producers can invest on organic prroduction.

d) Effect of proper appearance on the tendency to purchase organic vegetables

To determine this factor, consumers were asked: "Do you have a tendency to buy an organic vegetable that do not have proper appearance instead of non-organic vegetable with proper appearance?". As shown in table 3, from the calculated chi-square statistic, with the probability of 0.995 (α=0.005) and df=470, there is enough evidence to reject the H_0 hypothesis. So, there is significant difference between the answers. The results show that "proper appearance" cannot have a significant effect on the tendency tor purchasing organic vegetables; this would be a valuable advantage for the organic producers.

Tab. 3: Effect of "proper appearance" of vegetables on tendency for purchasing organic vegetables

Do you have the tendency to buy an organic vegetable without proper appearance instead of a non-organic vegetable with proper appearance?	frequency	Percentage	X^2	
Yes	344	73.19	101.1	**
No	126	26.81		

** indicates statistical significance at the 0.5% level

e) Determining the importance of "organic vegetable labelling" and certification of organic vegetables

To determine the importance of "organic vegetable labelling" and certification of organic vegetables, consumers were asked "Do you prefer to purchase an organic vegetable with an organic label by the governmental health or agriculture sector?" Table 4, results derived from the calculated chi square statistic and the df=470, with the probability of 0.995 (α=0.005) show that there is enough evidence to reject the H_0 hypothesis. In other word, there is significant difference in the population of the group who answered "Yes" and the group who answered "No" to the question in the whole population. The results should alert government and producers to make global organic vegetable production regulations more applicable in Iran.

Tab. 4: Consumers trend for consumption of organic vegetables with organic label by the governmental health or agriculture sector

Do you prefer to purchase an organic vegetable with an “organic label” by the governmental health or agriculture sector?	frequency	Percentage	X2	
Yes	458	97.45	423.2	**
No	12	2.55		

** indicates statistical significance at the 0.5% level

Discussion and conclusions

According to the results, about half of the respondents have knowledge related to the organic vegetables. In addition, the tendency for organic vegetable consumption is very high. These very positive factors allow governments and producers to invest in organic cultivation and take advantage of a new and promising market. Also results show that “proper appearance” does not have a significant effect on the tendency to purchase organic vegetables; this would be a valuable advantage for organic producers because producers who wants to change their system from conventional to organic are very worried about "non-proper vegetables' appearance" in organic cultivation and its effect on their market. As the results showed, almost all of the consumers prefer to purchase an organic vegetable with a governmental certified “organic” label. These results should alert governments and producers to make global organic vegetable production regulations more applicable in Iran.

It is proposed that organic vegetable production must to be introduced and supported by Iranian governments. Governments can increase the tendency for consumption of organic vegetables by increasing public awareness (such as programs and advertisements in TV) and governmental rewards and subsidy for organic producers.

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Market Integration Shape Organic Farmers' Organisation

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Abstract

Increasing consumption of organic products in globalised food chains will require the involvement of thousands more smallholder farmers in many regions of the world. A study of Egypt, China and Uganda identified the three key factors of property rights regimes, cultural differences and social organisation as determents of the supply chain organisation and farmers' degree of direct integration in the export markets. Patterns are emerging where smallholder farmers are being socially and economically linked to larger farmers who may do some processing before the raw materials are handed over to the contracting company. Where transactions costs are high, local communities may develop and contract out the land directly to exporting companies who farm using employees. Four organisational patterns are identified which each leads to different types of livelihood benefits for the producers; preliminary results indicate that income and a reliable market access are the dominant benefits.

Introduction

There is an increased conversion to organic farming on a global scale. The organic food systems are transforming groups of loosely coordinated market actors to globalised systems of regulated trading linking socially and spatially distant sites of production and consumption.

Although certified organic products make up a minor share of the world food market (1-2%), agricultural development organisations, such as IFAD and FAO, as well as many NGOs, increasingly see organic farming as a beneficial development pathway for smallholder farmers (Egelyng and Høgh-Jensen, 2006).

The primary drivers of conversion are an increased demand for organic products in the rich countries of the North and increasing domestic markets in large cities. This paper reports an investigation of consequences on farmers mode of market integration

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and their ways of organising themselves to meet the requested market requirements for organic products.

Materials and methods

A cross-sectional study approach (Yin, 2003) was chosen and strategic cases selected in China, Egypt and Uganda, due to these countries major role in global export oriented food supply chains. Cases were selected that reflects diversity in the global export integration at all sites. Open-ended interviews were conducted with farmers and key-informants in all cases. A questionnaire was developed and enumerators were used to collect data from approx. 20 farmers per case area (Mikkelsen, 2005). In addition, field data were collected and observations made as part of several ongoing field studies. The analytical frame for data interpretation was based on the Sustainable Livelihood Framework approach as developed by DFID (2007).

Results and Discussion

Organisation of the product chain

Four distinct organisational patterns emerged during the investigation of the organic product chain in the selected countries. First, in North East China, a private organic company aided local soybean producers in all aspects of production – from cultivation to certification. The company then purchased the produce directly from farmers prior to export. An important aspect of this case was that the company only approached farmers with sufficient and easy accessible land holdings. This approach traversed the traditional and administrative village structure and it was basically contract farming with select farmers in the area suitable for organic production. Secondly, in Mid-East China (Shangdong region), an organic company works together with villages as an entity, essentially making a contract with the village. In this way the village hierarchical power structure is used by the company to control production. Thirdly, smallholders farming less than one hectare for organic export either depend upon non-market forces (for example NGO's) for market linkages or upon businessmen for certification. Fourthly, exporting companies or traders may produce their own commodities on land they own or rent around large metropoles like Shanghai. Such cases also include contracted farms operated by farmers and supervised by companies.

In Egypt all four structures in farmers' way of organising were found, with farm size an important determinant of product chain structure. Large capital intensive organic farms, like those located upon reclaimed desert, normally have direct links to export markets. This direct linkage diminishes with decreasing farm size thus resulting in more steps in the chain and alienating small farmers from the final step in the chain. For example, some small farmers in Egypt supply to larger farmers, who may process a bit before supplying to the companies or to traders.

The second and third structure in farmers' way of organising resembles the case of Uganda; a developing country with a diversified organic production structure where various development agencies play active roles. The background of the organisation driving the organic agriculture initiatives influences the organisation of the production chain. It is in the interest of private sector players to organise farmers in such a way that cost are kept as low as possible. As in practice the private sector owns the organic certificate, the degree of production and marketing autonomy of small producers is low. Recent NGO involvement has contributed to the debate about options to organise the production chain in favour of smallholder farmers, especially through the participatory guarantee systems, where the farmer group themselves owns the organic certificate. Among the consequences of this debate are attempts to outsource some of the private sector activities to farmers, such as processing and value addition in general. Moreover, the type of the organic commodity influence the organisation of the production chain as the demands, requirements and capabilities of farmers to handle high value crops differs from low value / high quantity crops.

GO and NGO involvement

The level and scale of enforcement of farmers' property rights varies between countries. In Egypt and Uganda government has very limited if any involvement in the organic sector. In contrast, in peri-urban areas of Shanghai local government involvement in the organic product chain was evident in reaction to abandonment of small farms, invests in infrastructure for large scale production and then rents out the land to companies who run the farms based on farm labour. In Uganda, organic agricultural training and education is spearheaded by the informal sector and development organisations offer externally funded and market-led initiatives. NGOs and the private sector organise and conduct training, education and research with the support of external donors. This support of development organisations has given Uganda a significant break-through to the international organic market through export of coffee, vanilla, cotton, dried sweat bananas, mangoes and pineapples. Recently, research institutions and universities have started seeing the need for conducting research in the organic sector.

Farmers' livelihood

The manner in which farmers are organised is crucial for the benefits they may accrue from organic farming. The role of the size of their property is important. As described above, smallholder farmers' linkages to the market may be weak where middlemen are involved, reducing their financial gain. The organic farmers in the case area in NE China had larger land holdings than the conventional farms in the area, providing them not only entry to the organic market but also increased profits. Most conventional farmers in the area (with exactly the same cropping systems yet on smaller land holdings) had never even heard of organic farming. They sold produce on the local market or to the government. Indications are therefore that the '*village model*' of certification has the possibility of supporting all farmer types.

Involvement in the organic production chain was found beneficial to local organic associations. It facilitated smallholder certification and their access to markets on a large scale and enabled better economical benefits. Such local organic associations can help train farmers and enable experiences sharing in social acceptable ways. In Uganda, local organisations have enabled smallholder farmers to do their own research to reach an optimal quality of the desired product (Mursal, 2007).

All cases in the three countries indicate that that livelihood benefits that farmers derive through certified organic agriculture are skewed towards monetary benefits. In Uganda, agricultural growth has benefited poor people most where land ownership has been relatively equitable. Land ownership often remains inequitable, reducing the potential of organic agriculture to reduce poverty. Therefore well defined and secure property rights are very important in encouraging farmers to invest in their production systems. In Egypt, some organic farmers' organisations were organised by companies or traders in order to guarantee organic products supply flow for their export activities but without support to farmers' right needs and market linkages.

Organisation to get the market access

A number of trends can be identified from the ways in which the product chains are structured in the case areas. Generally, farmers are highly reliant upon organic companies that can ensure quantity and quality requirements for the export markets. In particular small scale farmers are dependent upon companies, when the state and civil society organizations are absent. The size of land-holdings and the type of production structure plays a pivotal role in farmers' market access.

Transaction costs influence the economic organization between smallholder farmers and organic companies. In the case of Shandong region, both organic companies and smallholder farmers had decreased their transaction costs by contracting. "Organic" companies have an excellent knowledge of markets, quick access to capital and new technologies. On the other hand, small farmers have a good knowledge level regarding vegetable production, access to lands and cheap labour. By contracting, both of the contractors have eliminated "*uncertainty*" problems, small farmers secured their markets and organic companies secured quantity and quality of their organic products. In the Shangdong case, smallholder farmers have increased their household income by adopting organic agriculture and secured their market by contracting with "organic" companies. Anecdotal evidence indicates that some farmers, who used to seek off-farm income, are coming back to the villages as organic agriculture offers an acceptable income. The opportunity costs on-farm and off-farm is the main factor whether to involve in organic agriculture (Sultan, 2007).

Conclusions

The rapidly growing organic markets in Japan, Europe and USA offer a significant opportunity for farmers in low-income regions to produce and sell high value products. The current study demonstrates four organisational patterns with which the farmers reach the global organic market chain. For the farmers, the opportunity costs on-farm and off-farm, property rights, the social relations to the other actors in the chain, and cultural boundaries seems the main factors determining the involvement in organic agriculture.

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Accessing the World Market for Organic Food and Beverages from Nigeria

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Key words: Export, Nigeria, market opportunities, organic food, organic beverages

Abstract

A study in 2005-2006 assessed the opportunities for and constraints to Nigeria accessing the international organic market. The study comprised semi-structured interviews with agricultural produce exporters and government officials in Nigeria, and with representatives of certification agencies in the UK, and focus group discussions with farmers' groups in Ogun State, Nigeria. Fresh and canned pineapple and mango, ginger, and herbs and spices were ranked as having very high potential for Nigeria in the international market. Fruit juice concentrates, palm oil, cashew nuts, honey and cotton were among those products classified as high potential. Constraints identified included lack of awareness of organic farming techniques, high certification costs, lack of institutional support, enabling policies, infrastructure, and marketing facilities, limited access to capital and inability to capture economies of scale.

Introduction

The demand for organic food and beverages in industrialised countries continues to increase and a significant proportion of this is met from developing countries. This is especially true for tropical beverages, fruits, spices and some off-season temperate vegetables (FAO 2001, Barrett *et al*. 2002, UNCTAD 2003). There is good evidence of the ability of smallholder farmers to be competitive in products such as coffee, cotton and cocoa (Barrett *et al*. 2001) and also in herbs, spices and some horticultural products (Coulter *et al*. 1999). In spite of the opportunities, there are challenging obstacles to developing countries accessing the global organic market (Harris 1998; Barrett *et al*., 2001, 2002). Therefore, the focus of the present study was to identify opportunities and constraints to the development of organic agriculture in Nigeria oriented towards export and to evaluate the potential for specific products that can be produced organically in Nigeria.

Materials and methods

Opportunities and challenges for organic exports from Nigeria were explored using secondary data sources, semi-structured interviews and focus group discussions. Ten agricultural produce exporters and twelve government officials in Nigeria, and two UK officials of certification agencies were interviewed using open-ended questions. International buyers of organic products, certification agents in the EU and reputable non-governmental organisations involved in organic agriculture farming in developing

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countries were also contacted informally to obtain their opinions on the opportunities and limitations of organic exports from Nigeria.

A focus group discussion was also held with five government Agricultural extension officers and repesentatives from two farmers' groups in each of the four ecological/geopolitical zones of Ogun State, Nigeria: Abeokuta, Ijebu-Ode, Ilaro and Ikenne. The discussions were held in a farmers' meeting room at the Ogun State Agricultural Development Programme head office in Abeokuta, Ogun State and were moderated by the lead researcher.

Results and discussion

Organic agriculture is at present poorly developed in Nigeria, though there are recent moves for the production of certified organic crops. The Nigerian farming system was perceived as "organic by default". Respondents noted a lack of policy or regulation covering organic agriculture in Nigeria and were apprehensive about the high cost of certification by foreign regulating bodies. Concerns were also expressed that farmers lacked knowledge of organic techniques and certification. From the exporters' point of view, opportunities existed for the export of tropical produce, diversification of the traditional export basket, increased export revenue and subsequent foreign investment in organic sector. However, it was thought that considerable efforts would be required to assure confidence of potential buyers in organic products emanating from Nigeria. Availability and timeliness of market information, lack of infrastructure and marketing facilities, limited access to capital and inability to capture economies of scale were all considered major obstacles.

Regarding the relative potential of products for export, USAID (2002a), emphasised the opportunity the organic fruit and vegetable sector presents to producers and exporters in Nigeria. Table 1 shows an assessment of the export potential of some products from Nigeria. Products with export potential characterised as very high and high are primarily those for which there are significant shortages in organic supply and production is mostly restricted to the tropical developing countries. For example, there are a limited number of countries involved in exporting fresh and canned organic pineapple and mango. On the other hand, the production potential of Nigeria for these products is high. For instance, Nigeria is already one of the world leading producers of pineapple, mango, cashew, papaya and oil palm and these crops grow well with little or no use of agrochemicals. Also, the country is already involved in international trade in conventional forms of these products, with the advantage of established relationships with importers in the major markets.

For some of the products listed in Table 1, such as cashew, the general conditions in terms of quality, logistics, price and reliability are not very different for the organic and conventional segments. For cashew in Nigeria, USAID (2002b) concludes that "the majority of Nigeria's production is considered 'organic by neglect' i.e. no chemical pesticides and/or fertilizers." It is therefore quite feasible to target both markets at the same time.

For products rated as moderate potential in Table 1 such as cocoa, coffee and sesame, the organic markets, particularly in Europe and the US have the potential to be oversupplied. Although Nigeria is a leading producer and supplier of the conventional cocoa and sesame, it would need to compete significantly on price and quality bases against other countries that already have well established relationships with organic buyers. The market for organic sesame is relatively large and has shown medium annual growth rate of around 5% recently. Unfortunately, it is oversupplied, which has caused prices to fluctuate by as much as 50% (EPOPA, 2005). In 2001, Nigeria became the largest supplier of sesame to the world's largest importer of sesame, namely Japan. Being a major player in the conventional sesame market, Nigeria can take an advantage of its position in the market to carve a niche in the organic sector as well. Other opportunities for Nigeria in the organic market are the production, processing and supply of speciality products such as honey, herbs, leather products, hides and skins.

Tab. 1: Potential of selected Nigerian organic products in the international market

Potential	Products
Very high	Fesh and canned pineapple and mango, peanuts, herbs and spices, ginger and ginger oil
High	Fruit juices, concentrates and pulps including papaya and mango, cane sugar, cashew nuts, palm oil, honey, cotton
Moderate	Cocoa, coffee, sesame, rice
Low	Bananas and plantain, vegetables, tomato pulp and puree, beef and chicken products
Very low	Citrus

For some products classified as low and very low potential, the market may be oversupplied, or have a slow growth rate, if any at all. And where demand exists, established exporting countries are more likely to take that advantage. For products such as citrus for instance, several countries are already significant producers and exporters, including EU and other industrialised countries with which Nigeria could not compete effectively.

In the case of bananas, until 1999, organic production came almost exclusively from small-scale banana farmers. However, large-scale plantations in the Dominican Republic and Ecuador have recently started exporting organic bananas (Barcus, 2001). Despite a growth in demand, the rate of production and level of investment and export from these well-established South American exporting countries makes the chances for Nigeria in the organic banana market very slim. For beef and chicken, imports from Nigeria are prohibited in Europe, either as organic or conventional, as a result of health and safety measures. However, opportunity may exist in the Gulf States for these products.

Conclusion

This study revealed that the formal organic industry in Nigeria is relatively underdeveloped, although much agricultural production in Nigeria may be described as "organic by default" with potential for increased yield from optimised organic farming. Additional potential benefits were thought to be environmental conservation, economic self-reliance, employment generation and reduced rural-urban migration. Fresh and canned pineapple and mango, ginger, and herbs and spices were ranked as having very high potential for Nigeria in the international market. Fruit juice concentrates, palm oil, cashew nuts and honey were among those products classified as high potential. Among the main constraints identified were farmers' lack of awareness of organic farming techniques, high certification costs, risk aversion, lack of institutional support, enabling policies, infrastructure, and marketing facilities, limited access to capital and inability to capture economies of scale.

Acknowledgments

This study formed part of the MSc studies of Abraham Okusanya, funded by the Ogun State Human Capital Development Programme, Nigeria.

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Perceived Constraints and Opportunities for Brazilian Smallholders Going Organic: a case of coffee in the state of Minas Gerais

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Key words: Brazil, Organic Agriculture, barriers, opportunities, certification.

Abstract

This paper presents the findings of an analysis of the perceived rationales of smallholders for declining or entering organically certified coffee production, in the case Poço Fundo region, Minas Gerais. Based on group interviews and questionnaires, the rationale for farmers who declined organic production were found to be avoidance of perceived risk of harvest failure associated with the process of convertion from conventional to organic coffee production. Rationales for farmers who entered organic production included non-market benefits such as environmental quality and life quality enhancement.

Introduction

Brazil has the strongest economy in Latin America, and yet rank a global second in income inequality, with a Gini-coefficient of 0.57 (World Bank, 2006). Any major reduction of this inequality requires policies targeting poor households, including smallholder agriculture (OECD 2005).

The organic sector in Brazil grew immensely over the past decade with annual growth of 30 - 50%. The country now has 19.000 organic producers, of which 90% are on smallholdings (Lernoud & Piovano, 2007), producing 70% of the total organic production (Darolt, 2005)

Organic agriculture has perceived potential to contribute to sustainable development and smallholders' livelihood. While certified products may help smallholders gain market access and induce price premiums, use of organic methods may bring additional, non-market, on-farm and intra household benefits. Compliance assessed organics, therefore, are increasingly considered a potential instrument for rural development in Brazil.

Coffee production is one of the economic cornerstones of national development, according to the Brazilian Ministry of Agriculture (MAPA). The vast majority of coffee farms belongs to smallholders, and is important for maintaining rural livelihoods.

On this background, the overall objective of this study is to explore the rationales of smallholder coffee producers for entering organic production under certification schemes.

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Materials and methods

The study was conducted in Poço Fundo, Minas Gerais, Brazil, during an overall period in Brazil from January 2007 through to May 2007. The study focused on a cooperative, COOPFAM, consisting of 215 smallholder coffee producers, whereof 115 farmers are organic and Fairtrade certified and 100 are only Fairtrade certified.

Data was collected using semi-structured interviews, Participatory Rural Appraisal (PRA) and questionnaires. The PRA exercises were based on a story line, a "post-it" exercise and a group interview with subsequent discussion. The "post-it" exercise enabled the participants to make a visual and dynamic ranking of constraints and benefits of organic production. The outcome the PRA exercises was used for questionnaire construction. Overall, 100 questionnaires were distributed and 40 completed questionnaires were gathered. As the total sample size is small, the findings can be seen as indications, not statistical significant. Within the questionnaire, two ranking matrixes were constructed (on the basis of the post-it exercise) to enable the farmers to rank benefits and constraints (five factors in each ranking matrix was provided).

Semi-structured interviews were conducted to gather qualitative information about the cooperative and to get more in-depth information concerning the questionnaire answers. Furthermore, semi-structured interviews were used to gather data from key informants from the Ministry of Agriculture, an export promotion agency and a certification body about certified organic goods and producers in Brazil[1].

Results

The organic farmers in COOPFAM are BSC-ÖKO Garantie certified as well as Fairtrade certified by Fairtrade Labelling Organization International (FLO). Through BSC-ÖKO Garantie the cooperative is smallholder group certified using an Internal Control System (ICS).

Group certification gives opportunities for smallholder farmers to enter the international market, as the cost of inspection from certification bodies, which is often seen as a constraint, is reduced. The cost reduction depends on the structure of the ICS as well as infrastructure in the area (Gwendal Bellocq, IBD). In the case of COOPFAM, the overall organic certification cost is reduced by 30% due to group certification and ICS.

Tab. 1: Benefits of certified organic coffee production.

Enhanced life quality	28%
Environment preservation	27%
Market guarantee/Market stability	18%
Higher price of coffee	14%
Better coffee quality	13%

Source: Questionnaire results – from ranking matrix; COOPFAM, Minas Gerais, Brazil, 2007.

1 Key informants included Gwendal Bellocq Instituto Biodinâmico (IBD); Ming Liu (Organics-Brasil); Luiz Carlos Rebelatto dos Santos, Ministry of Agricultural Development (MDA).

Organic coffee farmers in COOPFAM perceive enhanced quality of life and environmental benefits as the most significant factors when converting to organic coffee production, whereas the quality and price of the coffee were seen as the least important benefits (fig. 1).

Farmers expressed that local environmental preservation, through absence of agrochemical input, was important for family and personal health, as they had experienced health problems amongst friends and family members due to chemical use in the fields. Pesticide use is often done without proper restrictions in Brazil, leading to (severe) health problems (Ming Liu, Organics-Brasil).

Organic Fairtrade coffee gave 48% higher price premiums per coffee bag (60kg) than that of a nearby cooperative producing conventional coffee. Overall, from one hectare coffee fields, the organic producer could harvest, on average, 25 bags, whereas the conventional producer in the same area could harvest 30 bags. Thereby, per hectare, the organic producers had an increased premium, compared to conventional producers, of 23% (harvest of 2006). Through semi-structured interviews, and interviews with office personal from the two cooperatives, it was noted that the production costs were higher for the organic producers compared to conventional coffee producers in Poço Fundo, leading to lower net revenue for organic/Fairtrade farmers (25% reduction).

Tab. 2: Difficulties of certified organic coffee production.

Insufficient funding	24%
Conversion period	22%
More work with organic production	20%
Difficulties getting knowledge of org. management	18%
Bureaucracy/difficulties with documentation	16%

Source: Questionnaire results – ranking matrix; COOPFAM, Minas Gerais, Brazil, 2007.

Overall, farmers found limited financial credit as well as the conversion period to be central constraints when converting from conventional to organic coffee production (fig. 2). Through an interview, a farmer explained that he had planted everything over again in his field when converting as the conventional coffee plants could not survive organic management. Outcomes like his have made farmers in the cooperative risk averse towards converting to organic management.

Concerning perceived “bureaucratic” aspects of certification, the farmers could get help from the cooperative and this was therefore not perceived as particularly difficult. Some farmers stressed that without this help, this could have been a major constraint.

In Brazil, there is emerging a desire from smallholder farmers to move away from bureaucratic certification schemes, with highly complicated and administration intense third party documentation, to a more socio-oriented control, Participatory Guarantee System (PGS). The Brazilian organic law, 10.831, recognizes alternative guarantee systems for direct marketing, and this is especially emerging in the South of Brazil (Luiz dos Santos, MDA).

Discussion and Conclusions

The results indicate that major rationales for farmers in COOPFAM, Poço Fundo, converting to organic farming include (local) public good benefits such as (community level) environmental benefits and private (household) benefits – such as avoidance of health problems associated with pesticide use – and thus enhanced life quality. It was stressed that risk of crop failure and financial deficits were seen as main constraints when converting to organic production. Despite lower net revenues for the organic/Fairtrade producers, they chose organic production as it seemed to give a more stable income as well as reducing the negative effects of agrochemicals.

The farmers of COOPFAM experienced yield decrease when converting to organic. The farming system had, before conversion, been high-external-input intensive. A study in Mexico showed that when coffee producers converted to organic production from low-external-input systems, the production maintained its yield or even increased in yield as much as 67%. At the same time, the coffee producers in Mexico obtained price premiums, had low production costs, and overall gained higher net revenue (Dimiani, 2002).

Through producing in a cooperative the farmers of COOPFAM gained reductions in the cost of certification. As the reduction depends on the ICS organization, infrastructure and distances (travel expenses to third party inspector) these benefits can be harder to obtain in Northern parts of Brazil where farmers are scattered over a wider area and the farms are further away from the main certification agencies which are mainly situated in Sao Paulo.

Overall, farmers may have different rationales for entering the organic market, depending on their former production system, organisation of cooperative, conversion related risk assessment and their perceptions of benefits.

Acknowledgments

Special thanks to Fernanda Fonseca (PESAGRO), John Wilkinson (UFRRJ/CPDA), Zina Caceres (UFRRJ/CPDA), Thorsten Treue (Copenhagen University), locals of Poço Fundo, Gwendal Bellocq (IBD), Ming Liu (Organics-Brasil) and Luiz dos Santos (MDA).

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Socio-Economic Effects of Organic Agriculture in Africa

Lyons, K.[1] & Burch, D.[2]

Key words: global South; socio-economic impacts; food security; rural development.

Abstract

The African continent has experienced significant growth in the organic sector in recent years. This paper draws from in-depth interviews with fifty organic farmers across four selected countries – Egypt, Ghana, Kenya and Uganda – to document the socio-economic impacts associated with the uptake of organic farming practices. Our results demonstrate five benefits for farmers, farm families and surrounding communities arising from entry into organics: increased farm incomes; expanded marketing opportunities; empowerment of farmers; health benefits, and; sustaining environments. Our paper concludes with a series of recommendations to assist the on-going expansion of organics in Africa.

Introduction

The global South represents a burgeoning site for organic production, with around two thirds of new entrants to organics located in countries of the South (Parrott and Marsden, 2002). A number of African nations have experienced significant growth in organic production and the uptake of organic farming principles. The International Federation of Organic Agriculture Movements (IFOAM) has supported the expansion of organic agriculture in countries of the South for a number of years through its "IFOAM Goes Organic" (I-GO) Program, and in 2004 established an office on the African continent to assist local capacity building and training in organic agriculture across this region. This paper reports on a project commissioned by IFOAM to document the uptake of organic agriculture across Africa (Lyons and Burch, 2007). Through an analysis of case studies from Egypt, Ghana, Kenya and Uganda, we evaluate the socio-economic benefits for farmers and surrounding communities associated with conversion to organic practices. We conclude with a series of recommendations about future research and advocacy directions to assist on-going expansion of organics in the South.

Organic Agriculture in Africa

Recent research estimates around one percent of the world's certified organic land is in Africa, while African farmers comprise almost 10 percent of certified organic farmers (Parrott *et al.,* 2006; Willer and Yussefi, 2007). Africa's organic agriculture industry appears most developed in the East, and around fifty percent of Africa's certified organic farmers are located in Uganda alone. In addition, about twenty percent of organic farmers are in South Africa, while nineteen percent are located in the North Africa region, and five percent in the West (Parrott and Elzakker, 2003). It is important

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to note these figures refer to the certified organic sector. Prior research suggests the informal or *de facto* organic sector comprises a much larger – and less well understood – component of the African organic movement.

Farmers in Africa produce a diversity of organic crops (see Parrott *et al., 2006)*. The majority of certified organic produce is destined for export markets, and accessing these markets is dependent on organic certification. At the time of writing, Tunisia was the only African country with certification comparable to the EU organic standard – the destination for the majority of Africa's organic produce. As a result, the majority of African farmers rely on international organic certification services. This uptake of external standards and inspection services has been critiqued for establishing new forms of dependence for African farmers (Parrott and Elzakker, 2003). East African countries have recently formalised an East African organic standard, thereby establishing a regional organic certification service. This offers significant opportunities to improve the conditions of trade for East African farmers, by reducing costs and dependence on external auditors.

Research Methods

The data presented in this report draw from in-depth interviews with a range of actors engaged in the organic sector across four selected countries: Egypt; Ghana; Kenya; and Uganda. Interviews were conducted with fifty women and men organic farmers, as well as representatives from NGOs, government departments and development agencies. A non-random sample of women and men organic farmers was approached to participate in this study. Farmers were selected to ensure a diversity of participants. African farmers' experiences of going organic vary considerably, and it was important to ensure that sampling procedures would capture this diversity. For example, we sought to include the perspectives of: both women and men; those certified and non-certified; those engaged in a range of crop and livestock production; those selling into export and domestic markets, as well as those unable to find markets for their organic produce; as well as large and small scale farm operations.

Impacts Associated with the Uptake of Organic Agriculture in Africa

The main reasons farmers in Africa make the switch to organic production are in many respects, the same as those that motivate farmers in developed countries: the desire to produce wholesome chemical-free food in a sustainable manner; the wish to reduce the reliance on expensive and increasingly scarce carbon-based energy-intensive farming methods; and the need to produce food commodities that will find a ready market and ensure a good income for the farmer (Lockie *et al*., 2006). In the African situation all of these issues are important, but some are more critical than others. While African farmers would benefit by avoiding the use of capital-intensive and chemical-intensive farming methods, the ability of organic agriculture to deliver a higher price to farmers for the crops they produce is particularly important – the global trading system is heavily weighted against the agricultural economies of the South. Moreover, the possibility of receiving a premium for organic produce is not only a major incentive to individual farmers (and to small farmers in particular), but also provides greater opportunities for communities to become more self-reliant, and to generate new education and economic opportunities. At the same time, organic agriculture offers new opportunities to maintain soil quality, enhance the productive base of agriculture, maintain biodiversity, as well as enhancing the control by farmers of inputs such as seeds.

We provide a summary here of the main impacts farmers associate with the uptake of organic farming:

1. *Increasing farm incomes*: Farmers frequently stated that organic farming resulted in a reduction in the cost of farming, as they were able to replace expensive external inputs (including fertilisers and seeds) with organic inputs generally produced on the farm. Organic farmers were already familiar with composting, green manure crops and animal manure, and were able to utilise these inputs – at no cost – to maintain the organic farm. For some farmers, entry into organics also created new opportunities for on-farm income generating activities, by supporting the diversification of farming activities (eg. poultry rearing supplied both manure for the farm, as well as income through the sale of eggs and meat).

2. *Expanding market opportunities*: Farmers also frequently stated that conversion to organic farming methods created new opportunities to participate equitably in international trade. Organics also created new market opportunities on the domestic market for farmers in some countries where there was a growing domestic demand for organic produce. The domestic market in Egypt, South Africa, Uganda, Kenya and Tanzania are all currently experiencing significant growth.

3. *Empowering farmers*: Farmers reported receiving various levels of support during the conversion to organic farming methods. For example, farmers had participated in organic training programs, and had become members of local and/or national groups that provided a range of supports (including growing advice, market information etc). By joining an organic group for the purposes of group organic certification (via an Internal Control System (ICS)), farmers also gained access to communal equipment, as well as transport for their produce. Some farmers also stated that group certification provided new opportunities for collective bargaining power with buyers.

4. *Health benefits*: The uptake of organic farming techniques enabled farmers to avoid exposure to hazardous agricultural chemicals. In addition, many farmers reported increases in rates of year round productivity on the farm, as well as increased incomes generated from the sale of organic produce. Both of these factors have improved the capacity of farmers to feed their families.

5. *Sustaining environments*: The adoption of new organic farming techniques, including mulching, biological pest controls and crop rotations, has brought environmental benefits to both agricultural landscapes and surrounding environments.

Conclusions

The results of this research demonstrate there is a range of social and environmental benefits associated with the uptake of organic farming in Africa. This paper concludes with a number of recommendations to ensure these benefits are realised, and to ensure these benefits are realised by the broadest number of farmers. These recommendations include:

1. Expand donor and development agency support across *all* regions in Africa - to cover organic certification costs and development of international market links;

2. Expand domestic organic markets by providing financial and institutional support to local NGOs to engage in advocacy efforts to build local consumer recognition and demand for organic produce;
3. Build international recognition of national and regional African organic standards;
4. Support environmentally responsible value adding opportunities – including solar drying fruit facilities. These may further increase farmer incomes;
5. Simplify and make transparent organic global commodity chains as a strategy to ensure farmers receive a fair payment for their produce;
6. Promote both certified and non-certified organic farming methods as a strategy to improve household food security. NGO organic training efforts purposely target some of their campaigns to vulnerable communities – including the food insecure, poor, and those farming on marginal land;
7. Target some organic training programs expressly towards women;
8. Include indigenous knowledges about sustainable agriculture into understandings of organic agriculture in Africa. This offers the opportunity to increase the successful uptake of organic techniques, as well as avoiding the imposition of western values;

These recommendations will support the development of organic farming in Africa in ways that bring social and environmental benefits to the greatest number of farmers.

Acknowledgments

This paper is the result of a research project commissioned by IFOAM. We would like to acknowledge the support of IFOAM in the conduct of this research. We would also like to thank Ngugi Mutura, chairperson of the Kenya Organic Agriculture Network, who collected data in Kenya. Finally, we would like to extend our gratitude to farmers, farm workers, as well as representatives from numerous organisations that generously agreed to participate in this study.

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Cross-disciplinary Studies in Livelihood impacts of Organic Agriculture

Agroforestry systems and food security among smallholder farmers of the Brazilian Amazon: A strategy for environmental global crisis[1]

Abreu, S. de L.[2] & Watanabe, M.A.[3]

Key words: Food security, agrobiodiversity, small farmers, deforestation, ethical values

Abstract

The Amazon is known for its environmental importance for the climatic equilibrium, for its abundance and richness in biodiversity and its preservation is important to reduce global heating. Nevertheless, little research has analysed the possible positive role of the local farm population for environmental conservation. The paper investigates the possibility to conciliate the environmental conservation with the small farming expansion in the Amazon, to build agrobiodiversity, and at the same time improve food security. This social practice consequently would contribute to the reduction of deforestation and could thus falsify the old diagnosis of incriminating the poor farmers for forest and soil destruction. The study was conducted by the Associação de Produtores Alternativos, localized in territory of Ouro Preto d' Oeste, Rondônia, in the Southwest of the Amazon. The study documented a number of forest preservation and agroecological methods used and concludes that institutional support to strengthening of social organization and local sustainable development projects is fundamental for the consolidation and amplification of the ecological experiences in the Amazon.

Introduction

Among several Brazilian Amazon localities, there are emergency of agroecological experiences, having as basis the support to the development of agroforest systems, henceforward AF. The Amazon is inhabited by different social categories many of which are types of small farmers or forest people, such as cattle breeders and farmers, riverine people, rubber tappers, Brazil nut collectors and quilombolas. Because of unsustainable land use with monoculture and annual crops leading to soil depreciation farming populations have continuously moved on to clear more forest, leading to one of the classical problems of Amazonian deforestation (Fearnside, 1990). However, such negative experiences during the 1990'ties led some farmers in Ouro Preto d'Oeste, Rondônia, Southwest Amazon to experiment with agro-forestry practices combining a diversity of livestock, annual crops with cultivated trees and use of wild forest for products such as cacao, cupuacu, acai, pupunha (reference..). Along

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[1] This article is an integrant part of a research project results named "Percepções e representações sociais do meio ambiente e das práticas agroambientais em pólos pioneiros do Proambiente da Amazônia", which belongs to Embrapa – Brazilian Agricultural Research Enterprise.

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with this a number of products collected from the wild forest have been certified as organic and/or fair trade and –together with certified crops- contribute to the families' income. If such practices are more sustainable in terms of stability in food production and preservation of soil fertility these systems may help reduce the deforestation of Amazonian forests. The conversion process is fruit of the emergence of a critical environmental consciousness based upon in an ecological ethic, motivated by multiple elements: strong organization of political group previous experience with environmental problems, social necessity of survivorship, and ecological appeal realized by the small farmers during the interaction process with ecological entities articulated with global society. The development of the agroforest systems was conducted with the support of the Catholic Church entities non-governmental organizations and local public institutions. Since 2004, this governmental program recognizes and predisposes to remunerate the environmental services rendered by small farmers through the stimulation of the adoption of the sustainable production systems, valorization of environmental services rendered by small farmers community and forest recuperation. The environmental services can be of diverse nature: reduction of deforestation and land burning, reconstruction of devastated areas, protection with revegetation of hydrological resources and others. The aim of this paper is to assess the degree of food self sufficiency and variation in food utilisation and agro-biodiversity among organic agro-forestry farmers in Amazonia and to discuss how this type of farming may contribute to the preservation of natural forests in Amazonia.

Material and methods

After almost a decade of experiences with agroforest systems development, our research covered the biodiversity of small farmers established in Ouro Preto d'Oeste, Rondônia. More than 250 families are presently members of and association of alternative producers and 1000 others are in conversion. The collected material is the result of field survey conducted in several occasions: in 2005 a questionnaire was administered to 50 households, and following this, tape recorded interviews with 28 farmers, heads of associations and local environmentalists and politicians were conducted in 2006 and 2007. Tables containing the list of annual and perennial cultures conducted by the farmers were elaborated, as well as those related to animals raised in the production unities. The area with annual cultures and the number of plants of each species of perennial cultures and the number of each livestock species were established from the questionnaire. The food produced and consumed by the families was listed. The items belonging to feeding these farmers were compared with food items of riverine people from several localities of Acre, Amazon and Pará states using literature surveys. Comparisons were also made with the diet and the agrobiodiversity of the rubber tappers living in two protected in the Acre state: the *Reserva Extrativista Chico Mendes* and inhabitants of *Parque Nacional da Serra do Divisor* and surroundings.

Results and discussion

These two dimensions (the speech and practices), we classified the ecological sensitivity of the social agents according to the table below:

TIPOLOGY OF THE SOCIAL PERCEPTIONS AND PRACTICES IN THE TERRITORY	SENSITIVITY TO SUSTAINABILITY PRINCIPLES
	Low sensitivity (Productivist).
Modern activity	Cattle rancher's vision: Economy oriented to activity expansion and wealth accumulation. There is no adhesion to sustainable development.
	High sensitivity (Modern and Ecological)
Modern activity	Issue is an opportunity to production valorization
	Low sensitivity (Productivist)
Traditional activity	Conscious of environmental question as a market opportunity and to income augmentation.
	High sensitivity (Modern and Ecological)
Traditional activity	Behavior based on ecological tradition compromised with Logic ecological.

Source: Field data collection, Abreu & Watanabe (12/2007).

In this work we point out the familiar farmer's contribution who use low impact technology and with reduced utilization of external inputs. The farmers classified as of traditional activity and of high ecological modernity are those who cultivate 22 vegetable species and 26 fruit species, what guarantee a diversified food source . This social group needs institutional support in order to advance in terms of agroecological transition. They sell the surplus for fair trade system.

We observe that the productive activities types in Ouro Preto do Oeste, thus most of the families (98%), use some portion of their land for different types of agroforestal production often in combination with pasture and livestock. While most of the farmers actively preserve wild forest for environmental protection along rivers and around lakes following a public programme "Pro-ambiente", 50% of the families explore the wild forest for products used for home consumption and marketed as organic or fair trade products.

The most cultivated annual species in Ouro Preto d'Oeste were: rice, beans, maize, cassava, pineapple and sugar cane. Perennial cultures most frequently cultivated were: banana, citrus, mango, cashew, cocoa, coffee, papaya, avocado, *açaí, pupunha, cupuaçu*, coconut and others. A major proportion of the annual species are cultivated by women near their homestead and the fruit trees are cultivated around the houses or collected in the forest and are destined for domestic use. Fruit surplus like banana, papaya, *pupunha, cupuaçu* and coconut are destined for commercialization. The coffee and cocoa are typically cultivated for income generation. The major part of the annual cultures is cultivated for their home consumption, like cassava flour, rice and beans. The major part of maize production is destined for feeding domestic animals or consumed by the families as fresh (green) maize; the grain surplus are commercialized with neighbors or exchanged (escambo) with other products or with other local services.

The small farmers from Ouro Preto d'Oeste have as a difference from the other local communities, the insertion in the global market. The APA's products like honey, heart of palm, native fruit juices are commercialized in local farmers markets, in the Brazilian organic market (Sao Paolo, Rio de J) and overseas exported through Alter Eco (an international organization).

From the observed agrobiodiversity in the annual and perennial cultures, in the animal raising, and in the destination of these products for consuming (besides that ones destined to market), it indicates that these small farmers community enjoy a rich and diversified food, and are almost 100% self sufficient in food and only purchase items such as sugar and salt.

Another part of grain production is precariously stored in rustically-constructed granaries as seeds for next cultivation season. Because of these practices the small farmers, riverine people and rubber tappers of the Amazon have important role as guardians and perpetuators of a rich variety of germplasm of the cultures like cassava and other species destined to feeding (Amorozo, 2002).

The present study is part of a thematic research whose scope involves several localities of this country, aims to understand the Brazilian agrarian ecologization process, where it is studied the diversity of social models of production recognized by Brazilian legislation of 2003: Organic, biodynamic, permaculture, agroforests, etc. (Bellon & Abreu, 2005). It was observed that it is needed to deepen and qualify the contents of the different styles of ecologically based farming, aiming to understand their functionalities, related to food sovereignty, to the contribution to agrobiodiversity or linked to environmental conservation and environmental service rendering.

Conclusions

Amazonian rural populations depend upon, for their feeding, the products from annual and perennial cultures, products collected from the forest, products from animal raised in the production unities and hunting.

Thus, the small farmers cultivate diversified agroforestry systems, which express synchronously cultural values based in an ecological ethics, in the search of food security and finally they are providing environmental services. Moreover, they share with the global ecological society the principles of social development and ecological respect following the principles of organic agriculture as defined by IFOAM. Thus, reduction in deforestation and local landscape reconstruction can be reached with the development of diversified agroforestry systems and amplification of food security. The possibility of marketing part of the forest products as fair trade and certified organic add to the economic viability of these systems but the environmental services should be paid by the governmental organizations.

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Organic agriculture and rural livelihoods in Karnataka, India

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Organic agriculture, sustainable livelihoods, rural development, India, Karnataka

Abstract

The research explored the effects a change from conventional to organic farming had on the livelihoods of a group of farmers in Karnataka, South India. It involved semi-structured interviews with organic farmers, NGOs, consumers, marketing organisations, and the State Agricultural Department. The farmers in the case study perceived that they had improved their livelihoods over the long term by the conversion from conventional to organic farming. Reduced costs for external inputs and reduced labour requirements together with similar or higher yields and premium prices resulted in higher net-farm incomes. The conversion to organic farming reduced the reliance on credits and the risk of crop failure due to pests, diseases and droughts, thereby reducing vulnerability. In addition, the farmers mentioned enhanced natural assets, reduced risk of pesticide poisonings, improved food safety, higher levels of self-sufficiency, and the access to networks supporting knowledge exchange and political participation as important benefits of the conversion. However, almost all the case study farmers noted that the conversion period was difficult due to temporarily declining yields and a lack of information and experiences. This is likely to be a major constraint preventing asset-poor farmers from adopting organic agriculture.

Introduction

Agriculture is the most important livelihood strategy in India, with two thirds of the country's workforce depending on farming. Most farmers are small and marginal farmers cultivating areas of less than two hectares. Increasing land fragmentation, diminishing natural assets, high costs for external farm inputs, indebtedness, and pesticide-related health issues have threatened the livelihoods of many farming families (NCF 2006, MSSRF & WFP 2004, Ninan & Chandrashekar 1993). While incomes in urban areas have risen, farm incomes in real terms have declined in many parts of India during the past decade. Since the 1990s, a growing number of farmers have adopted organic agriculture to improve the economic viability of farming and combat negative social and environmental side effects of conventional farming (Parrot & Marsden 2002, UNDP 1992). Organic farmers' groups and NGOs have formed an 'organic grassroots movement' that supports organic farmers, establishes organic marketing channels and tries to influence policies. However, institutional and scientific support for organic farmers has been limited until recently. A proper understanding of the effects, potential and constraints of organic farming is necessary as a basis for political decision making, the design of support strategies for farmers and further research. Therefore, the aim of the research was to explore changes in the livelihoods of a group of farmers in Karnataka, India that had converted from conventional to organic farming.

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Methodology

The research was inductive and qualitative, although some quantitative data was used to support qualitative findings. Issues that were not considered before were able to emerge, and aspects that were not able to be quantified were explored in depth. Semi-structured face to face interviews were carried out with 15 farmers who had converted from conventional[1] to organic agriculture. They were asked about income sources, land ownership, their motivations for adopting organic farming, factors that had supported the conversion, and their perceptions of what effects the conversion had on their assets, their livelihood outcomes, including income, health, nutrition and self-sufficiency, their vulnerability, and their external environment, including policies, institutions, and processes. The interviews were held in the farmers' fields and/or in their homes providing the opportunity to gather additional information by observation. After ten interviews, no additional information was obtained, indicating that the important issues had been covered.

Most organic farmers in India are not certified or registered in any way, but organised in farmers' groups or supported by local NGOs. Therefore, collaboration with GREEN Foundation, an NGO supporting small and marginal farmers in Karnataka, and Sahaja Samrudha, the Organic Farmers' Association of Karnataka, was chosen as a way to identify a sample of farmers. GREEN Foundation provided background information and Sahaja Samrudha the contacts to organic farmers. The selection of eight of the 15 interviewed farmers was based on a contact list provided by Sahaja Samrudha. These eight respondents provided the contacts to seven other organic farmers in their communities who could be subsequently interviewed.

In addition to the interviews with organic farmers, background information was gathered through a review of literature and NGO documents and semi-structured face to face interviews with representatives of NGOs, marketing organisations, consumers, and the State Agricultural Department.

Results

The major motivation for the interviewed farmers to adopt organic agriculture was their negative experiences with conventional farming, e.g. deteriorating natural assets, continuous pest and disease problems, high costs for external farm inputs, and health problems that were related to the use of pesticides. The field research identified two major assets or processes that facilitated the adoption of organic farming as a livelihood strategy: firstly, education and information, and secondly, material assets, e.g. large land holdings, savings or off-farm incomes, helping to overcome the conversion period. Figure 1 summarises the case study farmers' perceptions of the effects the change from conventional to organic farming had on their livelihoods.

The interviewed farmers perceived enhanced natural assets, e.g. improved soil structure, improved water holding capacity and increased abundance of beneficial organisms, as a positive effect of the conversion to organic agriculture. Enhanced natural assets were said to allow production with less amounts of external inputs. Through encouraging farmers to experiment and actively enhance their knowledge, and through providing access to organic farmers' networks that support knowledge

[1] 'Conventional farming' or 'conventional agriculture' is a form of agriculture that includes the use of synthetic fertilisers and pesticides

exchange and social contacts, a conversion to organic farming improved the interviewed farmers' human and social assets. Organic farming was said to be more in harmony with cultural values and contributed to the preservation and continuous development of indigenous knowledge, an important element of cultural assets.

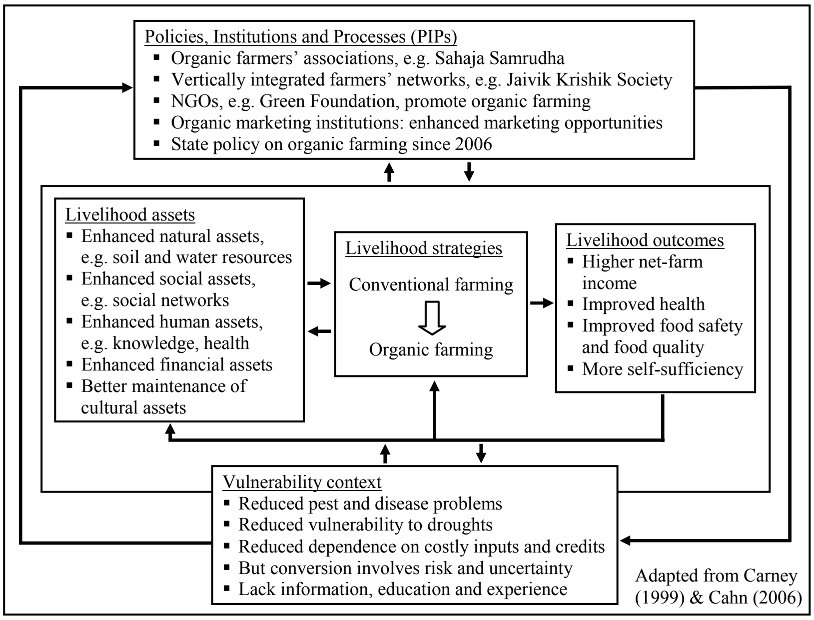

Figure 1: Summary of the effects a conversion from conventional to organic farming had on the livelihoods of the interviewed farmers in the case study

Reduced use of costly external farm inputs and lower labour requirements reduced production costs on all farms in the case study. This together with similar, or in some cases, higher yields improved net-farm incomes. Improved net-farm incomes enhanced the farmers' financial assets, contributed to reduced vulnerability, and provided the potential for investments in physical assets, such as drip irrigation systems. The exclusion of synthetic pesticides was said to improve food safety, to eliminate the risk of health hazards through exposure to pesticides, and hence to improve human health. Improved health is not only a livelihood outcome, but also an important human asset, in that it determines the ability to labour. Many of the interviewed farmers perceived higher levels of self-sufficiency as an important benefit of organic farming. They pointed out that the conversion to organic farming reduced their costs for farm inputs and thus the need for credit, which is a major source of vulnerability for farmers in Karnataka. In addition, many farmers in the case study perceived that the conversion had reduced their vulnerability to pests, diseases and droughts over the long term.

Until the early 1990s, institutional and political structures and processes did not provide any support for organic farmers. Since then, a growing number of farmers have adopted organic farming, and together they have changed the political and institutional environment. Organic farmers' associations and vertical networks provide platforms for the exchange of knowledge and expertise, and enable farmers to influence policies. The creation of separate organic marketing channels has improved marketing opportunities, and a number of NGOs and a recently introduced state policy support organic farming. The interviewed farmers perceived that the change from conventional to organic farming had improved their livelihood sustainability, not only environmentally, but also economically and socially. Without exception, all farmers expressed satisfaction regarding their decision to convert to organic farming.

However, the conversion process itself involved high levels of risk and uncertainty, and in many cases, farmers faced the problem of temporarily lower yields for a conversion period of one to three years. In addition, organic farming was said to require more knowledge about agro-ecological processes than conventional farming, which can be a major constraint for farmers to successfully adopt organic agriculture.

Discussion and conclusion

The organic farmers in the case study perceived that the conversion from conventional to organic agriculture had improved their livelihoods in a range of ways. They pointed out that over the long term the conversion had improved their net-farm incomes, reduced the risk of pesticide poisonings, lead to more self-sufficiency, improved food safety and reduced vulnerability, and improved the access to networks supporting knowledge exchange and political participation. However, risk and uncertainty related to the conversion period, such as temporarily declining yields and the lack of experiences and information, were mentioned as major constraints preventing in particular asset-poor households from adopting organic farming. To date, lack of institutional extension and educational material on organic agriculture require farmers to rely on their own knowledge and farmers' networks. This was highlighted as self-sufficiency in knowledge and expertise by knowledgeable farmers, but might be a major source of risk and uncertainty for others.

Acknowledgments

This research was carried out as part of the Master programme 'International Rural Development' at Lincoln University, New Zealand. I want to extend a very sincere thank you to the staff of Lincoln University who contributed to this programme, to Sahaja Samrudha and Green Foundation, and to all research participants in India.

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Impacts of Institutional Arrangements on the Profitability and Profit Efficiency of Organic Rice in Thailand

Setboonsarng, S.[1], Leung, P.S.[2] & Cai, J.[3]

Key words: Thailand, poverty reduction, institutional arrangement, NGO, profit , profit efficiency

Abstract

This study assesses the performance of organic small farmers in Thailand under different institutional arrangements and over time. It was found that while organic farmers were significantly more profitable and profit efficient than conventional farmers, the level of profitability varies under different intermediaries. Farmers organized by NGOs on degraded marginal land showed a pattern of increasing profit and profit efficiency over time, after the transition period. On the other hand, farmers organized by a private sector firm on newly opened forest land exhibited a pattern of stable profit and increasing yields over time. The results showed that farmers under non-profit NGOs received the highest level of profit, followed by farmers under the private firm and finally the for-profit NGO. These findings suggest that while organic agriculture can increase the economic performance of small farmers, institutional arrangement is an important factor in realizing the broader benefits of organic agriculture for poverty reduction.

Introduction

It is becoming clear to small farmers, NGOs and governments alike that the Green Revolution has led to stagnating yield, ecological degradation and worsening rural socio-economic conditions, particularly in marginal areas. Increasingly, countries such as Thailand are promoting organic agriculture (OA) to reverse these negative effects and reduce poverty. Although there is abundant anecdotal evidence of the broad benefits of OA, empirical evidence to support these claims is limited. To fill this gap, this study assesses the profitability and profit efficiency of OA farms over time and under different institutional arrangements, using household survey data from small farms in Thailand.

Data and Methodology

The 2002 survey covered 445 rice farms (223 organic and 222 conventional farms) in the Northeast and North regions. The organic farmers are under contract farming arrangements and are categorized based on contract partner (Table 1). The OA farms contracted by the non-profit and profit-oriented NGOs are located on degraded land in the Northeast region and practiced conventional agriculture (CA) until OA was

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introduced in the 1980s. In contrast, OA farms contracted by the private firm were organized on newly opened forest land in the North region.

The OA farms are also categorized into three groups according to stage of certification. 'Certified' farmers are certified according to international certification standards. 'Initial' farmers have one to two years experience in OA, while 'transitional' farmers have two to four years experience in OA and in principle should not use agrochemicals. Recognizing the importance of institutional arrangements in contract farming (Glover, 1984; Vellema, 2005), this study employs profit frontier methodology to assess the extent of their impact. This method is used extensively in efficiency studies in agriculture to portrays the maximum variable profit obtainable by a farm given the prices of inputs, outputs and production technology (Bravo-Ureta and Pinheiro, 1993; Setboonsarng et al, 2006).

Tab. 1: Characteristics of sample farms

	Private Firm	Profit-oriented NGO	Non-profit NGO	Total Organic	Non-contract/ Conven-tional
No. of farms	83	52	88	223	222
Age of household head (years)	48.2	47.8	49.2	48.5*	50.8
Education of HH head (years)	2.72	3.13	2.83	2.86*	2.36
Land allocated to rice (ha/farm)	2.20	2.37	1.99	2.15*	1.71
Chemical fertilizer (kg/ha)	50	0	0	19*	179
Organic fertilizer (kg/ha)	840	2,31	3,04	2,05*	803
Pesticides/herbicides (kg/ha)	60	0	0	22*	72

* indicates difference between total organic and conventional is significant at $p<0.05$

Results and Discussion

The profitability and profit efficiency are summarized in Table 2. OA farmers had a significantly higher profit over cash costs in the overall sample, generating US$434 per hectare, compared to US$287 per hectare for CA farmers.

Tab. 2: Profitability and profit efficiency of rice farming in sample farms

	Contract Partner (region)	Yield (kg/ha)	Profit (US$/ha)	Profit Efficiency
Organic	Private Firm (N)	2,940*	420*	0.76
	For-Profit NGO (NE)	2,316	400*	0.70
	Non-profit NGO (NE)	2,169*	468*	0.69
	All Organic	2,492	434*	0.72*
Conventional	Conventional (N)	2,862	356	0.76
	Conventional (NE)	2,138	244	0.56
	All Conventional	2,415	287	0.64

* indicates difference with total conventional is significant at $p<0.05$

Table 2 also shows the profit and profit efficiency of farmers under different contract partners, suggesting the strong impact of institutional arrangement. OA farmers facilitated by the non-profit NGO were the most profitable, followed by farmers organized by the private firm and farmers under the profit-oriented NGO.

There is considerable profit inefficiency among the sample farmers, as shown in Table 2. Profit efficiency is defined as the ratio of the observed profit to the potential maximum attainable profit. Although on average farmers could increase their profit by more than 30%, organic farmers were significantly more profit efficient than conventional farmers, as contract partners provided inputs and training to OA farmers. OA farmers organized by the private firm on newly opened land in the North (N) were more profit efficient than organic farmers on degraded land in the Northeast (NE). However, farmers under NGOs in the NE experienced dramatic gains in efficiency over time, as farmers in the certified group are significantly more profit efficient than the initial OA farmers and conventional farmers. This may be attributed to increasing yields and lower labor inputs over time as ecosystems are restored.

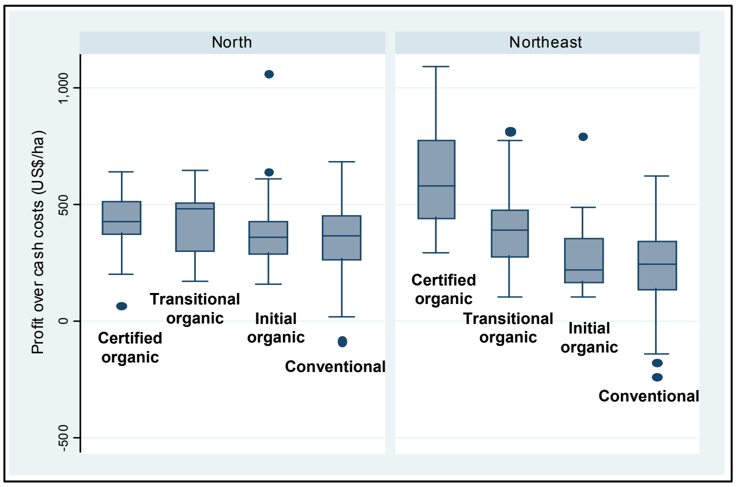

Figure 1: Profitability by Organic Status (US$/ha)

Figure 1 shows the levels of profit in different stages of transition. While levels of profit of OA farmers on newly opened land in the North were similar overtime, the level of profit increased dramatically among OA farmers in degraded land of the NE. It is interesting to note that initial OA farms in the NE are less profitable than CA farms due to the immediate drop in yield after stopping agrochemical use. This profitability pattern can also be explained by the price premiums provided by the different contract partners. The private sector firm offered a fixed margin of US$0.02 above the market price rice at harvesting time, while the NGOs offered a price premium based on negotiation with the farmers, ranging from US$0.03 to $0.09 above market price. The rice price for certified OA in the NE was higher than the price for transitional and initial OA, and nearly double the price for CA. It is noted that while there was no report of agrochemical use under NGO contracts, some farmers under the private firm reportedly used agrochemicals, due in part to ineffective monitoring by the firm (Table 1).

Conclusions

The study shows a distinctive development path under different institutional arrangements in different agro-ecosystems. Under NGOs on the degraded land of the NE, OA profit was initially low but increased dramatically over time as ecosystems restored themselves. As non-profit NGOs aim to achieve both social and financial goals, they offer a better price and more training and monitoring to farmers. Made possible by assistance from donors, these institutional supports effectively kept the farms chemical-free during the transition years, allowing them to become more profitable in the long run. Under the private firm on new forest land in the North, OA farms had higher profits than CA farms; however, price differentiation was minimal, as OA practices are not strictly enforced and the system does not effectively reward farmers who followed strict OA practices. Although the NGOs and private firm export rice at similar prices, it appears that farmers under the non-profit NGO receive a larger share of the organic price premium and benefit more financially and socially than farmers under the private firm or profit-oriented NGO. This analysis suggests that institutional arrangement is an important factor in the success of organic agriculture development and poverty reduction. While organic farming can be an effective mechanism to enhance the profitability of small farmers, its potential economic, environmental and health benefits are likely to be greater under an arrangement which has broad social objectives rather than a narrow financial focus. The findings of this study suggest that external supports to farmers are crucial during the initial and transitional stages of OA, and that non-profit NGOs appear to be the most effective institutional partner to facilitate OA adoption. This successful model should be adopted by governments and donors as a strategy to scale up OA development to achieve both environmental restoration and poverty reduction.

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Organic Agriculture as Livelihood Strategy: A Case Study in a Rural Community of Southern Brazil.

Moreno-Peñaranda, R.[1] & Egelyng, H.[2]

Key words: Brazil, Organic Agriculture, Agroecological Income, Livelihood Strategy, Market and Non-Market Values, Community.

Abstract

This paper presents the findings of a case study of a Brazilian community pursuing a livelihood strategy based on certified organic agriculture. Using the sustainable rural livelihoods framework, the paper identifies three different organic livelihood strategies involving varying degrees of capitals. The paper concludes that understanding the implications of these different organic strategies and their rationales is a prerequisite for policy-makers to tailor policies and programmes aiming to assist rural communities benefit from organic agriculture as a vehicle for advancing rural development.

Introduction

Organic foods and textiles are gaining market shares throughout the world. This is true not only from a global market perspective seeing organic volumes and market values exchanged internationally and in domestic and local markets. It is also true from a perspective seeing organics as a livelihood strategy involving non-market values and perhaps symbolizing a glocalization option: a chance to cope with globalization based on opportunities arising from a mix of global and local (Egelyng 2006). In southern Brazil organics are becoming an attractive option for rural residents to generate income and improve their livelihoods (Oltramari et.al 2002). This paper analyses organic agriculture as such a (community level) livelihood strategy. Inspired by the livelihood approach, particularly its ecological economics (natural capitals, environmental services and incomes) and social capital (networks) dimensions, the paper provides an analysis of market and non-market rationales for individual farmers as well as their communities to "go organic" and pursue organic agriculture as a rural developmental pathway.

Materials and methods

This paper draws upon yearlong field research in Santa Rosa, a community of small family farmers in the state of Santa Catarina in southern Brazil. More specifically, it focuses on socio-ecological implications of certified organic agriculture for local livelihood strategies. Data were collected using a variety of methods. These included participant observation, open-ended interviews, archival research and surveys (both quantitative and qualitative). The sustainable rural livelihoods framework (Scoones, 1998) is the approach used in our analysis.

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Results

Today a copyrighted trademark for formally certified organic foods, AGRECO is the outcome of professionals and entrepreneurs born in Santa Rosa who, with relatives and friends still farming in the community, established a local association in 1996, to promote “the quality of life of small family farmers through organic agriculture” – AGRECO. A project for small-scale agro-industrialization and a local association for agri-tourism supporting farmers and local residents developing tourism linked to organics part of the story as well as international development agencies, non-profit organizations, and prestigious academic institutions, supporting sustainable agriculture programs in Santa Rosa. Today, AGRECO operates in six different municipalities commercialising a variety of foods (cheese, honey, sugar, canned vegetables, jellies, etc). In 2003 its producers became “properly” certified organic - and Santa Rosa’s agri-tourism program keeps expanding.

The 44 certified productive units analysed have different agro-ecological patterns and farms sizes (figure 1). Farm size ranges from less than a hectare (farmers producing honey ‘renting’ the use of a forest area for their hives) to farms over 40 hectares (up to 90). Most of these are connected to a local agro industry (sugar, jellies, canned foods, cheese). In addition to size, land use patterns also vary significantly among farmers. While some producers devote significant portions of the farm to timber (eucalyptus and/or pine trees), others do not manage this resource. Despite this variability, farmers across municipalities do share two common land use trends: agroecological diversification and preservation of areas with native Atlantic forest.

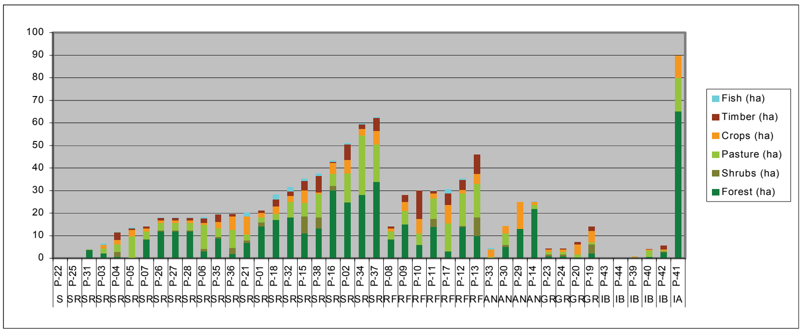

Figure 1: Farm size and land use: six “AGRECO” municipalities.

Besides differences in size and land use, local organic producers are diverse in terms of their livelihood strategies. Table 1 (below) shows three basic typologies of organic producers found in Santa Rosa. The main differences across these different types of organic ‘practices’ are the relevance of agroecological income in the household, and their position in the socio-economic network of organic activists, business communities, consumers and farmers. (Agro-ecological income can be defined as benefits flowing from practising organic methods, for instance in terms of extra wildlife to harvest or extra output resulting from conservation biological control where a biodiverse non-sprayed farm eventually provide habitat and food sources to beneficials, which help control pests). Family farmers (type 1) rely extensively on the agroecological resources of the farm for productive and reproductive functions, and they have lower levels of economic and social capital – less income and less education, less influential connections and less access to information. Family farms are located outside the 'downtown' of the village (the *praça*), often in places of difficult access, i.e hilly terrain, dirt roads and limited communications. In contrast, most mixed households (type 2) work with tourism and hire labor to plant, weed, harvest, and process). In mixed households, at least one adult work off-farm in local jobs as teachers or municipal employees. Joining organic production does not prevent such households from establishing residency in the *praça,* which in practical terms means direct access to local services (phone, bus, stores, school, bank, pharmacy, etc) and networks (associations, gatherings, etc). A third category of organic households, which we refer to as "instrumental retreats", corresponds to households which do not obtain significant agroecological income from organic production, but rather they use the 'farm' for personal, recreational, community service, and/or political articulation in the community. This category comprises professionals residing outside Santa Rosa, including absentee owners, who sympathize with the local association for organic farming. These 'instrumental retreats', which are also certified organic and part of the local association for organic farming, are partially productive. Some have fruit trees, or chicken, or hives. However, this category of organic agriculture may be better understood as spaces of social exchange. Meetings, assemblies, workshops, and symposia are articulated by these organic 'producers', who contribute with their knowledge and connections to the advancement of organic farming in the region.

Tab. 1: Household typologies among Santa Rosa's certified organic producers.

Criteria	Family farm	Mixed household	Instrumental retreat
Off-farm income	Sporadic	Regular	Always
Off-farm work	Agriculture (if any)	Local services	Professionals/entrepreneurs
Self-consumption	High	Low	Not relevant
Tourism	Not common	Most of them	Private/informal
Participation	Low	Medium	High
Organization	Nuclear family	Nuclear/individuals	Individuals
Residency	Farm	Town	Town/City
Labour	Family	Family/hired hired	
Services	Poor	Standard	Depending on use
Education	Primary	Primary/Secondary	College/Graduate

Discussion

A decade after a local association for organic farming was established in the region, three different typologies of certified organic producers can be identified in the community of Santa Rosa: family farms, mixed households, and instrumental retreats. These three types of 'producers' do not differ so much in terms of their agroecological practices (diversification), but in relation to the role that the income resulting from organic production plays in the households. This in turn is deeply correlated to the capacity of the household to access social and economic capitals. Households depending almost exclusively on agricultural incomes do not fully participate in the decision-making process of the association(s) they belong to and have less educational resources – a characteristic shared with non-organic small family farmers in the region such as tobacco producers. In contrast, organics have also fostered new typologies; the mixed household and the instrumental retreat. In mixed households, "organics" are an alternative extra source of income, and the tendency is to rely on services (tourism) rather than small-scale agro-industrialization. In instrumental retreats, unlike in the two previous types, organics are not that much of a productive, but a political tool. These institutional spaces serve to connect urban residents involved in AGRECO to the local reality of the producers. At the same time, retreats open the rich socio-economic networks of the urban/global society to the rural community.

Conclusions

The diversity of organic 'productions' found in the community of Santa Rosa can be interpreted as a response to adopt and adapt organics as a livelihood strategy in a rural community of small family farmers (Moreno-Penaranda, 2006). The three different ways in which organics occur in the community are deeply interrelated. While small organic family farmers manage the agroecological resources and their processing into foods, mixed households 'use' organics to develop alternative sources of rural income, such as agri-tourism. Both types of households are connected to the broader institutional, social, and financial dimension of organics through the networks of academics, entrepreneurs and other professionals involved in the experience. Given the complexity of these interactions, we argue that the role of organics as a livelihood strategy can be interpreted as a strategy to adapt organics to the local community. A policy to transform certified organics into an instrument of social change in rural communities ultimately depends on understanding the functioning of these networks.

Acknowledgments

The authors wish to thank the people from Santa Rosa who generously contributed to this research, as well as Professor Miguel Altieri and the Agroecology Brazil-USA exchange program at the University of California Berkeley for providing funding and logistic support for the project.

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Profitability of Organic Agriculture in a Transition Economy: the Case of Organic Contract Rice Farming in Lao PDR

Setboonsarng, S.[1], Stefan, A.[2], Leung, P.S.[3] & Cai, J.[4]

Key words: Laos, rice, contract farming, switching regression, profitability

Abstract

Poverty is prevalent among smallholder farmers in transition economies where market failures prevail and where the capacity of the public sector is limited. This study assesses the potential of organic contract farming as a private sector institutional arrangement to reduce rural poverty. Contract farming appears to facilitate market linkages for smallholder farmers to produce organic rice for export markets while providing necessary technical supports. Using an endogenous switching regression model to assess the profitability of organic contract farms and conventional farms in Lao PDR, it was found that organic farmers under contract earn significantly higher profit than conventional farms. The findings also showed that organic contract farming tends to provide the greatest increase in income to farmers with below average performance. These findings suggest that contract farming can be an effective mechanism to facilitate the development of organic agriculture and an effective tool to improve the profitability and raise incomes of small farmers, thereby reducing poverty in rural areas with limited market development.

Introduction

Agriculture is the dominant sector of the Lao economy, accounting for nearly half of the country's GDP and employing 77% of the national workforce (UNDP/NSC, 2006). Almost all of the country's agricultural output is produced on small family farms. Despite the importance of agriculture to the national economy, an estimated 87% of the country's poor live in households headed by farmers (NSC, 1999). The vast majority of farmers practice subsistence rice farming and lack access to the incentives and supports necessary to improve their productivity and income. The major constraint to agricultural development continues to be low market integration as the country transitions to a market-oriented economy.

Contract farming has been promoted as a strategy to facilitate Lao PDR's comparative advantage in organic agriculture and connect small farmers to rapidly growing export markets (Setboonsarng et al., 2006; Eaton, 2001). As the majority of traditional crops are produced without the use of agro-chemicals, conversion to organic production requires only marginal improvements on the existing technology. A number of organizations have established contract farming agreements with small farmers to

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produce organic crops for export. This study assesses the profitability of organic rice production under contract and compares the performance of small farmers with and without contract arrangements.

Data and Methodology

The 2004 household survey covered 585 rice farms (332 contract and 253 conventional farms) in Vientiane Province. The sampled contract farms produced organic Japanese *koshihikari* rice for export under contract with the private sector firm Lao Arrowny Co. Ltd. The contracted farmers receive a premium price for growing Japanese rice and are assisted by the firm on seed, organic fertilizer and technical assistance. In contrast, the sampled conventional farmers primarily planted traditional varieties for consumption or for sale in local markets.

To compare the performance of contract and conventional farmers, this study employs an endogenous switching regression model (Lokshin and Sajaia, 2004) to account for unobservable selection biases in farmers' decision to join the contract:

If $\gamma Z_i + u_i > 0$, farmer i chooses to join the contract, which is described by $I_i = 1$;

If $\gamma Z_i + u_i \leq 0$, farmer i chooses not to join the contract, which is described by $I_i = 0$;

Farmer i's profitability with the contract ($I_i = 1$) is $y_{1i} = \beta_1 X_{1i} + \varepsilon_{1i}$;

Farmer i's profitability without the contract ($I_i = 0$) is $y_{0i} = \beta_0 X_{0i} + \varepsilon_{0i}$;

In the model, Z_i is a vector of farm characteristics that affect farmers' decision to join the contract, including family size, land size, value of production assets, value of consumption assets, value of transportation assets and distance from farm to market. X_{1i} and X_{0i} are two vectors of farm characteristics that affect farmers' performance under the contract and without the contract, including farm size, family size and value of production assets. y_{1i} and y_{0i} are dependent variables measuring farmers' profitability; γ, β_1 and β_0 are vectors of parameters subject to estimation; and u_i, ε_{1i}, and ε_{0i} are three random error terms that follow trivariate normal distribution. After the parameters are estimated, the actual and counterfactual expectations of farmers' performance with and without the contract are calculated.

Results and Discussion

The simple mean comparison of organic contract and conventional farm characteristics are summarized in Table 1.Table 2 shows the mean profitability of commercial rice farming. Profitability is defined here as revenue less cash costs and does not include non-cash costs such as own labor, own seed, etc. Organic contract farmers are able to sell their rice at significantly higher prices than conventional farmers, averaging US$0.17/kg versus US$0.14/kg. In addition to receiving higher prices, organic contract farmers also had significantly higher yields than conventional farmers. The yield difference likely reflects the higher efficiency of organic production under contract, as farmers have better access to seed, organic fertilizer and technical assistance facilitated by the contracting firm (Table 1). As a result of higher yields and the price premium for organic rice, contract farmers have a higher mean profitability than conventional farmers, earning an average of US$304/ha and US$182/ha, respectively.

Tab. 1: Farm characteristics of sample farms

	Contract	Conventional	p-value
Plant area (ha)	1.11	1.43	0.0327
Distance from farm to market (km)	20.23	22.20	0.2224
Seed expenditure (US$/ha)	29	8	0.0009
Fertilizer expenditure (US$/ha)	85	55	0.0567
IPM (% of farmers receiving training)	34	24	0.1174

Tab. 2: Profitability of commercial rice farming in sample farms

	Contract	Conventional	p-value
Rice price (US$/kg)	0.17	0.14	0.0000
Rice yield (kg/ha)	3272	2603	0.0420
Revenue before cash costs (US$/ha)	545	367	0.0008
Cash costs (US$/ha)	234	185	0.1102
Profit over cash costs (US$/ha)	304	182	0.0307

A comparison of the actual and counterfactual profits estimated by the endogenous switching regression reveals more information about the impact of contract farming on farmers' profitability. Figure 1 depicts the distribution of profits of organic contract and conventional farmers under contract and without the contract.

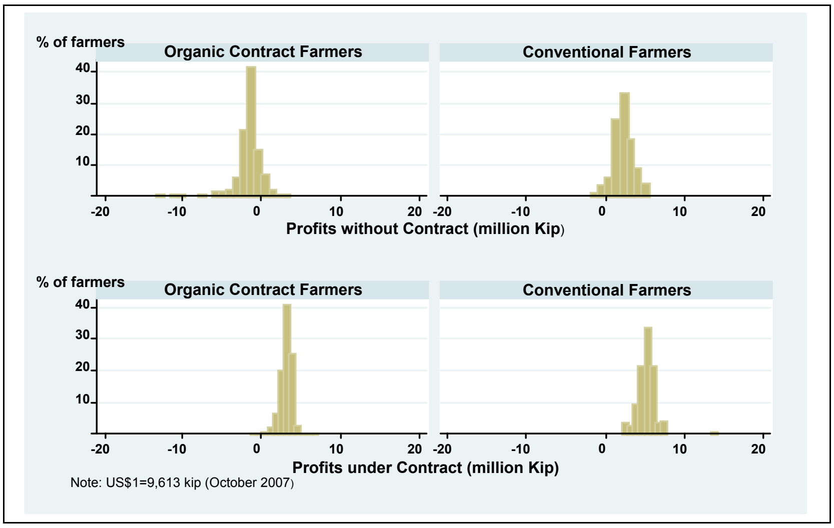

Figure 1: Counterfactual profitability comparison of organic contract and conventional farmers

The contract farmers' profits under contract (the southwest graph) are on average higher than their counterfactual profits without the contract (the northwest graph). Joining the contract is estimated to have increased the profits of contract farmers by US$482. In the case of conventional farmers, the counterfactual profits under contract (the southeast graph) are on average higher than their actual profits outside the contract (the northeast graph). In other words, the profits of conventional farmers would have increased by US$334 *if* they had joined the contract.

These results provide empirical evidence that organic contract farming tends to be more profitable than conventional farming and that the observed higher profitability is not simply the result of more profitable farms adopting organic contract farming. In fact, it is interesting to note that contract farmers have below average profitability[1] both under contract and without the contract. In other words, contract farmers are less profitable than conventional farmers, both under contract and without the contract (Figure 1). This suggests that contract farming tends to be more attractive and more beneficial to farmers with relatively low performance.

Conclusions

The sampled organic rice contract farmers earned significantly higher profits than conventional rice farmers under similar agro-ecosystem and socio-economic conditions. The switching regression comparison also indicates that organic contract farming has the greatest benefits for farmers with relatively poor performance. Contract farming of organic products, in this case Japanese rice, appears to capitalize on the comparative advantages of Laotian farmers who have relatively chemical-free land, excess labor, and traditional knowledge of organic practices. By linking to rapidly growing urban and regional markets for organic products, small farmers were able to improve their incomes while using sustainable agricultural practices. The results of this study suggest that organic contract farming can be an effective institutional mechanism to involve the private sector in reducing rural poverty. The contract arrangement provides farmers with an assured market for their produce and enables them to earn premium prices for high value products. Contract farming appears to be a promising institutional arrangement in rural areas where market failure remains prevalent, particularly in transition economies such as Lao PDR where agricultural production remains primarily subsistence oriented and institutions to facilitate market exchange are in an early stage of development.

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[1] "Average profitability" in this report means the average of the profits of all farmers, irrespective of their actual contract choices, either under the contract or outside of the contract.

Ancestral Livelihoods in Amazon River Floodplains

Madaleno, I.[1]

Key words: Livelihood Improvements, Socioeconomics, Developing Countries.

Abstract

Amazon's historical peasantries, the Caboclos, are the legitimate heirs of aboriginal knowledge, displaying a good repertoire of imaginative forms of natural resources management, adapted to climate change and its extremes in temperature and rainfall. Caboclos are capable of restarting livelihoods and breeding life after each flood, surviving on multiple functions, activities and tasks, maintaining a respectful relationship with the forest and the floodplains, as with numerous waterways that drive away from the Amazon and penetrate the jungle. Vegetable farming uses organic fertilisers, Caboclos tending the alluvial rich soil every time the river falls shorter in order to stock food surplus for the rainy season, to fulfil ongoing household nutritious needs, as to get cash to meet other basic necessities. The fundamental research objective is to recover traditional organic farming and forest management practises along Lower Brazilian Amazon River margins so that they might be presented as models for similar tropical environments.

Introduction

Lower Amazon Basin has been experiencing human presence for millennia without irreversible damage to the environment. From the midst of 20th Century, however, both the forest and the river margin areas started displaying a number of ecological problems. Overgrazing, over cultivation and deforestation are the main sources of such environmental stresses. Soil erosion is an obvious outcome and is often enhanced by mechanised agriculture, particularly as far as recent (2000's) soybean monoculture is concerned. Tillage of the soil using heavy machinery affects its infiltration capacity, sub-soil being compacted and therefore enhancing overland flow which erodes the lose topsoil. Eroded sediments are easily transported after heavy rainfall whereas the erosion process is further enhanced by the fragility of these formerly primary forest covered soils. The paper case studies a municipality located in Amazon River confluent Tapajós sub-basin revealing successful examples of ethno-development that persist along Amazon River margins, providing the opportunity to discuss multi-functional and ancestral organic farming models.

Materials and methods

Qualitative research uses images and descriptions whilst quantitative research relies mainly on numbers. The study followed the procedural sequence listed: (i) Literature survey, comprising historical documentation available on the lower Amazon fluvial settings; (ii) Fieldwork, including fifty in-depth interviews to four categories of informants. The first group targeted national, regional and local authorities in order to get a picture of current policy approaches to development. The second group aimed judges and lawmakers, technicians and university scholars whose insight contribution

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was decisive to understand the environmental status of the geographical spaces under scrutiny. The third group involved artisans, traders and service providers from the urban realm, an insight over urban livelihoods and an examination of their perception of the rural realm. Last but not least household surveys were conducted in the floodplains of Nova, Maica and Ituqui Islands, and along the Igarapé-Açu, a water channel located in the mouth of Tapajós where it meets the Amazon River, in the municipality of Santarém. Interviewing paid an important role though, making sampling measurement techniques possible in the four case studies. Furthermore we've used photographic and video graphic techniques in order to register and build a database. The archival, documental and recent scientific literature analysis has been fundamental to fully develop the ongoing ethno-geographic research. Use of a mixed methodology enabled the study to meet its aims of examining community organisation, water and soil management among *Caboclos* whereas the bulk of the research targeted multi-functional rural communities whose sustainable livelihood practices constituted the main objective of the fieldwork.

Results

Historical documentation encompasses descriptions of settlement, peoples and farming practises as early as the sixteen century, consisting of Amazon River Spanish and Portuguese discovery reports, written by Catholic priests, such as Carvajal in 1542 or Cruz in 1639 (Maderuelo 2002). While most of the river margin tracts were covered with impenetrable rainforest, there is detailed record of highly populated less than 10 metres high island settings where cassava and maize were grown during the dry season, and surplus carefully preserved in deep holes underground during the rainy season, in order to provide enough food for the Amazon Indian communities during inter-cropping periods. About one million residents have been accounted for in the 16th century along Lower Amazon River marginal areas, corresponding to an average human density of 14 inhabitants per square kilometre (Madaleno 2007).

European colonisation developed in cycles, such as wood, medicines and spices extractivism, followed by *Hevea* exploitation from the 19th Century to the First World War. Farming has never been intensive though, and the economic cycles have respected other species whilst in general they haven't depredated the intended ones. Nevertheless, during the Second World War as the Amazon River was isolated from the remainder Brazilian territory it became accessible for foreign contenders, navigating the Atlantic Ocean. The enormous wealth of the Amazon rainforest and the known soil and subsoil mineral resources led to protectionist measures intended to integrate better the northern territories. Consequently, from the 1950's onwards several terrestrial roads have been drawn, and new rural towns and mineral pole cities have been created by government planning. The perverse effect was that land availability and new accessibilities provoked wide internal migrations, some publicly promoted and subsidised, such as the National Colonization Plans (PIC's 1970-79) and others driven by necessity or greed (Becker 1998).

Deforestation trends have been remarkable from the 1970's onwards as end result, particularly within Para state, to which case-studied Santarém municipality belongs. According to Brazilian Spatial Research Institute (INPE), a total of 5,776,652 ha have been cleared in a 13 year period (1988-2000) in the Amazon basin (Homma 2003). As far as Santarém and the Tapajós River (Amazon tributary) is concerned, deforestation has been increasing in recent years, favoured by corporate investment in ports and local industry amelioration (Cargill), aimed at soybeans production along Route 163, an Amazon rainforest accessibility dating from the 1970's. The trend has been so intensive that not even National Parks are being preserved (FLONA and RESEX Tapajós), due to National Environmental Agency (IBAMA) disinvestment.

Under such unfavourable historical background, the second research objective was to inquire whether ancestral organic lower Amazon practises had survived to the industrial farming and modernisation trends. Fieldwork has been developed over two subsequent years (2006-2007) in Lower Amazon Nova, Maica and Ituqui fluvial islands as at Igarapé-Açu, located in the municipality of Santarém. All households have been examined during the dry season (from July through December), called on the shack used during the cropping period, for during the rainy season they displace their belongings to safe upland, *terra firme* (located above 10 metres high). That's because water level rises about 7 metres during the floods, total annual precipitation averaging between 1,750 and 2,000 millimetres. With two exceptions of male farmers living on high ground year-round and travelling to the floodplains everyday, during the cropping period, the remainder interviewed households spent about half the year on the fluvial islands and Igarapé-Açu margins ("Great Channel" in *Tupi* language), cleaning-up the soil, sowing, planting, tending both subsistence (10 to 60%) and cash crops, harvesting melons, watermelons, corn, beans, cassava and a dozen different horticulture species in order to sell them on the nearby city markets. Farming tasks are developed on a co-operative manner within the family.

Tab. 1: Soil fertilisation in case-studied Amazon River floodplains

Type of fertiliser	Nova Island	Igarapé-Açu	Maicá Island	Ituqui Island	Average/ Total Nº
Straw and manure mulching	70%	50%	50%	70%	60%
Tree leftovers	20%	50%	100%	100%	67.5%
Alluvial deposits	100%	100%	100%	100%	100%
Chemicals	10%	0	0	10%	5%
Nº of household interviews	10	2	10	10	32
Number of smallholders	30	100	100	800	1030

Source: Santarém municipality and 2006-07 household surveys

Results have shown that organic farming practises persist within *Caboclo* communities, people engaged on traditional horticulture and animal farming activities. Vegetables, melon and watermelons are irrigated, whilst subsistence crop cassava is not, usually tended on higher ground. Organic fertilisers such as tree leftovers ("*estrume de pau*") and a rich mulching of manure amassed with straw, forming powerful compost, are the universal fertilisers in the floodplains (see Table 1). Even though more than half the *Caboclo* population interviewed fertilises the alluvial soil, particularly on the case of Ituqui Island, the largest in surface area (about 20,000 hectares), where two melon, watermelon and tomato crops are grown per dry season, the survey has shown that some crops survive solely on rich alluvial deposits; the number of plot owners that use chemical fertilisers was rather small and it has been registered only on two island settings – Nova and Ituqui.

Discussion

Residents of Nova, Maica and Ituqui Islands as Igarapé-Açu settlers often constitute enlarged families even though in each shack visited only usually resides a nuclear household. The community presents linear layout along the Amazon River and its numerous channels, the island plots averaging 2 ha. *Caboclos* see nature in an integrative fashion because rivers, forests, fish and wildlife constitute food sources and income, which explains that they tend to preserve local biodiversity for sheer survival needs. A changing pattern is evident at Ituqui Island, though, in favour of commercial fishing, practised to feed households and supplement income in times of hardship. Ituqui is being ravaged by landownership quarrels either, for all marginal Amazon areas are public property, where there is official acceptance of local peasantries farming and recollection activities during the dry season, yet buffalo and cattle husbandry are not allowed for their depredatory effects on the ecosystem. *Caboclos* are usually small scaled chicken, duck, goat, pork and cattle raisers, except at livestock driven Igarapé-Açu, where plot surfaces increase tenfold. Conflicting situations arise when farmers accept to be cowboys during the dry season too, service providers for landlords to whom they've worked for generations during the hardship of the rainy season. Not only they waste farming space for they have to separate the cattle from the farmed areas but their plot becomes the new source of dispute. They have no option however, in order to secure their families on this wild and remote Brazilian territory, ravaged by landownership and natural resource exploitation conflicts. The crops tended along Amazon River floodplains (*várzea*) have a higher yield than highland production. *Caboclos* declared to produce about 1000 watermelons and 1,500 kg of melons on a single harvest. From August through September the first cash crop is available. Vegetable farming during dry season is essential for households' survival because the rainy season is usually a scarcity period. About 10 % households reside in the cities then, living on trade, fishing and services provision whilst the bulk of the interviewed continue with the farming activities upland, complemented with cattle husbandry for rich landowners, as said, and forest extractivism.

Conclusions

The new wave of globalisation is assigning developing countries a leading role in agriculture production. As the main driver in South America, and for decades a successful food, meat and biofuel producer, Brazil tends to increase its global share. Amazon forest is becoming the 'collateral damage' of such contended process. Even so research has shown that *Caboclos* persevere with their ancestral organic farming along Amazon River floodplains, despised by corporate industrial agriculture because of their vulnerable status, yet models of long-lasting and thriving livelihoods adapted to the shifting rivers. In times of climate excesses continuing and successful survival and environmentally friendly farming practices are a repository of hope in the future.

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Consumers in a food chain perspective

Consumers perceptions of combined “fair trade” and “organic agriculture” labels on food products

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Key words: ethical label, fair trade, organic agriculture, consumers’ representations

Abstract

Responsible, ethical, sustainable, citizen consumptions, those terms refer to new consumption behaviours more and more present in the market, society debates, or sociological and marketing research. This study is in the line with previous studies made on ethical consumption in the last ten years. We focused on the question “How do consumers perceive the combined « organic agriculture » and « fair trade » labels on the same product?” A qualitative survey, combining interviews and focus groups, showed the high diversity of representations and the interactions linked to those two concepts and their combinations. If the two labels are used by food chain stakeholders as complementary, they have been differently perceived by consumers: more, some consumers perceived some contradictions between them. We can distinguish six different profiles of consumers on the basis of perceived specific interactions: from the total synergy to the contradiction between “organic agriculture “and “fair trade”.

Introduction

According to Vermeir and Verbeke (2006), the last two decades have seen a rise in consumer ethical concern, particularly in Europe. These ethical concerns express themselves in the purchase of ethical products and a responsible consumption behaviour. On the ethical food market, organic agriculture (OA) and fair trade (FT) products remain the stars performers in terms of sales growth; besides each of these products can be proposed distinctly or combined to consumers. While the organic movement deals with the environmental questions, fair trade is about social concerns and is supposed to contribute to better life conditions of southern producers. These movements were “alternative trades” for a small part of producers and consumers, they are also now becoming an important business for companies which had the idea to combine those concepts on products (Moreno-Penarada, 2006). If inside the movements, the stakeholders debate on the complementarities or contradictions between these movements, our study investigates if the consumers perceive the compatibility between OA and FT labels.

Recent studies indicate some confusions (De Ferran, 2007) or interactions (Tagbata, 2006) between these two attributes for consumers. This double labelling package could be perceived differently, sometimes negatively by the consumers (Tagbata, 2006). However, the usefulness of these results is limited by the poor description of the origin of those interactions. Thus, our study aims at understanding these

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interactions by revealing the representations (Gallen, 2005) and the trade-off between selfish and altruist values. Personal values are fundamental psychological variables to understand ethical behaviours (Vuylsteke and al., 2002). Many studies show that the main motivation of organic products purchase is, not first the environment (altruist motivation), but health and enjoyment (selfish motivations) (e. g., Henson and Traill, 2000). In fair trade case, several papers mention “the support of small consumer” as the main motivation (Sirieix and Codron, 2004). But we can suppose that these motivations are not homogeneous and that there are also selfish motivations like the originality of an exotic product, the traditional skills respect, a more authentic taste or novelty seeking. Thus, these heterogeneous motivations and the interactions between representations could be a basis for consumer misunderstanding.

Materials and methods

Our objective is to reveal the diversity of OA and FT representations in order to describe the interactions between these notions for consumers. We used two complementary interview styles: the individual interview and the focus group. In all, we interviewed 45 persons in order to have a very heterogeneous sample. We paid attention to socio demographic data (17 men and 28 women, age from .22 to 70, different working activities), consumption behaviour (OA or FT buyers or not) and involvement (in environmental or social associations or not). Based on thematic and individual analysis, the data allowed us to put in light the diversity of the consumers’ representations and finally, six types of combined OA and FT representations.

Results

We collected all the consumers FT and OA representations: movements, ethical-labels, consumers and producers representations. In general, the OA representations were complex, very heterogeneous and linked to a high diversity of vocabulary. We made a distinction from the most individualistic to the most altruistic ones: health, nutrition, fashion, taste-pleasure, environmental representations and finally political and social representations. In the same way, we collected the FT representations. Even if the vocabulary was less complex than in OA representations, as supposed in the main hypothesis, fair trade product purchase motivations were very heterogeneous. We can distinguish the natural, pleasure, social, cultural and political representations.

Once identified these representations, we examined their combinations. This study revealed that not all consumers favourably perceive the combined OA and FT labels on the same products. We interpreted the perceived complementarities and contradictions with the congruency and dissonance concepts. The analysis of the combined representations resulted into six profiles that consumers can adopt depending on the moment, the information received, their lifestyle, the nature of the products. Our typology is inspired by Ruwet (2007), who built a typology of engaged consumers from the image they had of production and farming of these movements. Within our six consumer profiles, three of them are related to Ruwet’s typology: supporters, inspired and tradi-moderns. The consumers are organised in three classes of combined representations:

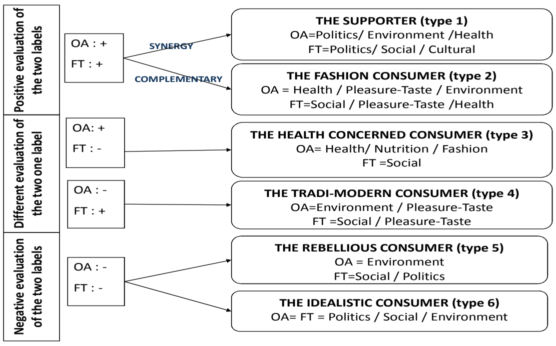

Figure 1: Description of combined representations (inspired by Ruwet (2007))

- Consumers in the first class consumers value OA and FT products. Supporter (type 1 in Figure 1) distinguishes himself by his sense of altruism and the perception of a synergy between the two attributes. The OA and FT movements are a credible alternative for conventional market and production. The fashion consumer (type 2) is more self oriented and purchases these products to keep up with a trend, to value himself or to belong to a social group of responsible consumers. He perceives an imperfect congruency between the two labels: he considers organic agriculture for the health aspects and fair trade for the "support of small producers" and for a better taste of these products. He purchases these products with an idea of double profit: «I have pleasure to taste this product and in the same time, I help the producers ».

- In the second class consumers do not value one of these two attributes and who have a negative image of the product with the two labels: The health concerned (type 3) and the tradi-modern (type 4) consumer. It is a self-dissonance phenomenon related to the image they have of the consumer profile of this kind of product. It means a gap between the image they have of themselves and the image they have of the label or of consumers who choose these products. Thus, the health concerned consumer who buys organic products for selfish motivations is in opposition to fair trade "engaged" consumers altruistic values he imagines. However, he can be reassured on sanitary security of FT product if it is also OA labelled.

- In the third class consumers fundamentally agree with these movements principles but are opposed to the shape they are getting. They associate the label to a brand and criticize this growing business. They do not buy OA and FT products. It is a functional dissonance phenomenon; it means a gap between ethical consumer concerns and the label perceived reality. For these consumers there is a strong incoherency between their label representation and the ideal representation of the altruistic movements.

The fact that no respondent declared that he just not cared about OA or FT may seem surprising. However, we can explain it by the social desirability bias induced by ethical issues.

Discussion

Our results show the nature of the interactions shown up in Tagbata (2006) and De Ferran (2007) works. Congruency and dissonance theories allowed to understand bringing to light some interaction mechanisms: congruency and self dissonance in relation to beliefs, to attribute aims, to labels and to ideal representations.

This distinction between the movement and its shape, the label, is recurrent in consumer speech and seems to be very important to take into account in this kind of study. We distinguished these different interaction mechanisms, but they are not exclusive the ones and the others and can be combined by one person. For example, a person « health minded » will consider that the « fair trade » label is incoherent with the image he has of himself (self dissonance), but the certification « organic agriculture » will reassure him on sanitary conditions of production (imperfect congruity between attributes).

Conclusion

This qualitative survey, combining interviews and focus groups, showed the high diversity of representations and the interactions linked to OA and FT concepts and their combinations for the consumers. If those two labels are used by food chain stakeholders as complementary, they have been differently perceived by consumers: more, some consumers perceived some contradictions between them. We have distinguished six different profiles on the basis of perceived specific interactions: from the total synergy to the contradiction between "organic agriculture "and "fair trade".

From a methodological point of view, this survey focused on an exploratory work and qualitative objectives. A quantitative survey will allow collecting more data to evaluate the weight of the profiles that we described.

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Are Organic Consumers Healthier than Others?

Krarup, S.[1], Christensen, T.[2] & Denver, S.[2]

Key words: Organic consumers, health, diets, consumer values.

Abstract

Recent research results indicate that organic consumers have a healthier diet than other consumers. This suggests that there might be a positive relationship between organic consumption and a healthy lifestyle. One aim of an ongoing research project is to analyse whether consumers with a high organic consumption have a higher interest in nutrition and a healthy living than other consumers. In order to test whether such a causal relationship exists, purchase data from Danish households are combined with information on these households' perception of organic food and their health concerns.

Introduction

Denmark has experienced a boost in the consumption of organic foods in recent years. In order to maintain the growing demand for organic food it is of importance to understand the reasons for this increased demand. Some might be explained by the general income increase, but recent research indicates that consumers buy organic foods due to a concern for animal welfare, a clean environment, trust in the organic production and taste. Also health concerns are drivers of organic consumption.

In this paper we will analyse whether there is a relationship between a high consumption of organic food and health concerns. Moreover, we will analyse whether consumers with a high organic consumption perceive organic food to be healthier than conventional food and in general have a higher interest in nutrition and a healthier living than other consumers. This description will be followed by a socio-demographic description of the different types of consumer groups.

Materials and methods

In order to analyse the relationship between actual purchasing behaviour and consumer values, two types of data are used, namely a postal questionnaire and a household panel data set, which includes more than 2000 Danish households (GfK ConsumerScan household panel). The panel data include information on daily purchases of a large variety of organic and conventional foods, as from 1997 and thereafter. The information includes prices, quantities, labelling, brand, store choice etc. In addition, background variables such as socio-demographic characteristics and media habits are registered for each household member. A questionnaire was sent to all 2376 households in the GfK panel and completed by 2022 households in the period from 24 April to 15 May 2007 implying a response rate of 85%. The questionnaire aims at revealing concepts, values and attitudes that can be subsequently analysed in

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relation to data regarding behaviour. By merging the GfK panel data set with the data from the questionnaire it is possible to classify and group panel members according to purchasing behaviour, perceptions of the organic products, interest in a healthy living and consumer characteristics.

Results

Consumption patterns of different user groups

We analyse the purchasing pattern of organic as well as non-organic food in the GfK panel of the four different consumer groups. To construct these groups we take advantage of the household-specific character of the data which allows us to divide households into groups according to organic budget shares (defined as the shares of the expenditures on 32 products with organic varieties). Households with no organic consumption are categorised as non-users, households with an organic budget share less than 2.5% are light users, households spending between 2.5-10% are medium users and households spending more than 10% of their food budgets on organic varieties are denoted heavy users. Around 9% of the households did not buy any organic products in 2006 and could thereby be categorised as non-users. In 2006, approximately half of the panel was light users and one out of four was medium user. 15% of the households spent more than 10% of the food expenditures on organic varieties.

Next, we look at the product-specific organic consumption by the four consumer groups in 2006 by dividing the 32 products into 11 categories (bread, eggs, fruits, vegetables, coffee, meat, flour, milk, butter, fermented milk + a rest-category denoted 'others'). Heavy users hold the highest organic budget share for all product categories whereas medium and light users can be heavy, medium or light users of the different product groups. Heavy and medium users have a remarkably high demand for organic milk and eggs – 80% of the milk purchased by heavy users is organic and 40% of the milk bought by medium users is organic. Similar, 65% of the eggs demanded by heavy users is organically produced against 30% for the medium users. The organic share for the product group *other* is below 5% indicating that the most frequently purchased organic products are captured by the ten product categories included. In particular, it is worth noticing that medium and light users have much higher organic budget shares in vegetables than in fruits despite the fact that those categories often are recommended jointly in public health campaigns etc. An analysis of the price premiums indicates that the price premiums for fruits are 35-70% while for vegetables 20-45% (Denver et al. 2007) which might indicate that medium and light users are more sensitive to price premiums than heavy users are, but further research is necessary to validate this interpretation.

Knowing that organic food varieties are more expensive, it was surprising to see that while differences in organic expenditures exist across user groups the overall food budget is approximately the same for all consumers. This raises the question of whether the four user groups differ with respect to their general diet. Figure 1 reveals to some extent differences in diets across consumer groups.

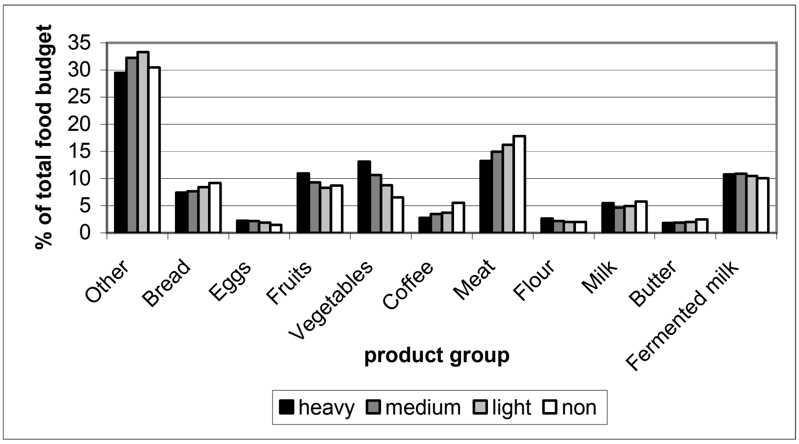

Figure 1: Distribution of the total food budget.

Source: GfK ConsumerScan, Denmark.

It seems from figure 1 that there is a positive relationship between the organic budget share and the consumption of fruits and vegetables. This indicates that heavy users consume more fruit and vegetables than other types of consumers. In addition, a negative relationship between the organic budget share and the consumption of meat, coffee and butter can be seen. The data therefore indicate that heavy users have a healthier diet than other consumers.

As a supplement to this healthier allocation of the budget by heavy users, we apply a healthy eating index (HEI) (Smed 2007). The HEI links nutrition data to the products and volumes purchased by the panel members. This initiative makes it possible to evaluate the state of nutrition across households. When linking the HEI to user group affiliation, we found a clear and positive relation between organic budget shares and a good state of nutrition.

Organic consumers' health perceptions

The aim of the second part of our analysis is to test whether heavy users perceive organic food as healthier than other consumer groups and whether heavy users in general have a more healthy living than others. The results from the questionnaire show many signs of heavy users being more concerned and aware of a healthy life style. Firstly, we found that own and children's health is a major argument for heavy users for buying organic food and it is perceived much more important than for other organic buyers. Secondly, for two thirds of the heavy users as opposed to only one third of non-users, it is vital that their diet is healthy. Besides, more than half of the heavy users answered that they do not prefer tasty food to healthy food (if they had to trade off). Thirdly, it is significant that heavy users know what to eat to have a healthy diet as opposed to only one third of non-users. This shows, that many consumers think that healthy eating is important – and in particular heavy users. More than 80% of heavy users relate healthy eating to organic food as opposed to only 20% of non-users.

Discussion & Conclusion

To our knowledge no other studies exist that analyse the relationship between actual (organic) consumption and consumers' concern for a healthy living. However, some studies exist that find organic consumers to be more concerned with health and perceive organic foods as healthier than conventional food, cf. Williams & Hammit (2000), Torjusen et al. (2004) and Wier & Calverley (2002). Also Magnusson et al. (2003) find that health concern is the best predictor of attitudes towards organic foods and actual purchase of some organic products. Shepherd et al. (2005) find that perceived health benefits from consuming organic food are strongly correlated with attitudes towards organic food and buying intentions. This is supported by Huang (1996) who finds that organic consumers are more nutritionally conscious than others. It therefore seems as if it is generally agreed that consumers buy organic foods at least to some extent because it is perceived to be healthier.

Another angle, which we have merely touched upon in the present paper, is why organic consumers have a healthier diet – is it because of their attitudes towards healthier eating or is it for budgetary reasons? With our future analyses we hope to shed some light upon these potential relationships.

Acknowledgments

The analysis is carried out within the project The Viability and Stability of Demand: The Future Outlook for the Organic Market in Denmark (CONCEPTS) which is part of DARCOF III (2005-2010) and funded by the Danish Ministry of Food, Agriculture and Fisheries.

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Consumers Values and Motives regarding Organic Food Products in Poland

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Key words: consumer, organic food, motives, values

Abstract

Poland, like all new European Union member states has experienced significant growth in organically managed land and the number of organic farms in the last few years. However, there are still many barriers to overcome to stimulate the consumption of organic foods. There is a need to learn more about the emotions, cognition and behaviour of Polish organic consumers in order to develop effective marketing strategies. Polish consumers are motivated to buy organic food because of its perceived health and safety attributes. The highest interest in organic food is observed among consumers who value animal welfare, environment protection and self-fulfilment.

Introduction

The organic foods market has become one of the most rapidly growing sectors in the European Union. Poland, like all the other countries that joined the EU in 2004 has experienced high growth in the number of organic farms and the total area under organic production due to financial support in the form of area payments. The supply of organic foods is increasing but demand is stagnating. The question that arises is what is driving consumers' decisions to buy organic food, what values are shaping Polish consumer choices? The existing studies on consumer motives to buy organic products show that organic food is mainly bought due to non-altruistic motives such as care for one's own health or taste. However, there are cross-cultural differences in the hierarchy of motives to buy organic food and Northern and Central European consumers more frequently cite environmental concerns as being their main buying motives (Zanoli et al, 2004). Consumers are increasingly expressing concern about how their food products are produced, processed, and regulated. Food scandals and uncertainty about food safety, experienced by European consumers in the last decade, have increased interest in safety aspects. One can argue that organic food produced according to strictly defined standards is a product that meets the expectations of contemporary consumers concerned with various aspects of food safety and buying organic food could be a strategy to reduce risk. Despite the fact that there is no unambiguous evidence that organic foods are healthier than conventional foods, organic foods contain less harmful residues than conventional foods. On the basis of the precautionary principle alone, choosing organic foods appears to be an entirely rational decision (Chen, 2007). Ethical concerns expressed by contemporary consumers that belong to credence attributes meaning that they cannot be experienced directly through consumption (Oude Ophuis, Van Trijp, 1995) are also playing an increasingly important role in the hierarchy of motives to purchase organic food. The main objective of the study was to gain an insight into the motives

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underlying Polish consumers' decisions to buy organic food in the context of the values that drive their choices

Materials and methods

The research was conducted in December 2005 on a representative sample of Polish consumers. The total sample consisted of 995 respondents, 519 women and 476 men. The majority of respondents were recruited from urban areas, while more than 1/3 could be considered as residing in rural areas. The most frequently represented group in terms of educational background were respondents with a secondary education; the least represented group were those with higher education. Face-to-face interviewing technique was used to collect data for the study. Questions concerning consumers' motives to buy organic food were worded in the form of a sequence of statements, towards which the respondents, on a five-degree scale, expressed a set degree of conformance. A ten-degree scale was applied to the question concerning values, in which respondents had the ability to rate on a scale from 1 to 10, where "1" meant – totally disagree, and "10" totally agree. Respondents were confronted with a set of values representing domains such as: health, love, family life, independence, living according to norms, self-fulfilment, travelling, meeting new people and cultures, prestige, welfare, environment protection, animal welfare and living in an independent country. Data analysis was carried out using SPSS 12 for Windows and responses were, in the first stage of the analysis, evaluated using descriptive statistics followed by a segmentation of the sample population. The variables representing values were used in the factor analysis to reduce the data into four dimensions: absolute values, self-fulfilment, materialism and care for the environment. Principal Component Analysis with varimax rotation revealed four segments of consumers: "traditional" (19%), "active" (45%), "convenience seekers" (25%) and "indifferent" (11%).

Results

In the hierarchy of motives to buy organic food, health concern is the primary motive regardless of the cross-cultural differences. Polish consumers tend to choose organic food because they are convinced that organic food is safe and 49% strongly agree with this statement (Figure 1).

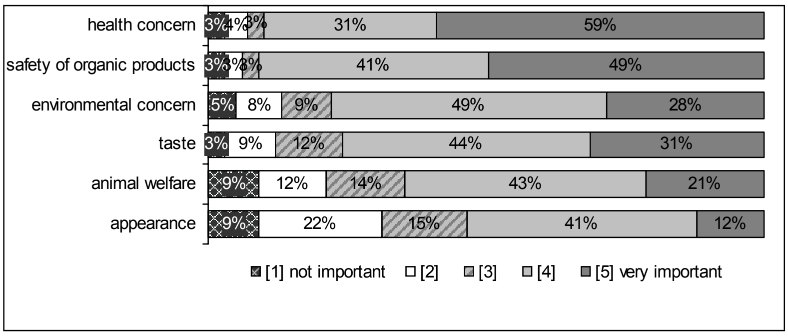

Figure 1: Motives to buy organic food among Polish consumers, N=995

Source: own research

Environmental concerns and taste play an important role in consumers' decisions to buy organic food with an average score of 3.91 on the 5-point scale. Issues related to animal welfare are considered as very important by 21% of respondents. Attributes related to the appearance of organic food are not highly scored as a factor affecting consumers' decisions to buy organic food and more than 30% of respondents admitted that appearance "is not important" or "rather not important" when purchasing organic food.

The consumers belonging to the segment of "active consumers" more frequently declare a motivation to buy organic food. They are younger, better educated, most of them live in urban areas (up to 200 000 inhabitants) and they have incomes above the average in the sample. The segment of "active" consumers is more concerned with animal welfare and environment protection. However, traditional consumers ranked environment protection the highest. Active consumers more frequently claim to be open to new cultures, willing to travel, gain knowledge and place less importance on the values of religion and living according to certain norms and rules. The traditional and convenience seekers segments do not differ significantly in terms of buying organic food but their value system and socio-demographic profile varies. Traditional consumers are particularly concerned with values related to family, religion and health and they do not regard self-fulfilment as an important aspect of their lives. The convenience seekers are the least concerned with environment protection and animal welfare. There is a relationship between the consumer values to protect the environment, animal welfare and the interest in organic food.

Discussion

The most important motives to buy organic food are in the opinion of Polish consumers health and safety. However, these credence attributes of organic foods are interrelated. The research on Polish consumers' food risk perception shows that they believe organic good consumption can minimize such risks and they associate organic food with safety (Ozimek et al., 2005). However, health related attributes cannot be used in any promotional activities. Moreover, there is still not enough scientific evidence that organic food contributes positively to human health and food safety. Magnusson et al (2003) point out that health and environmental motives differ in the sense that concern about health can be regarded as egoistic (benefits the individual or his/her family) while consideration for the environment and animal welfare are more altruistic (benefits for society rather than the individual). Thøgersen (2006), based on the results of cross-cultural research, express the opinion that beliefs about health, taste and environmental consequences apparently have the strongest influence on attitudes towards buying organic whereas beliefs about costs have relatively little influence on attitudes. In the case of countries like Poland and other Central and Eastern European new EU member states, where the share of food expenditure is high, price remains an important determinant of consumer decisions when buying food. The association between organic products and higher prices, but not higher quality, as compared with conventional products (Magnusson et al., 2001), is a negative factor for the image of organic products. Polish consumers perceive availability and high prices as the main barriers to buy organic food (Żakowska-Biemans, 2006). Thus, it is necessary to communicate various aspects that affect the prices of organic products, particularly those related to organic standards, to show the benefits of organic food consumption in terms of environmental protection and animal welfare because these factors are influencing Polish consumer choices. Moreover, to attract consumers, food attributes such as appearance and convenience cannot be neglected.

Conclusions

The primary motives of Polish consumers to buy organic food cannot be considered as altruistic. Health and safety aspects are the main factors affecting the decision to buy organic food. The values underlying organic consumer choices are related to environmental protection and animal welfare and these attributes should be used more effectively in communicating organic farming and organic food to overcome the demand related barriers to its consumption.

Acknowledgments

The research was founded by the grant of Polish Ministry of Science and Higher Education.

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Exploring close consumer-producer links to maintain and enhance on-farm biodiversity

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Keywords: local selling, on-farm biodiversity, producer – consumer links, diversification

Abstract

This paper deals with the question of whether local selling of farm products improves on-farm biodiversity. In contrast to the main agricultural trend of farms specialising and increasing in size in response to the national and global markets, increasing numbers of Swedish farmers are instead diverting their efforts towards selling at local markets. Based on a study of six farms, the paper explores the nature of diversity on these farms and identifies factors supporting diversity. The study shows that farmers who interact with consumers are encouraged to diversify their production. The actual crops and varieties grown are determined by a combination of the natural conditions prevailing on the farm and the conditions created by the farmer in terms of marketing strategy for the products.

Introduction

Although the relationships between landscape heterogeneity, biodiversity and the provision of ecosystem services are not fully understood, a number of studies strongly support the idea that reduced heterogeneity in the agricultural landscape reduces the biodiversity and affects the generation of ecosystem services negatively (Altieri, 1999; Benton et al., 2003; Tscharntke et al., 2005). Thus agricultural heterogeneity – in the sense of e.g. habitat diversity of natural pastures, varieties in crop sequences and fields with extensively cultivated border strips – is of crucial importance for the maintenance of biodiversity, as it provides food, shelter and nursery areas for wild flora and fauna (Benton et al., 2003). The species making up the diversity, including their complex and still largely unknown interactions, are in turn crucial for the generation of ecosystem services (Daily, 1997), such as the maintenance of soil structure and fertility, local hydrological cycles and recirculation of nutrients. As these services support agricultural productivity, they are important for the development of more sustainable agriculture. They are decisive for the adaptability of agriculture to the demands for food and raw material under changing environment and climatic conditions, as well as for the prospect of reducing the use of non-renewable resources (Tilman et al., 2002). Despite EU subsidies aimed at inspiring and supporting farmers to adopt practices that maintain biodiversity, the heterogeneity and diversity of the agricultural landscape of Europe is threatened today (Donald et al., 2006). In contrast to this mainstream trend in agriculture, a group of farmers seem to base their

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enterprises on continuous diversification, not only in terms of crop species, but also when it comes to methods for product processing and spreading of socio-economic risks. These farmers depend on local markets, which enable frequent face-to-face communication with customers and/or end-consumers. In this paper, we explore the nature of these aspects of diversity and discuss some effects and potential underlying driving forces. Some types of farms are more suited for selling locally than others (Tscharntke et al., 2005). Studies in the United States show that farms with fruit and vegetables are by far the most represented at local markets. Farms that sell locally are also to a large extent certified organic or in practice producing organically though not certified (Tscharntke et al., 2005). Welsh and Lyson (1997) showed that farms that sold on local markets had smaller average herd size, were less likely to use chemical pesticides and fertilisers and also adopted an intensive rotational grazing system that reduced purchased inputs rather than maximised production, in comparison with farmers selling to conventional milk buyers. Furthermore, engagement with customers and other farmers at local markets contributes to social learning, enhancing innovation in marketing and vending and increasing the likelihood of producers diversifying to sell on additional markets.

Material and methods

Both quantitative and qualitative methods were used in this research. Quantitative methods such as transect walks and data from geographical information system (GIS) were used to assess physical features of the farms, e.g. the numbers of crops grown and the mosaic of the farmland and the landscape surrounding the farm. Qualitative methods, mainly interviews and observations, were used to collect physical data and to explore any relationship between the feature of the farms, the perception of the farmers and the characteristics of their selling. The study material comprised six Swedish organic farms, of which three specialise in horticulture; two mainly rear animals (sheep or cows); and one mainly produces cereals and sells mill products. The farms sell locally from the farm gate, at farmers' markets, directly to local grocery stores, schools and restaurants and/or direct to consumers through the Internet. One of the farms is run as a type of Community Supported Agriculture (CSA). The word 'local' was not defined in terms of geographical distance between producers and consumers. We assumed that food systems that enable personal meetings between the actors involved were sufficiently 'local' for the purposes of the study. The assessments of cultivated and habitat diversity on the farms were used in order to decide the degree of planned and associated diversity respectively (Altieri, 1999). Planned biodiversity is the result of the crops and varieties that are grown on the farm, while associated biodiversity describes wild flora and fauna present as a result of the farming practices.

Results and discussion

Local selling was of considerable importance for the economy of the six farms, as it comprised between 40% and 100% of farm income. For all farms, selling on local markets was a way to cut out the middlemen, thereby increasing the possibility to get higher prices for the products. The main factors characterising these study farms, in comparison with average Swedish farms on fertile plains selling the production to middlemen, are that they are relatively small and work-intensive and have a low monetary turnover and generally few purchased inputs. Saying this, one has to bear in mind the large variety of farm size and production methods in Sweden.

The number of different vegetables and the varieties of these grown on the vegetable farms were remarkable. The farmers on one farm grew 169 vegetable species/varieties while another grew 115. For example, one farm had nine different varieties of tomatoes and seven of white cabbage. The planned diversity also affected the size of the fields. The vegetable farmers often chose to separate cropping sequences into two separate sequences managed on separate parts of the farm, in order to secure appropriate growing conditions for all crops in respect to pest regulation and soil demands for different crops. In practice, this meant that larger fields were divided into smaller parts in a permanent mode. In essence, the field area on the vegetable farms was composed of a mosaic of different crops with broad field edges covered with grass. Different vegetables were grown in rows of a couple of metres, providing corridors of crops with different genetic composition and structural diversity. Such corridors are, depending on their character, known to be habitats for certain wild species, conduits for movement, barriers or filters separating areas or sources of environmental effect on the surrounding areas. This mosaic created heterogeneity at field level, making up a diversity of habitats supporting wild flora and fauna.

According to the interviews, the vegetable farmers had a strong interest in diversifying their vegetable production, and the local market made this possible. The farmers gave several reasons for the actual vegetables grown on their farms and the sequence in which they were grown on the fields. This proved to be a combination of the demands that the farmers perceived from the market and their interests and proficiency in optimising the conditions of their farm and enterprises. The actual crops and varieties grown were the result of a combination of the nature-given conditions on the farms and the conditions created by the farmer's marketing strategy for products. The animal-producing farmers proved to have a different diversification strategy, driven by the opportunity to market meat locally and obtain a higher price for added value. These farms did not present any remarkable diversity in crops grown. The average field size was similar to that on other farms in the region (3-5 ha). The contribution to diversity from these farms was instead that by keeping grazing animals, they maintained the semi-natural pastures that are characteristic of the landscape in which the farms are located. In essence they did not produce diversity by what they were growing, but they maintained important diversity associated with their extensive way of rearing animals.

The semi-natural pastures that are maintained by interested farmers and their grazing animals are among the most diverse areas in the Swedish agricultural landscape. Half the threatened plant species on the Swedish Red List (Gärdenfors, 2005) are connected with the agricultural landscape and of these, a large proportion are connected with semi-natural pasture. One reason for rearing animals in this way was that the access to local markets and other alternative ways of sale involved options of communicating added value to consumers and thereby getting a higher price for produce. Therefore it is reasonable to argue that the option of getting paid for the added environmental value of this kind of production at a local market was an important factor for the sustainable management of these semi-natural pastures on the study farms. Without this option farmers would have been forced to choose more intensive or extensive production methods in order to survive. The farmers expressed a complex set of reasons why they chose to grow and sell so many different products. Our interviews with farmers and their customers indicated that consumer feedback was of outmost importance for farmer satisfaction, and one strong reason why they continued, even though it required a lot of work.

Conclusion

The vegetable farms selling locally in our study introduce small-scale diversity due to the increased motivation to grow a variety of different crops. They contribute to planned diversity at field and farm level, which furthermore adds to wild flora and fauna in the landscape. The farms concentrated on animal husbandry maintain associated diversity due to their production being well adapted to species-rich semi-natural pastures. These pastures run a high risk of being abandoned according to the overall trend of extensification in such areas in Sweden. The farmers were better paid and received a great deal of positive feedback from consumers. Moreover, the farms, situated in a small-scale landscape, suited such kinds of production. The local selling made it possible to stay in business, without increasing in scale, which might be impossible according to the landscape or not commensurate with farmers' preferences. Consequently, selling locally forces them to diversify in order to perform better, as more products to sell:

- Spreads the financial risk, which is essential for the small producer
- Gives more income per customer visiting the market, due to the possibilities of offering more different kinds of products, leading to better income from participating
- Attracts greater numbers of customers, giving better income from participating
- Leads to more positive feedback from customers appreciating the abundance of variety

Acknowledgments

This research was funded by the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning.

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Consumer Appreciation of Carcass Quality of Organic *vs* Conventional Suckling Lamb Production

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Key words: suckling lamb, carcass quality, meat colour, consumer acceptance.

Abstract

Carcass characteristics of sucking lambs (n= 40) of two breeds reared under conventional and organic conditions were analysed including objective and subjective parameters for fatness and conformation, meat and fat colour. Consumer acceptance was also studied using the home-use test. Results showed that the characteristics of the carcass of suckling lamb were similar for both types of production systems pointing out that organic production system did not affect fatness or muscle development. However, organic meat was darker (higher L and a* values) probably related with the higher amount of exercise, although fat was not more yellow. In contrast consumers did not consider organic meat darker and there were not significant differences in appearance related with the similar conformation. These results reflect that consumer perceive organic meat as at least as good as conventional production not only regarding environmental quality but also regarding carcass quality.*

Introduction

Organic meat production is supposed to use ecological resources, such as natural grass-lands and by-products with low alternative value. For organic meat production to expand in a sustainable way, consumers must perceive it as at least as good as conventional production regarding environmental quality and price.

Grazing and exercise which are part of the organic farming management system may produce darker meat and yellow fat (Nielsen et al., 2005) and also affect muscle conformation and carcass fatness. Suckling lamb carcass quality has traditionally been mainly based on weight, fatness, meat and fat colour. The visual aspect of a carcass, described as previously mentioned, is one of the most important attributes. This is the first characteristic seen by the consumer, and it has a direct influence on the acceptance of the product. Information has been obtained on the effects of breed, sex or carcass weight but to our knowledge, no scientific work has dealt with any suckling lamb organic carcass characteristics, despite the advantages of having well characterized quality label meats. Indeed, there are not studies that correlate objective

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determination of carcass quality and the consumer acceptance. Taking it into account, the aim of this work was to compare both types of production systems for suckling lambs in terms of carcass quality, including colour, to study the correlation of this parameters with the consumer appreciation and to determine consumer preferences between organic and conventional suckling lambs.

Materials and methods

The material included 40 suckling lambs, ten animals per production system (organic or conventional) and breed, of two Spanish sheep breeds (Churra and Castellana) all of them from the same production area (Fariza, Zamora, Spain). Suckling lambs did not receive any kind of feed and were raised exclusively on maternal milk from birth to slaughter. The suckling lambs reared under organic conditions spent the day at pasture with their dams; however lambs reared under conventional conditions remained in a dry lot where their dams were fed with commercial concentrate. The animals were slaughtered according to current legislation, in abattoirs licensed, inspected and certified by the Castilla y León Organic Agriculture Conceal (CAECYL). Carcasses were chilled under commercial conditions at 4ºC and 80% HR for 24 hours.

After chilling, the carcasses were weighed (CCW, cold carcass weight). Fatness were subjectively assessed (FS) using a scoring system that took into account the carcass as a whole (1-4 points) (EEC Regulation nº 461/93). Conformations were also subjectively evaluated (CS) using the scoring system suggested by Colomer-Rocher et al., (1988) (1-5 points) according to photographic patterns. To determine objective carcass conformation, the following measurements were taken on the whole and half carcass: carcass external length (K), carcass internal length (L), pelvic limb length (F), buttock length (G), buttock perimeter (BG), chest width (Th) and chest circumference (U). Meat and fat colour were measured on 72 h aged carcasses with a MiniScan XEPlus (Hunter Lab) with a 25 mm measuring head and diffuse/8º optical geometry. L* a* and b* were recorded with a D65 illuminant at a 10ºC standard observer in the CIELab space (CIE, 1976). Meat colour was measured on fat free surface of the m. *L. thoracis* (between 8^{th} and 9^{th} ribs) after 1 h blooming at 4ºC and fat colour was determined on fat-cover of the left loin.

The affective analysis was carried out using a home-use test (Lawless & Haymann, 1998) involving 35 families (4 to 5 members) coming from the province of Zamora. Three-day aged half carcasses were delivered to each family with a questionnaire from where assessment characteristics of meat were collected A 9-point hedonic scale, in which 1 corresponded to “I don’t like it at all” and 9 corresponded to “I like it a lot” was used to measure the global relative preferences for the samples. The attributes assesed by consumers in fresh meat were general appearance, meat colour, colour and appearance of fat and inviting to eat.

Data of each variable were analysed by one-way analysis of variance (ANOVA). The statistical significance of factor considered (sample) was calculated at α=0.05 level using the *F*-test. In tables and figures, different letter (^{a,b}) means statistically significant differences at α=0.05.

Results and Discussion

Table 1 contains the objective conformation values that fall within the range of those reported for several Spanish breeds (Miguélez et al., 2007). Production system, in general, did not significantly affect these parameters except for chest width (Th) that were significantly higher for organic suckling lambs, however chest circumference (U) did not show significant differences. Regarding subjective conformation parameters, fatness scores (FS) and conformation scores (CS) were higher than those reported for suckling lambs (Díaz et al., 2003) and were not affected by production system. These results revealed that organic production system, characterized by higher amount of exercise, produced similar muscle conformation and did not implies less fat as milk diet is associated with greater animal fatness.

Tab. 1: Means for subjective and objective carcass measurements, fat and meat instrumental colour of conventional and organic suckling lambs

Carcass parameter	Conventional	Organic	Colour	Conventional	Organic
CCW	6.0^{a} (0.7)	6.1^{a} (0.5)	L* (fat)	75.6^{a} (5.9)	73.8^{a} (6.2)
K	49.1^{a} (2.0)	48.3^{a} (1.6)	a* (fat)	2.2^{a} (1.2)	1.9^{a} (0.9)
L	43.1^{a} (1.8)	40.9^{a} (6.8)	b* (fat)	11.0^{a} (2.6)	10.1^{a} (2.5)
Th	19.0^{a} (1.2)	19.9^{b} (1.0)	L* (meat)	53.3^{b} (5.0)	51.1^{a} (3.1)
U	46.7^{a} (2.9)	46.2^{a} (1.6)	a* (meat)	11.2^{a} (2.6)	12.8^{b} (2.3)
BG	38.9^{a} (2.1)	39.0^{a} (2.0)	b* (meat)	16.8^{a} (1.2)	16.5^{a} (2.0)
G	12.0^{a} (0.9)	11.9^{a} (0.8)			
F	29.0^{a} (1.4)	28.2^{a} (6.1)			
FS	2.3^{a} (0.8)	2.3^{a} (0.7)			
CS	1.95^{a} (0.68)	2.0^{a} (0.64)			

^{a,b} Different letter means statistically significant differences at α=0.05.

In contrast, significant differences were observed for instrumental colour parameters of meat. Organic meat showed significantly lower values for L* (Luminosity) and higher values for a* (redness), pointing out that this meat was darker than meat produced in conventional systems. As above mentioned, the exercise is part of the organic farming management system and it may produce darker meat and yellow fat but in this case no significant differences were observed for fat colour parameters.

Regarding consumer appreciation of raw meat, Figure 1 shows the results of the affective test carried out. Organic meat had lower values for some of the parameters but the differences were not statistically significant for any of them, agreeing with the lack of differences observed for the carcass fatness and conformation. Spanish consumers prefer very pale meat that is related with milk feeding and although organic meat was darker, consumers considered it as good as conventional because both were very pale.

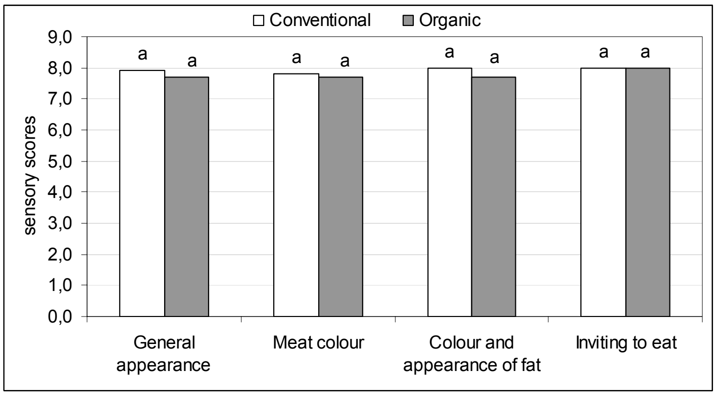

Figure 1: Sensory scores for the parameters evaluated by consumers in raw meat. [a,b] Different letter means statistically significant differences at α=0.05.¨

Conclusions

The characteristics of the carcass of suckling lamb determined in this work were similar for both types of production systems pointing out that organic production system did not affect fatness or muscle development. However, organic meat was darker probably related with the higher amount of exercise, although fat was not more yellow. In contrast consumers did not consider organic meat darker and there were not significant differences in appearance related with the similar. These results reflects that consumer perceive organic meat as at least as good as conventional production not only regarding environmental quality but also regarding carcass quality.

Acknowledgments

Authors are grateful to Spanish Junta de Castilla y León for financial support and for a pre-doctoral fellowship and to Caja Rural de Zamora for financial support.

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Producers and Consumers Relationship Strategies in the Organic Market in Brazil

Darolt, M.R.[1] & Constanty, H.[2]

Key words: Organic consumers, network organic farmer, consumers organization

Abstract

The paper deals with marketing strategies in different sales channels and organic producers and consumers relationship. The empirical study was conducted on 41 organic horticultural farms in 16 municipalities within the Curitiba Metropolitan Area, Paraná, Brazil. Two types of farmers were identified: 1-Rural, with origins and life trajectories in the rural area and 2-Neorural, with urban area background having migrated to the rural milieu. Farmers who sell directly to consumers use more than 3 marketing channels, their production systems are diversified (+ than 20 products), management is complex and the farm is versatile (inn, restaurant, pick-and-pay, rural tourism) and producer/consumer relationship is bigger. Integrated farmers (indirect sales) have only one sales channel. Farmers follow production plans from the buying companies and the output is marketed through supermarket chains. Farming systems are simple (- than 5 products) and relationship with consumers is insignificant. Events such as visit to organic farms, advanced buying, producer/consumer direct credit and organic farming courses or field days, have strengthened producer/consumer relationship and provided consumer support to an organic farms network.

Introduction

Most of the Metropolitan Area of Curitiba (RMC) (56%) is destined to environmental preservation, especially water supply source areas, therefore it is particularly suitable for sustainable agriculture undertaking. Since 2000 the number of organic farmers has risen (50%) and demand for organic products increased (35%). Besides, marketing channels and spots have also increased (Darolt, 2002). In this context, the study of strategies to approach rural and urban communities can encourage direct organic production marketing and redirect farms toward more sustainable and diverse agricultural activities. Also, there is a need to stimulate conscious comsumption, to provide the perspective of fairer markets and to create new marketing channels.

This study also intends to appraise initiatives including organic consumers support to organic farms networks and to propose public policies directed towards agroecological farming.

Material and methods

The study was based on the farming systems approach mixing quantitative and qualitative research using structured questionnaires for farmers and consumers and

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interviews with key informers. An overall study of the area concerning its organic farms and marketing places was made first (Fig. 1).

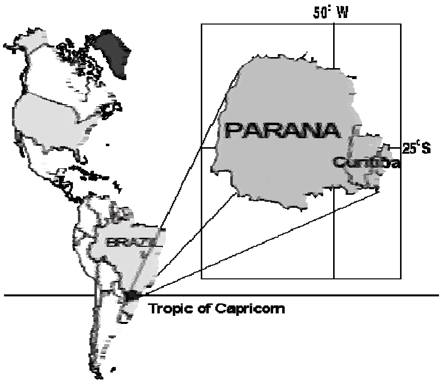

Figure 1: Study area with counties in the Metropolitan Area of Curitiba, Parana, Brazil

Forty one organic farms were first selected from a total of 300 according to the following criteria: 1. direct sales to consumers; 2. certified organic farms (group or individual); 3. farms visited by the local organic consumers association in recent years; 4. farms participating in local rural development circuits or associated to formally organized groups (association, cooperative); and, 5. farms that were representative of the regional organic farming practice. Each farm had to comply with at least three of the criteria. Finally, thirty farms, those with the more complete set of data, were selected to be closely studied.

Farms were diagnosed using data collected through the questionnaires concerning their technological, social, ecological and economic historical path. Then farmers were tipified according to their origins and life trajectories and marketing strategies they employed.

Evaluation of the strategies used by the Organic Consumers Association of Paraná (ACOPA) in its relationship with regional organic farms was done at the same time. This was accomplished through organic consumers visits, when they were able to get familiar with the production systems and even to suggest improvements. The exercise proved useful to establish farms networks and to improve consumer/producer relationship.

Results

Farmers typology in Paraná, Brazil are shown in the following table 1.

Tab. 1: Category of organic farmers from Parana, Brazil

Attribute	Rural	Neorural
Origin	Life trajectory in the rural environment. Former conventional farmer who migrated to organic farming due to personal and economic reasons	Life trajectory in the urban environment. Migration to the rural area searching for a sustainable way of life based on organic farming

Source: Based in Karan (2001)

Collected data show basically two channels of consumer/producer relationship when it comes to market strategies (tab. 2).

Tab. 2: Organic market strategies compared

Characteristics / Channels	Direct Sale	Indirect Sale
Sales	Emphasis on local production and consumption (fairs, delivery, on farm sales, small shops, restaurants, lodges, farmer markets) (more than 3 channels)	Emphasis on supermakets
Number of products (farming system)	20-40	3-5
Consumer relationship	Close	Distant
Form of payment	In cash or short time	Long time (30-60 days)
Family labor	High	Low

Consumers attitudes to get closer to the organic farmers

Some consumer attitudes help to improve their relationship with organic farmers:

Farm visits to get acquainted to the production system
Organic horticulture courses to consumers
Festive and/or field days at organic farms
Farmers credit support
Advanced buyingPick-and-pay

Increasingly, urban dwellers are coming back to the countryside for leisure and re-discovery of regionality and traditional food cultures. Furthermore, organic farms within or near protected areas offer ecotourism and rural hospitality activities. More and more organic farmers are becoming involved in agritourism or local catering of specialty food (Scialabba, 2007).

Discussion

Organic farmers who sell directly to consumers employ diversified production systems growing diverse products (an average of more then 20 food crops) and have a complex and autonomous system of farm management. They undertake several activities beyond farming (rural tours, sightseeing tours, lodge and restaurants) as additional cash sources. It seems that research and extension agencies have to think about urban consumers when dealing with options to small farmers.

Direct sales imply more diversified farming systems sometimes including non-agricultural activities. It also may mean stable incomes but a more complex production system. Farmers who work associated with companies (indirect sales) have smaller autonomy. Companies dictate production systems selling the output to supermarkets chains. Farmers must achieve productions scores. Production systems are simpler (-5 products). Farming systems logic is very similar to conventional agriculture valuing more the economics aspects then social and ecological ones. As a result these farms are less attractive to consumers. These findings show the lack of public policies encouraging consumer/producer relationship as well as the absence of educational strategies valuing organic farming. Reference indicators provided by consumers related to these aspects also do not exist. According Farnworth (2004) an interactive learning process between producers and consumers is key.

Conclusions

The research has shown that organic farmers interested in strengthening direct relationship with consumers have to consider other possible functions for the farm (landscape, tourism, gastronomy, amusement and sport), beyond agriculture. Another finding is that urban consumers have to be considered in the rural development process.

Direct sales are related to diversified farming systems as well as with farms with different economic activities beyond agriculture. Farms are ecologically and socially stabler and more attractive to consumers and their visits. On the other hand farming systems are more complex and laborwise costlier. They are also technically and economically less efficient.

Integrated farmers who choose indirect sales need less labor and are more specialized growing fewer produts. Thus, farming systems are simpler and similar to conventional ones, being more efficient both technically and economically. It is believed that these characteristics make them less attractive to consumers visiting.

Public policies should create programs to train farmers in public relations so that they could better host and sell directly their products to organic consumers. These farmers should also be prepared to undertake other economic activities beyond agriculture thus diversifying their sources of income. Finally, organic farmers should be able to explain their farming systems to consumers who want to be more familiar with them.

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Food for Thought about Environmental Values and Food Demand

Henseleit, M.[1]

Key words: Environmental Preferences, Consumer, Labelling.

Abstract

It is a controversial discussion whether consumers are taking care of environmental issues when buying food. This question seems to be of significance to understand the demand for organic products, and thus many investigations have been made in this field. However, no strong relationship between attitudes and knowledge about environmental issues on the one hand and consumption behaviour on the other hand could be confirmed yet, and still there is a gap in thorough understanding of the demand for eco-friendly produced food. In this text it is discussed to what extent people are both willing and enabled to consider environmental footprints in their food choice by applying recent surveys of environmental preferences and food labels.

Introduction

Research into attitudes towards environmental concerns as well as investigations of the willingness to pay for environmental goods and services usually show a high level of awareness of environmental issues. In contrast to that, many investigations conclude that most consumers are taking environmental issues rarely into consideration when shopping for food, whereas only a minority[2] consider ethical factors regularly (Thøgersen 1999; Birner et al. 2001; Halkier 2001; Verbeke and Vermeir 2006; Codron et al. 2006 and many more). The majority of investigations on this subject are based on the demand for organic products. Usually social and psychological factors, and in particular peoples' attitudes and concerns, are focussed because they are deemed important, if not even the main factors for the choice of organic products (Lintott 1998; Weber 1999; Belz 2001; Rubik and Frankl 2005; Honkanen et al. 2006). In some studies environmental concern has been found to be a major determinant of buying organic food (for example, Brombacher and Hamm 1990; Van Dam 1991; Grunert 1993; Honkanen et al. 2006). Indeed, many studies, and in particular the more recent, come to the result that health concerns are more important than environmental values (e.g. Sirieix and Schaer 1999; Halkier 2001; Bruhn 2001; Codron et al. 2006; European Commission 2007; Nocella et al. 2007). Accordingly, the critical question remains, whether consumers are both willing and enabled to turn their expressed interest in environmental problems into actual purchasing habits (Martin and Simintiras 1995; Weber 1999; Torjusen et al. 2004; Vermeir and Verbeke 2006).

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[2]However, the categorisation of consumers depending of stated or revealed environmental consciousness has to be regarded carefully as it is often based on the attachment of meanings on some variables. Thus it may be the same as the basis for the segmentation, so that the results become merely tautological (Torjusen et al. 2004, 32). Therefore, the categorisation is itself an interpretation and may be a useful basis for strategic marketing decisions, but it is not suitable for the explaining or understanding of the changing patterns of consumption in the longer term.

Materials and methods

Food production usually goes along with multiple impacts on the environment. In order to discuss the question, whether ecological side-effects could change the value of products in the view of consumers, preferences in the form of stated willingness to pay values for environmental goods are considered. It is also discussed how far consumers are enabled to regard environmental preferences easily when buying food.

The environmental impact of food production, processing and consumption can be described as a summation of influences on environmental goods and values like water, soil, air, climate, structure of landscape, genetic resources and non-renewable resources. In the following table willingness to pay values from selected representative environmental valuation studies are given. In order to ease the comparison, monetary values are converted into US $ per household per year by applying the consumer price index (CPI) of 2000. Only the data for farm animal welfare is weekly.

Tab. 1: WTP for environmental values

Landscape	Species	Water, Soil, Air, Climate	Animal Welfare
Agricultural landscape: $ 340 (Drake 1992, SE) $ 100 (Tronstad 1993, NO) $ 256 (Roschewitz 1999, CH) $ 68 (Brink et al. 2000, various) $ 46 (Moran et al. 2004, UK) $ 46 (Bonnieux, Le Goffe 1997, FR) Open landscape: $ 15 (Sirex 2004, FR) $ 112 (Ollikainen et al. 2004, FI)	Preservation of endangered species: $ 144 (Holm-Müller 1992, DE) $ 106–209 (Hampicke 1991, DE) $ 130 (Brink et al. 2000, various) Single species: $ 5–126; Multiple species: $ 18–194; Ecosystems: $ 27–101 (Nunes et al. 2001, various). Enhanced biodiversity: $ 14 (Travisi et al. 2004, various)	Groundwater Quality: $ 65-1,341 (Boyle et al. 1994, US) $ 209 (Brouwer et al. 1997) Nitrate free drinking water: Reduction of 50%: $ 58-77; Additional complete reduction: $ 0.1–10 (Crutchfield et al. 1997, US) Fresh water quality: $ 97; Riverine quality: $ 113 (Brouwer et al. 1997, various) Small improvement: $ 13; Medium improvement: $ 32; Large improvement: 48 US $ (Bateman et al. 2006, UK) Soil conservation programme: $ 18.5–34.5 (Colombo et al. 2006, ES) Air quality: Reduced - harmful substances: $ 360 (Diener 1999, CA) - toxicity of vehicle emissions: $ 112 (Bateman et al. 2002, UK) Address problems of climate change: $ 252 (Curry et al. 2007, US)	Raising welfare standards of veal and hens: $ 13.42 Ban on egg cages: $ 1.60 Slaughtering pigs more humane: $ 4.68 (Bennett et al. 2002, UK) Improvements for - laying hens: $ 4.24; - dairy cows: $ 4.15; - chickens: $ 3.78; - pigs: $ 3.02 (Burgess et al. 2003, UK) Price premium for animal friendly products: $ 12.73 (Nocella et al. 2007, various)

Source: Own Compilation

Stated willingness to pay (WTP) often diverges highly within the same environmental amenities. Monetary values for the prohibition of negative environmental externalities and, respectively, for the supply of positive ones can be biased due to several reasons, like, for example, embedding and prior information. Differences in WTP values can be caused by survey methods and in particular by the payment vehicle, but also by the question format or by the way of sample selection. Accordingly, WTP answers can hardly be treated as absolute values in economic calculations. However, stated preferences can be intended to some extend for comparison purposes as well as an indication that people do hold significant values for such environmental goods (Bateman et al. 2002, 39).

Results

Not surprisingly, people seem to be first of all willing to pay for the prevention of threats to vital resources like climate, water and air. Also farm animal welfare and the omission of chemicals in general are valued highly, as they may affect the quality and safety of food directly. However, issues which mainly provide non-use values in the view of consumers are of importance as well, likewise due to a desire to prevent rare goods from deletion. This motivation may be driven on the one hand by moral values (like, for example, the right to live for every creature) and on the other hand by risk aversion, which means that people are afraid about losing something forever.

Regarding WTP values for environmental goods and the basis of information on which consumers are choosing food products, there seems to be potential to affect the food market by applying sustainable production techniques combined with reliable product information. An alternative to do so would be to introduce more informative eco-labels in order to gain consumers' trust and to assure demand in the long run. Currently consumers buy organic food mainly because they think it is healthier. As long as there is no evidence, that organically produced food significantly provides higher health benefits, there remains the risk that simply the criterion 'organic' will lose its power as a sales argument. Therefore, it could be useful for certified organic products to provide more information about environmental impacts. This could provide an opportunity for suppliers to differentiate from competitors by applying technologies which are less harmful to climate, water and other environmental goods and which imply improved farm animal welfare.

Discussion

An obvious way to emphasise comparatively low negative impacts of food products for the environment is product labelling. However, several important questions need to be considered in terms of eco-labelling. First of all, a necessary condition for the spread of moral environmental reasoning to buying decisions is that characteristics, which connect the purchase to environmental problems, become salient in the buying situation. This means, other characteristics of the purchase should not be too highly involving and thus not 'monopolize' the attention of the consumer as it is usually done by the price. Additionally, the individual should feel a high degree of concern for an environmental issue that is associated with the particular buying decision (see also Thøgersen 1999, 441). It is also important to consider the amount of information people can take into account when purchasing food. Usually consumers don't spend much time for daily shopping, because food is a low-involvement good. Thus, only a limited number of product characteristics are crucial for the buying decision. Also the level of knowledge about environmental risks and issues is very different across people. Therefore, the kind of information given about environmental impacts and its way of presentation has to be elaborated carefully in order to convey benefits of sustainable food production and processing methods.

Finally, it appears to be important to anticipate the abuse of 'green' claims and misleading advertising, because consumers' confidence in environmental certificates still needs to be consolidated (Martin and Simintiras 1995, 17; Karstens and Belz 2006, 189). Hence, consumers often are distrustful if products labelled as 'organic' indeed are produced according to the rules of organic farming. Also the use of pictures and images on products and for promotion is quite often misleading. For example, many diary products have lucky cows, green meadows and flowers on the package although the milk comes from industrialised farming systems without free range. Since these symbols stand for animal welfare, healthy nature and nice scenery, consumers don't get the right impression about the conditions of production.

Conclusions

Labelling concerning ecologically sound production and processing methods is probably most effective when these characteristics are seen as an indicator of product quality. On the one hand, this can stimulate the demand, but on the other hand, intangible characteristics like a reduced application of pesticides and fertilisers can become experience attributes in this way, which means that expectations can be confirmed after purchase. Such an association can possibly raise potential barriers for increasing demand because consumers could reject their perhaps unrealistic expectations regarding, for example, better flavour or positive health effects of eco-friendly products after consumption. Thus, marketing experts should communicate eco-friendly characteristics with a maximum of transparency, but without creating unrealistic expectations.

Indeed it remains to be seen if the labelling of environmental impacts will have an influence not only on the product choice of ethical consumers, but also on the consumption behaviour of the mass market. Further research is necessary to understand consumers' conception of environmental sustainability, quality and healthiness. The effects of more transparency in terms of externalities of food production, as well as labelling strategies, have not been studied very well so far and thus more investigations are required

Acknowledgements

I wish to thank anonymous reviewers for helpful comments.

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Marketing from multiple perspectives

Local food networks and the change of the agrofood system

Lamine, C.[1]

Key words: food systems, consumers, food democracy, system redesign, trajectories

Abstract

Can alternative local food networks, through the relocalization of production and consumption and the higher proportion of organic practices, bring significant changes in the agrofood system? Drawing on the case of French Amaps, the distinction between an "input substitution paradigm" and a "system redesign" paradigm, which is at the crossroads of agricultural and social sciences, will help to assess the changes which occur in consumers and producers practices and in their interactions.

Introduction

AMAPs are CSA-type box schemes which emerged in south-eastern France in 2001 and gather in mid-2007 about 500 different groups all over France. They take the material form of weekly boxes composed of diverse agricultural products (most often, fruits and vegetables) grown "without using pesticides and chemical fertilizers" (the organic certification is not compulsory even though farmers should obey organic rules). Basic principles are the long-term subscription and the variability of the assortment, with consumers being unable to select their products. A stable price is set in advance, in principle based on farm costs and incomes, and the boxes are paid for before the beginning of the season. Behind these common principles, the systems are quite diverse: they include one or several producers, only fruits and vegetables or also meat, eggs, honey, cheese or other transformed products. Each AMAP is generally a specific organisation created by the consumers to run the system and take in charge part of the distribution tasks.

AMAPs belong to local alternative agro-food networks (AFNs), which also include farmers' markets or shops and many cooperative forms and can be defined through what they contest, i.e., deregulation, globalisation, and/or degradation of agro-ecosystems; and what they defend, i.e., a construction of trust based on direct relationships and the relocalization of production and consumption.

In the social sciences, many studies have analysed these AFNs ambition and potential to create meaningful change in the food system. Some consider they are more oriented toward developing new alternatives for consumers in a more diverse food system, than toward changing the dominant food system (Allen et al., 2003). Others analyse the relocalization of food systems as rather defensive and being possibly part of what may be called a neoliberal governmentality (DuPuis et Goodman, 2005). Finally, more "optimistic" analysts try to overpass the tension between the alternative potential of these AFNs, which relies on a pragmatic and incremental way of acting, and their oppositional potential, which supposes more classical political action, by suggesting the notion of food democracy (Hassanein, 2003).

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On their side, biological and agricultural sciences have suggested a distinction between an “input substitution paradigm” and a “system redesign” paradigm (Altieri et Rosset, 1996). The first paradigm defines organic farming as the ban of certain inputs and/or the recommendation of others (list of non chemical methods to “fight against” pests and diseases). The second one defines organic farming in a more qualitative way and refers to the construction of diversified production systems following the ecological model considered as the “natural” one, where interactions between components guarantee fertility, productivity and resilience properties. These paradigms could help us assessing the changes occurring at different levels of the food chain in the case of AMAPs.

Methods

The empirical data was collected through a hundred in depth interviews of horticultural producers and consumers lead between 2002 and 2007 and through an ethnographic analysis of these initiatives based on observations (e.g. distribution of the boxes, interactions between farmers and consumers, farm visits) and participation to various meetings of their network at regional level between 2004 and 2007. The interviews combine a life-story approach and a more systematic review of the different changes occurring in the food and production practices. The notion of trajectory is used in order to describe the changes in patterns at three levels: consumers, producers, and the systems and organisation that link them through these box schemes.

Changes along consumer and producer trajectories

For consumers, belonging to such a scheme might involve minor changes in the food practices. One could perfectly eat the same kind of products, cook them the same way, and not change much to his provisioning patterns beyond the box itself. We could then talk of a mere substitution in provisioning patterns and in products, with the replacement of non organic products by organic ones. However, nearly all consumers talk of profound changes in their practices and in their diet, much more than in other short circuit schemes like farmers market or producers shops. One of the reasons might be that in these networks, there is a large diffusion of some strong arguments regarding the alternativeness of the scheme. Indeed, as the content of the box is imposed and variable, consumers have to cook according to what they get each week. Most consumers also consider they eat more vegetables since they entered an AMAP. Moreover, once there, they often get interested in other alternative food systems such as fair trade. This would suggest a possible redefinition of food practices which takes place over time and is favoured and facilitated by the diffusion of values, arguments and information across the networks as well as the access to new circuits.

On producers side, trajectories were depicted as temporal organizations with successive phases whose boundaries are specific events, decisions or changes. The trajectories were formalized through a comprehensive sketch combining the main changes regarding technical and managerial dimensions, marketing, learning processes, and interactions with consumers. This allowed the comparison of the different cases and their analysis from a combined agronomical and sociological point of view. The analysis of these trajectories showed that conversions to OF can be more direct (for example following a health incident or economical difficulties) or more progressive (when a former rupture with conventional agriculture was to be identified long before conversion to OF was considered) and that a decisive aspect of these trajectories, and especially of their progressiveness, was the issue of plant protection.

In this regard, the two paradigms of substitution and redesign can describe different trajectories or different moments in the farmers trajectories. Some farmers replace forbidden inputs by eligible ones but remain in the aim to “fight against” pests and diseases: “*We do not use the same products, but we do the same treatments*”. Others would redefine things more globally and consider “*that a new ecosystem can rapidly appear as there is no chemical intervention*”, aiming more at doing “with” pests than at fighting against them. In this paradigm of system redesign, interactions between techniques and the components of the “agro-eco-system” have to be built so as to enhance natural regulation processes and partial or indirect effects. A third intermediary paradigm is also observed, in which substitution (of conventional chemical by organic inputs) was followed by a reduction of these organic inputs themselves. All the dimensions of the trajectories are linked in such evolutions: the adoption of such a box scheme gives the farmer a guarantee of income which allows him to take certain technical risks, especially regarding plant protection, and in some cases, to turn to organic. Indeed, the changes do not only concern agricultural practices, but also marketing choices (table).

Agric. Practices ->	Already certified	Turned to OF	Non certified
	46%	19%	35% (half are conside-ring conversion to OF)
Marketing choices->	Already in short circuits before	Gave up long circuits	Combine short and long circuits
	47%	36%	17%

Source: survey among 54 Amap vegetable growers in Provence, 2006

Redefining the agro-food system?

Beyond these changes along consumers and producers trajectories, how can these schemes contribute to larger changes in the agro-food systems? This question is hardly tackled in these networks, even though it is very central as a claimed aim. Several possible types of changes can be identified and are partially experimented: 1/ enlarging the number of involved consumers (and producers); 2/ enlarging the number of different products in each scheme and box; 3/influencing the dominant system through the creation of hybrid schemes or approaches; 4/ influencing the definition of public policies at different levels.

The two first possibilities aim at going beyond the current “niche effect” and relate to the substitution paradigm. The third one might be closer to the redefinition paradigm but for the time being, it emerges rather from outside these alternative systems. For example, many similar box schemes are now proposed by more “conventional” food chain actors such as organic wholesalers and do not include any direct commitment and links between producers and consumers. In France, the fact that many extension structures have recently acquired competences in short circuits might also be considered as an effect of such initiatives on the dominant agrofood system, even though it is often perceived in terms of “recuperation” in the alternative circles. Finally, the fourth mode of change combines substitution and redesign. For example, some AMAPs try to have local schools or hospital establishing contracts with their local producers, which means a substitution in their sourcing practices but also a potential redefinition of local policies. Another possible effect, which goes beyond the question of food production and consumption and towards potential redesigning effects, is the participation of such local networks to local or larger environmental and land use issues. The necessity to fight for a common (threatened) environment through civic engagement and “civic agriculture” might indeed be more involving than the mere acquisition of a weekly box of vegetables.

Changes at the interface between production and consumption

Even though AFNs often appear very ambitious regarding their possible effect on the agrofood system, it might be more modestly at the interface between producers and consumers in local groups that some effective change can occur. In the AMAPs, the principle is that consumers negotiate collectively the process of production (e.g., the content of the box over the growing season, the choice of crop varieties, etc.) with the farmer(s) as well as the system of distribution, which allows them to take part in decisions which they are ordinarily excluded from. Such negotiations are made possible through learning processes of both farmers about consumers’ taste and culinary uses, and of consumers about farmers’ production and distribution constraints. This allows for a re-skilling of consumers which is a reaction to the consumer deskilling achieved by the corporate system (Jaffe et Gertler, 2006). The decision to ask for organic certification might be discussed in the case of non organic farmers and the consumers might propose to pay for the costs or might decide, together with “their” farmer, that trust rely on proximity and direct relations more than on any label. Such an issue rarely leads to a conflict at local scale but has been a major source of conflict at regional scale. In Provence, the AMAP network is currently elaborating a participatory certification scheme so as to solve this (Lamine, 2008).

Conclusion

By establishing strong commitments between consumers and producers, AMAPs intend to redefine both the consumption system and the production system. The study of their networks over a 5 years period of time shows that not only substitution but also redefinition processes can be observed along time both in farmers and in consumers practices as well as in their interactions. However, such changes are mainly visible at the scale of local groups and the conditions of an “upscaling process” are still unclear. It will be necessary in the future to follow the trajectories of such initiatives....

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Direct marketing of beef in organic suckler cattle farms: economic results and impact on breeding system management

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Key words: beef, suckler cattle, direct marketing, organic farming

Abstract

In response to the bovine crises of 1996 and 2000, and also to the poorly structured organic beef market chain, direct marketing of beef to consumers by the farmer has developed. We studied the impact of this marketing system on economic performance and farming practices. The results show that direct marketing can generate added value, despite the extra costs. Farmers have made the necessary changes to their practices, and have adapted their herd management. Through strengthening the link between the farm and the outside world, direct marketing offers an alternative to the expansion of farms, making it possible to support a greater workforce with the same structure.

Introduction

In the last ten years several crises have occurred in the beef market chain (BSE). These crises caused a temporary drop in French consumers' confidence and a collapse of meat prices paid to the producers.To try and control the risk of price fluctuations, and also to make better use of extensive animal production from grasslands, which enjoyed a good image, some farmers chose direct marketing of meat (Lozier et al., 2005). Direct marketing (DM) of beef is still marginal in France, concerning only 0.8% of the national market. Beef from organic farming (OF) -certified farms represents only 1% of the domestic market, while only 1.6% of suckler cows are OF-certified. More than half the animals produced from OF suckler cattle are not sold on the organic market, owing in part to the poorly structured OF beef marketing chain (Veysset et al., 2006). OF beef producers turned massively to direct marketing to find an outlet for their production with a remunerative price. Direct marketing now represents 22% of the organic beef market (Agence Bio, 2007).The objective of this study was to assess the impact of direct marketing on economic results and farming practices for both OF and conventional suckler cattle farms.

Materials and methods

Direct marketing is taken here to mean the sale to consumers of meat from farm animals.

Surveys were carried out in 20 private suckler cattle farms in central France. These farms were specialised in beef production, with cow-calf and finishing systems (Limon, 2006). The sample covered the full diversity of the systems: (i) organic and

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conventional (Conv.) production systems, (ii) range of animals sold (calves, steers, bulls, heifers, cows) and (iii) butchery management either internalised (carried out on-farm in a specific building) or externalised (carried out off-farm by a service provider).

Interviews were used to determine the type, number and weight of the animals sold on-farm. The selling price to customers and all the costs and investments directly related to the DM were identified. The husbandry pattern and the management of the animals to be sold on-farm were described by identifying, jointly with the farmer, the changes made by category of practices (feeding, reproduction, replacement, range of animals, calendar sales). We used multivariate analysis to assess the consistency of the change processes.

Lastly we collected data on the organization of this activity and the estimated labour time requirements from slaughter to market.

Results

a) Sample and range of animals sold

Twenty cattle farms were surveyed, comprising 8 farms with OF and 12 farms with Conv. system. Table 1 shows the main structural characteristics of the farms, and the range and number of animals sold on-farm.

OF farmers sold more young animals by DM; 44% of the animals sold on-farm were calves (25% for Conv.). For adult sales, OF sold as many males as females, while Conv. sold predominantly females on-farm. The males from the French suckler herd were mainly sold as stock animals for the Italian market. There is no organic market for this type of animal; the organic farmers have to fatten their males if they want to sell them on the organic meat market.

Table 1: Size of farms, and range and number of animals sold by direct marketing

	Area (ha)	Calvings (nb.)	Animals DM (nb.)	Animals DM (%)	Animals sold DM (number/year)					kg carcass DM
					Cows	Heifers	Steers	Bulls	Calves	
OF	99	39	16	44	3	2	4	0	7	4 491
Conv.	150	94	24	25	6	9	2	2	5	7 686

b) Economic results

The average selling price charged by the farmers was 9.8 €/kg for meat from adults and 12.9 €/kg for veal. These prices were close to those charged by the supermarkets for beef (9.9 €/kg) and below those charged by butchers (14.1 €/kg). The OF label permitted an added value on the retail sale price of about 20% for adults and 7% for calves, although according to the farmers, the customers valued the direct link with the farmer more than the OF label.

The selling prices of the animals per kilo of carcass, were 7.3 € and 9.2 € respectively for OF adults and calves (6.1 and 8.3 €/kg for Conv).

The average specific costs linked to the DM amounted to 1.92 €/kg carcass distributed over three major items: (i) transport of animals and meat: 0.23 €/kg carcass, (ii) slaughtering, butchering, processing, depreciation of butchery unit: 1.56 €/kg carcass,

(iii) water, electricity, administrative management, advertising: 0.13 €/kg carcass. We did not differentiate between OF and Conv., because these costs were not linked to the production system but mainly to the butchery management. However, we note that the transport costs were 0.14 €/kg carcass higher for OF owing to a shortage of OF-certified slaughterhouses, resulting in longer transport distances.

The threshold for the minimum volume of meat enabling the farmers to invest in specific butchery equipment was 8 tons of carcass per year, equivalent to 20 adult animals (400 kg carcasses).

Table 2 shows the net prices (€/kg carcass), which are the differences between selling prices and direct costs. Overall, in DM, OF adult animals earned an added value of 18% compared with Conv. We did not observe this added value for OF calves, because conventional calves have high value in DM.

Comparison with the classic marketing chain was made on the basis of the 2005 conventional market prices. The OF market being poorly structured, we could not indicate average OF prices. DM generated an average added value of almost 50% for OF and of 30% for Conv. This added value was higher for the adult animals.

Table 2: Net prices (€/kg carcass) calculated for DM and observed in conventional classic market chain (CMC)

Category		OF DM	Conv. DM	CMC	OF DM /CMC (%)	Conv. DM /CMC (%)
Adults	Cows	5.3	4.6	3.22	+65	+43
	Heifers	5.1	4.4	3.59	+42	+23
	Steers	5.3	4.3	3.43	+55	+25
Calves	Milk	7.0	10.2	7.36	-5	+39
	Older	6.3	6.4	5.6	+13	+16

For the whole herd, taking into account the percentage of animals sold by DM, the gain was136 €/LU/year for OF (50 €/LU/ year for Conv.). The average labour time spent in DM was 29 days per year, for a total added value of 6,900 €, or 350 € per day to finance the additional workforce requirements (240 €/day for Conv.).

c) Farming practices

Concerning the management of the cattle, the main systematic change was an increased replacement rate (inducing a younger average age of cows in the herd) and an increased number of calving periods to produce young calves throughout the year.

The changes in farming practices associated with the animals to be sold concerned: the animal range, the ways of combining the oldest and the youngest animals throughout the year to ensure regularity of sales and the fattening schedule over the year. Two strategies were identified (figure 1). One was focused on the quality of feeding without changing the type of animals (a more "technical" strategy). The other was focused on animal categories, without changing the feeding management (a more "commercial" strategy). The link between these strategies and the economic results of the farms showed: (i) a sophisticated feeding and fattening management system with limited investments, to optimize the technical performance and the economic value of each carcass (ii) a wide range of animals sold and a specific organization requiring investments both in time and money, with a strong involvement in the marketing activity, and with a broad offer to satisfy the consumers.

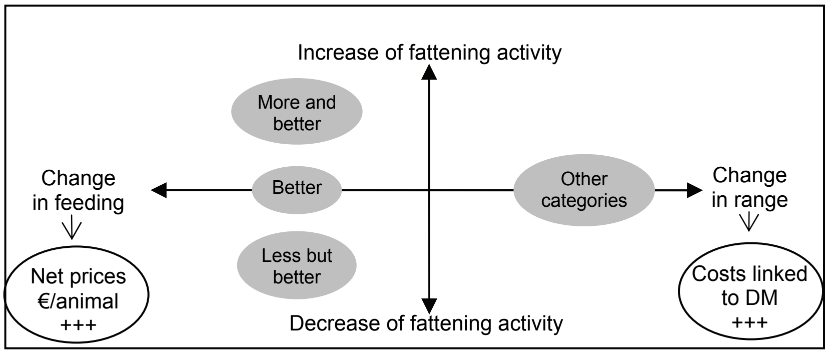

Figure 1: Changes in the management of animals to be sold

Discussion, conclusion

Direct sales make it possible to add value to animals when there is a market opportunity. It is also a good way to sell animals that are not "standard" (e.g., steers and heavy calves) and at the same time satisfy the customer.

Only some of the animals produced by the farm are intended for direct sales. Hence at least two marketing circuits exist side by side. This creates a need to sort the animals. There are various strategies for directing animals according to the category to which they belong and their quality.

Direct selling adds value in spite of extra costs. The farmer's degree of commitment to direct selling cannot be assessed solely in terms of the quantity sold, because the farmer also makes choices in terms of investment and additional working time.

The practice of on-farm marketing is an alternative to enlarging structures because it makes it possible to create more added value and to provide a living for more workers from the same structure.

The development of this marketing method always brings about changes in herd management. How the farmers react is also important, because they adapt quickly and direct sales strengthen the farm's links with the outside world.

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Innovations within the organic food sector – basis for novel business relations between agricultural and processing enterprises

Gottwald, F.Th. & Boergen, I.[1]

Keywords: Innovative products and processes, cooperation, organic food industry, organic farming, processing industry.

Abstract

Innovations within the processing sector may stimulate new, and extend and stabilize existing business relations with agricultural enterprises along the market chain. Due to their regional focus, small and medium-sized businesses in organic food production are eminently dependent on collaboration. On the basis of the evaluation of 140 applications for the Innovation Contest, this paper demonstrates how new and sustainable revenues can be built up by entering economic collaborations with innovative businesses of the processing sector.

Introduction

The competitive standards within organic food processing have increasingly changed over the past years. Participation of larger businesses, store brands and international as well as national certifications have been contributing to these changes. Innovations in the processing sector can help managing the new market situation. As in other sectors, the uniqueness of an innovative business solution in organic production is of particular importance in order to be successful (Gottwald et. al., 1982). This also includes effective marketing strategies, which highlight the positive image of organic products (Reuter and Kunz, 2006). The major condition for a successful innovation is its awareness level, i.e. the identification of the innovative idea with the producer or the brand. Research has shown that innovations often are encouraged by the legal framework, for instance prescriptive limits or environmental codes of practice. The *Innovation Contest* was launched by the Schweisfurth Foundation in 2003, amongst other reasons, in order to empirically assess how the EU-certification of organic food stimulates the business relationships between agricultural and processing enterprises. The competitions took place in 2003, 2005 and 2007 and figured out innovative business solutions in different sectors of the processing industry (http://www.innovationspreis-bio-verarbeitung.de). Following Hauschildt (2004), the concept of the *Innovation Contest* aims at identifying innovative business solutions from their development to their marketing and highlighting their contribution to complex societal interactions. The main objective of the contest is, to gain information about innovative capacities of the processing branch and make them accessible in order to encourage more companies to break new ground. The second objective is to motivate enterprises which are already operating in the organic food industry to improve their products and performance via innovations. Thirdly, the contest enriches the pool of ideas which is necessary for the success of the organic food market and helps combating prejudices against the sector. For the competition and for this paper,

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innovation is understood as the introduction of new goods, new methods of production and/or the conquest of new sources of supply. The innovation can be original (the introduction of a completely novel product or production method) or incremental (the transfer of an already existing product or production method to a novel business area).

Materials and methods

The present study is a qualitative analysis of 140 applications the Schweisfurth-Foundation received for the *Innovation Contest* in 2003, 2005 and 2007. The applying enterprises were classified into three categories: small enterprises (1-15 employees), medium sized businesses (16-299 employees) and large-scale enterprises (300 employees and more).

First of all, the innovations were examined with regard to their contribution to *Five Dimensions*. These dimensions are:

Technology
Production and raw materials
Nutrition and health
Corporate culture, marketing, cooperation and communication
Environmental responsibility and climate protection.

The 140 applicants have assigned each of their innovations to one or more of these five categories, depending on the subject of the innovations. These 389 innovations in the different categories were quantitatively analyzed. In a second step, the innovations were typified into four categories in order to assess the impact of the innovation on stimulating, extending and stabilizing new business relations within the organic food sector. These categories describe the impact on developing new or expanding existing:

Supplier cooperation (initial production)
Market relations
Supplier cooperation (process technologies)
Scientific cooperation

According to the classification within the five dimensions, the different aspects of the innovations were assigned to one or more of these criteria.

Results

Overall, most of the 140 applicants were medium-sized businesses (53,6%), followed by small businesses (38,5%). Following, the results for small and medium-sized businesses are presented, since only 11 applicants were large-scale businesses (7,9%) within the three years. Medium-sized businesses were contributing most of the innovations:

Tab. 1: Proportion (in percentage) of innovations for small, medium and large businesses in 2003, 2005 and 2007

	2003	*2005*	*2007*	Overall
Small	44,3	26,9	49,3	41,4
Medium	50,3	61,5	42,6	50,6
Large	5,4	11,5	8,1	8,0

Tab. 2: Number of innovations (in percentage), categorized by business size (s=small, m=medium), year and the five dimensions.

Year	*Size*	*Tech-nology*	*production & raw materials*	*nutrition & health*	*corporate culture, marketing, cooperation & communication*	*Environmental responsibility & climate protection*
2003	s	25,8	21,2	18,2	21,2	13,6
	m	21,3	26,7	10,7	29,3	12
2005	s	28,6	32,1	3,6	32,1	3,6
	m	17,2	26,6	15,6	32,8	7,8
2007	s	17,9	19,4	29,8	19,4	13,4
	m	13,8	22,4	25,9	19,0	19,0

Discussion

The kind of innovations not only differs by business size, but also by the year of application. For instance, the focus on the dimension *nutrition & health* has increased with the years. Innovations in this dimension are most frequent in 2007, for small (29,8%) and medium (25,9%) businesses (table 2). One explanation for this result can be the increased awareness of health, wellness and nutrition as a sales argument. Small enterprises have least innovations in the dimension *environmental responsibility & climate protection* (table 2). This effect also exists over the years and could be explained by the lower personal and financial scope of small enterprises. Hence, larger investments into environmental technologies or programs are more unlikely for small, than for medium or large enterprises. The quantitative analysis of the 140 applications shows, that innovative business solutions create new potentials with regard to new and/or existing collaborations. The results of table 3 suggest that business innovations within the organic food sector may contribute to building up new market and business relations. As expected, innovations within the technology sector mainly may lead to collaboration with suppliers of process technologies (small businesses: 64,9, medium-sized businesses: 85,7%). Innovations around raw materials have the largest impact on cooperation between processors and suppliers who deliver these materials (small businesses: 75%, medium-sized businesses: 88%). Innovations within the dimension *environmental responsibility & climate protection* are most likely to lead to new market relations and supplier cooperation with regard to new process technologies. Innovations within the dimension *nutrition & health* mainly contribute to new market relations; this result can be explained by the high number of innovations in this dimension which are subject to concrete consumer interests (e.g. special products for allergic persons or people with food incompatibilities). Communicative or marketing-innovations also can lead to new market relations (table 3). The study indicates, that innovative products and processes are appropriate to building up economic collaborations and networks within the organic food processing sector.

Tab. 3: Percentage of innovations (small and medium enterprises) which have an impact on (1) supplier cooperation (initial production), (2) market relations, (3) supplier cooperation (process technologies) and (4) scientific cooperation, sorted by the five dimensions:

Small enterprises					
	technology	*production & raw materials*	*nutrition & health*	*corporate culture, marketing, cooperation & communication*	*Environmental responsibility & climate protection*
(1)	48,6	75	33,3	50	42,1
(2)	45,9	50	87,9	83,3	68,4
(3)	64,9	27,8	27,3	19,4	68,4
(4)	13,5	5,6	6,1	2,8	5,3
Medium enterprises					
	technology	*production & raw materials*	*nutrition & health*	*corporate culture, marketing, cooperation & communication*	*Environmental responsibility & climate protection*
(1)	31,4	88	48,5	55,6	44
(2)	54,3	68	100	90,7	72
(3)	85,7	38	39,4	29,6	84
(4)	8,6	4	12,1	9,3	16

Innovative business solutions on the basis of reliable contractual relationships, fair producer's prices and high quality standards may stimulate and -at the same time- require stable business relations between producers and processors.

Conclusions

On the basis of innovations within the processing sector, reliable and promising cooperation between processors and producers can be built up. However, this thesis needs further research.

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Development of organic farming in Central and Eastern European countries

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Key words: Central and Eastern European countries, Land use structure, Organic farming, Organic livestock

Abstract

The total organic area in the eight examined Central and Eastern European countries (CEECs) increased to 907,900 ha and represented 2.73% of the utilised agricultural area (UAA) in 2005. This corresponds to an annual growth rate of 23.13%. However, the area of fodder crops represented over 65% of this increase. Estonia and the Czech Republic have the highest share (over 7%) in total organic area of UAA. At the same time these countries have seen a steady decrease of in-conversion area, which limits the potential for further growth. In the organic production structure, grassland and the production of fodder have become the main organic crop areas, mainly in Slovenia, the Czech Republic, Slovakia, Estonia and Latvia. In relation to organic livestock, beef production dominated with 67% in total CEECs organic livestock units, followed by dairy and sheep production with 14% and 8%, respectively, in 2005. Overall, sheep are the most popular species in nearly all CEECs when shares in total production are compared. Despite the rapid growth of organic farming (OF) in CEECs in recent years, the current arrangement of organic production can be noticed as one of many factors hindering the development of the organic food market and diversification of supplies.

Introduction

The proportion of organically managed land of total UAA is comparable to that observed in the former EU-15 countries but the supply of organic products in CEECs is limited. A well-developed market is one of the biggest problems facing the CEECs and the current land use structure does not sufficiently contribute to the enhancement and diversification of organic products and food supply. The aim of this paper is to give an overview of the current state of OF and highlight trends in the level and structure of organic production in 8 CEECs between 2000 and 2005.

Materials and methods

Statistical analysis is hampered by the lack of data in most CEECs before 2004. Therefore, a survey based on a questionnaire sent to national experts in CEECs was carried out to collect the relevant information. Data collection was held in 8 CEE countries: Czech Republic (CZ), Estonia (EE), Hungary (HU), Poland (PL), Lithuania (LT), Latvia (LV), Slovenia (SI) and Slovakia (SK) and was carried out in 2003 and 2004. The questionnaire focused on general statistics covering data about the number of organic farms, area under organic production, organic crop composition and the

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amount of livestock during years 1997-2004. The Eurostat format was used for statistical data collection. Data for 2005 is based on Eurostat database supplemented by national sources and FAOSTAT where needed.

Results

The total organic area in 8 CEE countries, both in-conversion and fully converted, increased from 71,881 ha in 1997 to 907,900 ha in 2005. This increase corresponds to an average annual growth rate of 21.02% between 2000 and 2004 or of 23.13% until 2005, and represented 2.73% of UAA in 2005. There are substantial differences between the individual CEECs regarding the importance of OF. In absolute figures, in spite of slower growth, CZ recorded the largest total organic area (more than 254,000 ha and 28% of CEECs), followed by PL, HU and LV in 2005 (see Table 1). The picture is different if the countries are arranged according to their share in total organic area of UAA. Due to quite an impressive growth in EE in recent years, this country showed the largest share equal to 7.16% in 2005, followed by CZ with 7.07% and LV with 6.84%. Among CEE countries with the highest average annual growth rate of total organic area over the period of 2000 - 2004 were LV (77.73%), LT (73.78%), EE (46.93%) and SI (43.43%). However, only the Baltic countries (LV, LT and EE) recorded higher growth of total organic area in 2005 also. In addition, PL and SK recorded significant increases in total organic area in 2005 (102.76 and 69.91%, respectively). In contrast, CZ and HU for the first time experienced decreases in organic area and SI stagnation.

Tab. 1: Total organic area, average annual growth rate and share in 2005 UAA

	Total organic area (ha)				Annual growth rate (%)		Share of UAA (%)	
	2000	**2003**	**2004**	**2005**	**2000-2004**	**2004 - 2005**	**2000**	**2005**
CZ	165,699	254,995	263,299	254,982	12.27	-3.16	4.60	7.07
EE	9,872	42,573	46,016	59,741	46.93	29.83	1.18	7.16
HU	47,221	116,535	133,009	128,576	29.54	-3.33	0.81	2.19
PL	25,000	49,928	82,730	167,740	34.87	102.76	0.16	1.05
SI	5,440	20,018	23,023	23,499	43.43	2.07	1.07	4.60
LT	4,709	23,289	42,955	64,544	73.78	50.26	0.17	2.28
LV	4,400	24,480	43,902	118,612	77.73	170.17	0.25	6.84
SK	58,458	54,479	53,091	90,206	-0.02	69.91	3.01	4.65
ALL	320,799	586,297	688,025	907,900	21.02	31.96	0.97	2.73

The actual proportion of in-conversion area of the total organic area can indicate potential growth in the organic sector in the near future. The differences in the potential increase of organic production are shown in Figure 1. CZ and EE corresponded to the overall CEECs development with the percentage of in-conversion area constantly decreasing. The potential for further growth is limited especially in CZ, where the share was less than 15% in 2005. On the other hand, these two countries have the largest share in organic area of UAA nowadays. HU, PL, LV and SK showed a balanced development, with a certain increase realized in the last two years in the case of PL, LV and in particular SK. Only in LT the proportion of in-conversion area steadily increased, except for the last year investigated (2005).

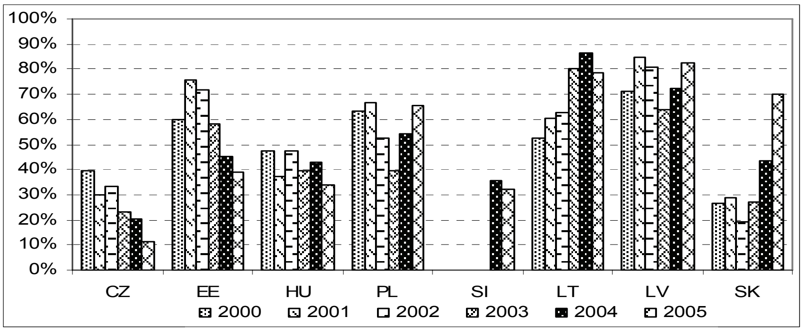

Figure 1: Proportion of in-conversion area of total organic area by country, 2000-2005

The total organic land use structure in 8 CEECs did not differ significantly from those observed in EU-15. In 2005, out of 907,900 ha of organic area around 22% were covered by arable crops, 71% by grassland and fodder crops, followed by 2% under permanent crops and 5% occupied by other uses. The CEECs contributing most to the total organically cultivated arable land in recent years were HU, PL and LT and these represent higher potential of organic production. Conversely, nearly 50% of organically managed grassland was located in CZ, followed by HU and SK. In the case of permanent crops, HU and PL had the largest shares over the whole period studied, supplemented by a significant increase in LT in 2005. Production of grass and fodder crops was the most important use of organic land in most CEECs and even more significant (over 75%) in SI, CZ, SK, EE and LV. In the case of the two latter countries, green fodder on arable land covered a significant share (80% and 70%, respectively). The highest share of organically managed arable land in total arable land was recorded for LV (8.31%) and EE (7.77%), mainly due to covering of fodder production. The highest share of pastures and meadows in total permanent grassland was recorded for CZ (24.62%) and the highest share of permanent crops was found in LT (9.09%) and EE (8.44%).

Tab. 2: Organic livestock (number of heads), 2005 and % changes 2004-2005

	Organic livestock				**% changes 2004-2005**			
	Cattle	**Sheep**	**Goats**	**Pigs**	Cattle	Sheep	Goats	Pigs
CZ	67,956	24,230	1,725	3,108	-32	-23	-34	129
EE	9,289	11,163	333	253	-8	3	-3	-36
HU	12,235	29,829	3,071	1,877	45	-2	-27	-27
PL	13,913	12,192	1,958	17,918	x	x	x	x
SI	14,539	21,071	3,827	1,966	11	17	10	59
LT	3,843	3,658	388	70	-42	-3	21	-16
LV	21,439	6,109	928	6,580	114	210	40	217
SK	20,133	57,830	1,006	206	58	114	52	565

NB: PL - data from 2004 is used.

The most important organic livestock category in CEECs was beef production (67% of total livestock units), followed by dairy production (14%) and sheep production (8%). The percentage of organic livestock category in total production shows that sheep were the most popular species in nearly all CEECs (7%). In EE, as many as 29% of sheep are bred organically. The share of organic cattle was significant, over 5%, in CZ and LV. Certified pig and poultry production was less developed in all CEECs and the share of organic in total pig and poultry production was under 0.5% in 2004. All organic livestock categories are on the increase in SI, LV, SK and on the decrease in CZ, EE, HU and LT with the exception of always one livestock category (Table 2).

Discussion and conclusions

The rapid growth of organically managed land in nearly all CEECs since 2004 can partly result in better availability of organic raw materials. Moreover, the highest growth was realized in the acreage of arable land (in 67% of CEECs). However, the area of fodder crops represented nearly 72% of this arable land growth, and meadows and permanent pastures were still dominant uses of organic land. At the same time, the lowest area payments were provided to organic grassland in all CEECs, with the exception of LV, where one general payment rate has been applied since 2004. Considering that, the current structure of organic production can be seen as one of the main factors hindering the development of the market for organic food and diversification of organic supplies. Since the OF area payments are one of the most powerful and almost the only support for the organic sector, the payments should remain in existence but under the proviso that higher payment levels for arable crops, vegetables and permanent crops in comparison with grassland was provided, and that the difference between area payments for organic and integrated production was ensured. Moreover, other supporting measures (mainly demand-pull), such as support for marketing initiatives, promotion, professional advisory services, education and R&D, are needed for the stimulation of more market-oriented production in consequence of the increased demand for organic produce and contribution to sustainable OF development in CEECs.

Acknowledgments

This paper presents results obtained mainly within the EU project QLK5-2002-00917 on “Further Development of Organic Farming Policy in Europe, with Particular Emphasis on EU Enlargement” (www.irs.aber.ac.uk/euceeofp).

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Construction of prices for organic products enhancing farmers' profiles diversity in the South East of France

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Key Words: marketing choices, agricultural techniques, values, price

Abstract

The Provence-Côte d'Azur region is a French leader for organic farming, both in term of bulk production and number of farmers. This study aims at identifying organic farmers' profiles diversity within the region and at creating a framework in order to understand the construction of prices for organic food. Targeting technical, economical and marketing channel choices issues, elaboration of prices for organic commodities is studied through 20 interviews, where farmers' values were also considered. As results, first enhancement of the organic products is highly correlated to the natural and logistic resources. Moreover, most organic farmers have elaborated innovative marketing channels in order to cope with the local supply and demand. Indeed, a large number of farmers are involved in direct selling, even in combination with other marketing channels, in order to enhance their production through prices. Finally, farmers' values have an important influence on final prices. Indeed several organic farmers pay a great attention to social, ethical, environmental issues, beyond a basic compliance with the organic standards. As a result, fairness, environmental issues, or rural development lead farmers to implement innovative techniques and marketing strategies with a final incidence on price construction.

Introduction

Organic food and farming are taking an increasing importance in the global food sector over the last years. In European Union, since 1991 and the implementation of the regulation on organic crop productions (regulation EEC N°2092/91), organic farming has developed constantly, until reaching nowadays in France two percent of the agricultural production (Agence Bio, 2007).

The French organic sector is faced today with a challenging issue, which stands in the increasing share of the total food production and consumption. Moreover, society is paying more and more attention to environmental aspects of food and the sustainability of agriculture. Likewise, political frame is willing to support ecological and high quality agriculture.

With more than 900 organic farmers, the Provence-Côte d'Azur is one of the leading regions in France for organic farming. The present study aims at pointing out the farmers' profiles diversity and at understanding the elaboration of prices for the organic food, through farmers' interviews.

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First, highlighting general trends of farmers' initiatives, both in terms of technical and marketing practices, the study then describes in depth examples of individual or collective trends with their consequences on price elaboration. Finally, confronting the literature review, the study shows the dynamic dimension of farmers' approaches.

Methods

Twenty interviews were conducted. Case studies were chosen according to a framework which classifies organic farmers in "ideotypes" according to their involvement into the organic standards and the choice of marketing channels (Sylvander *et al*, 2006). This frame allows dividing organic farming into four models. Sheep husbandry is particularly targeted in animal husbandry, fruits and vegetables for crop productions, as well as wheat production.

Interviews, conducted through a questionnaire dealing with both semi and fully opened questions, were registered. Interviews were planned to last less than an hour; however semi opened questions often needed more time. Interviews were divided in three main parts: technical aspects (mechanisation, production costs, labour force, and soil fertility management), marketing aspects (marketing channels, relationship with customers and price) and values (involvement into the organic movement and standards, social and societal considerations, evolution and enhancement of both systems of production and marketing).

Results

For all farmers, enhancement of the organic products is highly correlated to the natural and logistic resources. Indeed the presence of an organic chain at the slaughterhouse (for sheep production), water resource through artificial channels (for vegetable production), or the distance between the farm and potential markets are serious limiting factors. Due to the small number of farmers and the limited amount of sheep produced, slaughterhouses in the studied region do not implement specific organic chains. As a result, farmers can not enhance their production as organic which entails a clear incidence on selling price and financial viability of the farm. Conversely, two of the most important French wholesalers for organic food are located in the region. It clearly allows farmers in the surroundings, especially for vegetables and fruits growers, to create financial security. However, for farmers located far away, transportation costs do not lead farmers to deal with these wholesalers.

In details, three trends can be highlighted.

In a first group, farmers have elaborated innovative marketing channels in order to cope with the local demand. Through direct selling, these farmers offer a large diversity of products, especially corresponding to specific consumers' demands for fresh, organic and locally produced food. Among them, one organic livestock farmer producing goat cheese with a Protected Denomination of Origin (PDO) prefers not to sell the cheese as organic. He noticed that the combination of PDO and organic does not correspond to his customers expectations. Thus, organic farmers involved in direct marketing develop strategies to combine, as much as they can, organic and local attributes.

In a second group, interesting cases can be identified trough diverse experiences of organic farmers' organisations within the region. A first example corresponds to a wheat producer, growing traditional varieties of wheat which have found marketing and technical development, associating the Regional Park of Luberon, in order to create a brand linking his wheat variety with the park. In this way, he has developed partnerships with other farmers, mills, bakers and consumers within the region, enhancing his production. On the other hand, organic sheep farmers expect the slaughterhouse to implement an organic chain, but no collective action is engaged. Thus the incidence of individual requests on the slaughterhouse remains insufficient.

Finally, as long as the construction of price stands mainly on a tricky combination between demand and supply, a third group of farmers is targeting the national market. They are producing a large amount of quality food and specialising in a few products. A close relationship with wholesalers enables such farmers to sell the bulk of the production, certainly at a lower price, but with the guarantee to dispose of the merchandise.

In all cases, elaboration of prices is first a result of a sum of technical and economical issues. Moreover, farmers' values have an influence on final prices. Generally, organic farmers are often not only dealing with issues related to organic farming, but also with environmental issues, the place of farmers within the society, high quality food, fairness and rural development. Through the following examples, new trends can be highlighted, especially in the scope of the evolution of the compliance of farmers with the organic standards.

Six farmers prioritize the employment of farm workers rather than maximize their incomes. The value behind is the willingness to keep workers in rural areas. All farmers involved in direct selling express the willingness to produce and sell locally. Producing locally is not typical of organic farming, but makes sense when organic farming aims at preserving environment and enhancing local resources. Indeed, those farmers find absurd to grow organically on the farm and sell hundreds miles away (in terms of environmental costs). Other farmers, especially in vegetable production, are willing to sale their products at a fair price (just covering the production costs), even in direct selling, in order to allow financially consumers to reach a healthy food (free of pesticide).

Discussion

The first component of price states in the availability of the market, of the resources, infrastructures and services. Indeed, as for the sheep farmers interviewed in this study, the lack of organisation between farmers to engage a collective request for an organic chain at the slaughterhouse got a clear incidence on final price, with a meat not sold with the organic label.

Research on organic marketing initiatives has already shown the interest of farmers for direct marketing, especially in order to reduce price due to the several middlemen (Weier and Caverley, 2002). However, some of the farmers interviewed in this study aim at selling their products even more expensive than the production costs, arguing that the final product presents more than the basic qualities of an organic product, *e.g*. locally grown, contributing to rural development (Schmid *et al*, 2004), until reaching the limit of the consumer' willingness to pay (Michelsen *et al*, 1999).

Farmers dealing with wholesalers clearly assume that it implies clear constraints, such as tricky relationship with customers, lower added value on final price, but this market channel choice allows farmers to focus on their job, *i.e.* organically growing (Schmid *et al*, 2004).

It is relevant to mention the dynamic approaches of farmers within the region, lying in the evolution of practices and marketing channels choices in time, already described in other European regions, especially in the frame of the Omiard (Organic Marketing initiatives and Rural Development) project (Schmid et al., *op. cit*).

Conclusion

The present study aims at describing the construction of prices, for organic commodities, through farmers' interviews. Different components, such as production cost recovery, incidence of redesigning the practices management or the added value due to marketing strategy are first studied. Then, a large part of this study deals with the enhancement of the organic products through organic farmers' values. Indeed, in most cases, issues such as rural development, ecological impacts of farming, fairness with consumers, lead to have a significant incidence on final prices.

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Carbon storage and energy use

Carbon sequestration in organic and conventional managed soils in the Netherlands

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Key words: organic matter, carbon sequestration, farm management, organic agriculture

Abstract

Next to other important agronomic and ecological aspects, the organic matter sequestration in the soil plays an important role in the CO_2 balance. Based on detailed farm registrations, the input of effective organic matter and the changes in carbon sequestration in the soil was calculated for a large number of organic and conventional farms in the Netherlands. Results show that both organic and conventional management resulted in a decrease of the pool of organic carbon in the soil. The average decrease for the conventional management was 401 kg ha^{-1} $year^{-1}$ and for the organic management 261 kg ha^{-1} $year^{-1}$. The input of effective organic matter in the soil was significantly higher in organic than in conventional farms. Animal manure was the main contributor to this difference.

Introduction

Changes in the organic matter in the soil are crucial for agronomic aspects like nutrient dynamics, structure and water storage capacity as well as for the environmental performance of a farming system like biodiversity, nitrate leaching and recently in focus, carbon storage in the soil. Organic matter in soils acts as a large carbon sink and plays an important role in the CO_2 balance. This paper will deal with the changes of the organic matter in the soil under current organic and conventional management practices in the Netherlands.

Materials and methods

Data for the calculation of the changes in soil organic matter were obtained from detailed farm registrations of 101 organic and 85 conventional farms in the Netherlands divided in three regions: Central clay, South-west clay and South-east sand. Each region represents a group of farms on a similar soil type and under similar climate conditions. Data were registered in the period 1998 to 2006. From every farm there were 1 to 4 years of registered data available. Both the amount and type of organic matter input were registered including crop residues and green manures.

From the data an average organic matter input and the so called effective organic matter input were calculated for organic and conventional farms in a certain region. The effective organic matter is defined as the organic matter that is still available one year after incorporation in the soil. For every type of organic matter, standard data are used for the remaining percentage of organic matter after one year of incorporation in the soil.

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To predict the effect of different organic matter management strategies on organic and conventional farms, the decomposition model of Janssen (1996) was used. This model describes the decomposition of organic matter or carbon (C) in the soil as:

$$Y_t = Y_0 \cdot EXP\ (\ 4.7\ ((a + t \cdot f_{temp})^{-0.6} - a^{-0.6}\ )\ )$$

Where Y_t = remaining amount of OM after t years; Y_0 = initial amount of fresh organic matter added to the soil; t = number of years after application; f_{temp}= correction factor for temperature (f_{temp}= 1 when average temperature is 9 ^oC); a = initial age of the organic material.

The increase of organic matter in the soil caused by the yearly input on the one hand and the loss of the present soil organic matter (SOM) on the other hand, were calculated separately. The a-value is based on the type of organic matter that is incorporated in the soil and can be derived from the humification rate of the incorporated organic matter in the first year. For this study an average a-value was calculated per region and farm type, based on the average organic and effective organic matter input per region and farm type and this value was used in the model. The decomposition rate of the present SOM of the involved farms is unknown. From results of long-term experiments in the Netherlands by Kortleven (1963) an average a-value for SOM of 16 was determined (Janssen, 2002). From a long-term pot experiment with 36 Dutch soils Wadman & De Haan (1997) found a-values ranging from 14 to 50. On two different sand locations in the south east of the Netherlands Postma & van Dijk (2004) found a-values of 16 and 19. According to Van Veen & Kuikman (1990) finer, clayey soils show on average slower decomposition rates and a higher retention of organic matter than coarse, sandy soils. To calculate the carbon loss of the involved farms for this case an a-value of 21 is used for the clay soil regions and of 16 for the south east sand region. The a-values correspond with a decomposition of the soil organic matter of 2% respectively 3% between t_o en t_1. For all calculations the average year temperature in the region is used for the calculation of the correction factor f_{temp}.

Results and discussion

It shows in figure 1 that the main contributions to the input of effective organic matter are made by the input of crop residues (roots, stubble etc.) and by the input of animal manure. Animal manure is available in abundance in the Netherlands. The main difference between organic and conventional management is the amount of input of animal manure, vegetable manure (mainly compost) and green manure.

Table 1 depicts the results of the model calculations. It shows that both with the conventional and the organic management the amount of carbon in the soil is decreasing in the course of the coming 25 years. However the organic management loses on average 140 kg of carbon per year less than the conventional management.

A critical comment on the better performance of the organic management is that in the Netherlands the majority of the applied animal manure on organic farms is still coming from conventional farms. So it derives part of its better performance in carbon losses from the conventional sector.

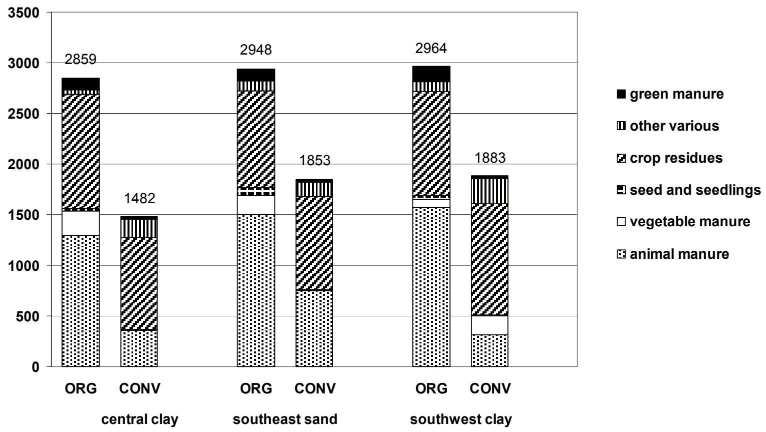

Figure 1: Input and origin of effective organic matter (kg ha^{-1} year^{-1}) per group of farms in a region.

Tab. 1: Average percentage of organic matter (o.m.) in the soil and calculated changes in sequestered carbon in the soil per group of farms.

Region	Type	No of farms	%soil o.m.	Carbon change (kg ha^{-1} year^{-1})		
				increase	loss	net change
central clay	organic	22	4.0	320	670	-351
	conv.	17	3.4	138	589	-451
southeast sand	organic	38	3.0	339	659	-320
	conv.	34	2.9	174	640	-465
southwest clay	organic	41	2.4	326	437	-111
	conv.	34	2.6	176	463	-287
total	organic	101	3.1	328	589	-261
total	conv.	85	3.0	163	564	-401

The decomposition of organic matter may better be described by the model of Yang (Yang and Janssen, 2000). However this model uses two parameters for the decomposition rate and the values of these parameters for different types of organic matter are unknown yet. Furthermore the used Janssen model, does not account for soil properties affecting the decomposition rate of the organic matter such as texture.

The result of the calculated net change of soil carbon largely depends on the decomposition of the present SOM (for this case the setting of the a-value). When the a-value is changed into 18 or 30 for clay soils and 13 or 25 for sand soils, the average net change of soil carbon varies from -360 to -71 kg ha^{-1} year^{-1} for the organic farms and from -496 to -219 kg ha^{-1} year^{-1} for the conventional farms.

The net decrease of organic carbon in the soil on arable land is confirmed in several studies. Vleeshouwers & Verhagen (2002) come to the same conclusion for the European arable soils. Although their estimation of net carbon losses are almost double the values found in this study. In long-term comparisons of farming systems in the Netherlands on southeast sand and central clay soil organic matter content declined as well for the conventional as for the biological farming systems (Dekking, 2003; Van Geel & De Haan, 2007). The inputs of effective organic matter were comparable to the amounts mentioned in figure 1 for the two regions and farm types. Pimentel et al. (2005) however measured a net increase of organic carbon in the soil for both organic and conventional agriculture. The results concerning the additional carbon sequestration in organic soils compared to conventional soils correspond with the study of Freibauer et al (2004). Freibauer (2004) concludes that organic farm management could sequester between 0 to 500 kg of organic carbon per hectare per year more than conventional agriculture.

Conclusions

Field experiments as well as model calculations show that with the current farm management in practice on Dutch arable farms the amount of organic carbon stored in the soil decreases, both in organic as well and in conventional managed soils. However the decrease with the organic management is lower than with conventional management.

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Should organic farmers be rewarded for sequestering C in soil?

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Key words: organic farming, soil organic carbon, carbon sequestration, greenhouse gas emissions

Abstract

The question of whether farmers, and organic farmers in particular, should be rewarded for sequestering C in soils is controversial. A review of the literature on long term experiments comparing organic and conventional systems, demonstrates that soils under organic management tend to have higher soil organic carbon (SOC) contents than conventionally managed soils. But the logistics of designing a system that compensates individual farmers for this ecosystem service are challenging. Agreements would have to be reached on the baseline system used for calculation of relative gains in SOC, values for emissions of other GHGs from soils (e.g. methane and nitrous oxide), the direct and indirect CO_2 emissions associated with energy use and crop production inputs in the C sequestering system, and emissions associated with sources of SOC imported onto the farm. Alternatively, the evidence for generally higher SOC under organic management could justify an additional payment, for example under the UK Government's Organic Entry Level Scheme.

Introduction

In general terms, C sequestration is the conversion of atmospheric CO2 into organic C (C fixation) that is protected or prevented from oxidizing back to the atmosphere. The storage of organic C in soils is one form of C sequestration. While it is acknowledged that the UK will need to adopt a variety of strategies to meet its commitment to the Kyoto Protocol, there is considerable potential for carbon mitigation through changes in agricultural land-use and management that increases soil C (Smith et al., 2000).

Currently, changes in soil C resulting from land use change (LULUCF sector) among four broad categories: forestland, grassland, cropland and settlement, are included within the UK's national GHG inventory (Baggott et al., 2007). Differences in soil organic carbon (SOC) among systems of agricultural production on grassland and cropland, however, are not included in the inventory.

Do organic farming practices increase soil C?

Practices that increase soil organic carbon contents include reduced tillage, ley periods in the crop rotation (e.g. grass or grass/clover crops), the use of organic amendments like compost or farmyard manure (FYM), and increasing biomass production per unit area (in some cases through the judicious use of mineral fertilisers). Organic standards prescribe many of these practices.

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There is a high degree of variability in management practices and soil fertility outcomes, even within specific categories of organic farms (Stockdale and Watson, 2002). Nevertheless, when researchers have compared organically and conventionally managed soils, they have often found that on average SOC contents are higher under organic management. This result was found in paired comparisons of soils from organic and conventional farms in the same region (Armstrong Brown et al., 2000; Drinkwater et al., 1995), and in long-term trials that more rigorously compare organic and conventional systems (Table 1). In these trials, SOC values are frequently higher where organic fertility inputs are used. In the DOK trial at the Institute for Organic Agriculture in Switzerland (FiBL), the plots receiving biodynamically composted manure and slurry at a rate equivalent to 1.4 livestock units per ha (BIODYN 1.4), had the highest SOC relative to the mineral fertilizer treatment (here including clover leys) after 21 years (Fließbach et al., 2007). Raupp and Oltmanns (2006) had similar results comparing composted manure with (CMBD) and without (CM) biodynamic preparations, with inorganically fertilized crops, at three different application rates. After eighteen years, the two higher rates of compost had significantly greater levels of SOC than the inorganically fertilized treatment. In the Rodale Institute Farming Systems Trial (Hepperly et al., 2006) there were significantly higher SOC contents in the organic, legume-based system (LEG) compared to the conventionally fertilized system, even with similar annual returns of crop residues to the soil.

Tab. 1: Difference in soil C relative to conventional management (∆ C) for organic treatments in several long-term experiments

Experiment	Treatment[z]	∆ C t ha^{-1}	Duration of experiment	Reference
DOK trial	BIODYN 1.4	3.82	21 y	Fließbach et al., 2007
	BIOORG 1.4	0.6		
IBR Darmstadt, DK	CM rate 3	3.8	18 y	Raupp and Oltmanns, 2006
	CMBD rate 3	5		
Rodale trial	MAN	10	21 y	Hepperly et al., 2006
	LEG	8		

[z]BIODYN 1.4 = biodynamic compost and slurry at 1.4 LU ha^{-1}; BIOORG = rotted FYM and slurry at 1.4 LU ha^{-1}; CM rate 3 = composted manure at a total N rate of 140 kg N ha^{-1}; CMBD rate 3 = composted manure with biodynamic preparations at a total N rate of 140 kg N ha^{-1}; MAN = organic manure and legumes as N source; LEG = legumes only as an N source

Calculation of total sequestered C

Carbon sequestration is not just a function of soil organic carbon levels. King et al. (2004) defined total sequestered carbon (TSC) in agricultural systems as a function of soil organic carbon (SOC), direct energy (DE) used on site i.e. to power machinery and operations, indirect energy (IE) used on site i.e. to manufacture and supply fertilizers, agrochemicals, etc., and greenhouse gases (GHGs) other than CO_2 emitted from soils This relationship can be summarized as the TSC equation:

$$TSC\ (kg\ ha^{-1}\ yr^{-1}\ CO_2\text{-}C) = SOC - DE - IE - GHG$$

Increases in TSC can be achieved by gains in SOC, or by decreases in DE, IE and GHG, or by a combination of these. Literature values for energy usage on-farm and in the production of inputs can be used in the calculation, as well as default values for emissions of N_2O and CH_4 under different management scenarios (King et al., 2004).

The calculation of TSC requires an estimate of the annual rate of change in SOC. According to standard methods of modelling SOC dynamics (first order kinetics), this rate declines with time and eventually becomes insignificant as the soil approaches a new equilibrium SOC content. There is no consensus on how long it takes to achieve equilibrium SOC contents: SOC models like ROTH-C are generally run for 100 years after a perturbation in order to obtain some certainty about the equilibrium SOC contents (Webb et al., 2003), yet King et al. (2004) assumed that gains in SOC were negligible by 10 years after a change in soil management.

The source of the C used to increase SOC levels also needs to be considered. When C is imported from off-site, e.g. as livestock manure or crop residues, there are off-site emissions (OSE) associated with that C source, that need to be included in the TSC equation to get a true estimate of the sequestration benefit of increasing SOC in this way.

Crediting management-related changes in TSC on agricultural land

Changes in SOC due to soil management could be incorporated into the UK Greenhouse Gas Inventory (Baggott et al., 2007). A similar approach to the method currently used to estimate changes in SOC due to changes in land use (e.g. from cropland to grassland) could be adopted to reflect changes to C sequestering practices (e.g. from conventional to organic production). This would require the estimation of rates of change in SOC for different management systems, and an inventory of land areas under improved management. The DE, IE and GHG values used to calculate TSC on a given area of land, are already accounted for in the National Inventory under the Energy, Industrial and Agriculture sectors. In order to maximise C sequestration in soils, a reward system for C sequestration by individual farmers would be desirable. This would require agreement on the baseline conditions for calculation of TSC. While the UK Greenhouse Gas Inventory uses a 1990 baseline, this may penalize farmers who are already farming in a relatively C-efficient way, as they will find it difficult to further increase their TSC. A better option may be to estimate the maximum potential SOC values for a given soil and climate (SOC_{max}), under optimum agricultural land management, and reward farmers based on their actual SOC contents (SOC_{act}) relative to optimum levels. Separately, emissions from DE, IE and GHG, as well as OSE from imported C sources, could be calculated. While this approach would provide clear incentives to individual farmers to maximize C sequestration, it would require detailed estimates of the maximum potential SOC values for all soil types in the UK, and separate agreements with individual farmers. The design of a system to reward individual farmers for C sequestration presents logistical challenges. Alternatively, the evidence for generally higher SOC in soils under organic management would support claims for an additional payment, for example under the UK Government's Organic Entry Level Scheme (OELS). Currently, the OELS pays organic farmers £30 per hectare in recognition of the public goods of enhanced biodiversity and reduced pollution that they deliver. Under the OELS, it would be possible to provide recognition of the higher average SOC levels achieved by organic farming, and the ecosystem services including C mitigation, that this provides.

Conclusions

Research results have consistently shown that for similar crops and soil types, organic farming practices which include compost or FYM results in higher levels of SOC than conventional farming practices. Nationally, the C sequestration benefits of these increases could be accounted for in a similar way to the current method of calculating SOC change in the LULUCF sector. At the farm scale the ecosystem services provided by SOC could be recognized by rewarding organic farmers for maintaining high SOC through the existing UK OELS.

Acknowledgements

The authors gratefully acknowledge funding from the European Community financial participation under the Sixth Framework Programme for Research, Technological Development and Demonstration Activities, for the Integrated Project QUALITYLOWINPUTFOOD,FP6-FOOD-CT-2003- 506358.

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A comparison of energy use in organic and conventional agriculture in Spain

Alonso, A.M.[1], González, R., Foraster, L., Guzmán, G.I. & García, R.

Key words: Organic Farming, Ecological Agriculture, Agroecology, Sustainable Agriculture, Energy Efficiency.

Abstract

The current situation of worldwide concern over the emission of greenhouse gases and its effect on the climate demands an evaluation, from the perspective of energy efficiency and more specifically of non-renewable energy sources, of tendencies for change in the management of agricultural systems that have arisen in recent years. This article uses energy balances to evaluate the contribution of organic agriculture to the increase in the energy efficiency of Spanish agriculture. The results show the higher nonrenewable energy efficiency (NREE) and the lower use of nonrenewable energy (NRE) in organic systems compared with conventional ones. Nevertheless, agricultural systems in general could still improve their energy efficiency.

Introduction

In recent decades concern has grown among researchers and society as a whole over the sustainability of farming. Within the European Union this interest has mainly arisen in relation to its environmental problems and their repercussions for food safety. A sign of interest in sustainability is the growth of organic agriculture, which occupied about 31 millions hectares in the world by 2006, of which more than 925,000 ha were in Spain. Therefore, the vast surface area occupied by organic agriculture guarantees that any change in management to save on fossil energy will have a very high impact.

The environmental and socioeconomic benefits anticipated from switching to organic management are multifold: an increase in biodiversity, a reduction in pesticide residues in the environment, less erosion, an increase in edaphic organic material, higher income for farmers, etc. (Alonso *et al.* 2001, Gliessman 1997, González de Molina & Guzmán, 2006). With respect to energy, we can expect organic production to contribute significantly to saving nonrenewable energy (Pimentel *et al.* 1983, Dalgaard *et al.* 2001, Wood *et al.* 2006), although this is not always the case (Pimentel *et al.* 1983, Helander and Delin 2004).

In this article we aim to evaluate the contribution of organic agriculture to the increase in energy efficiency of Spanish agriculture, estimating its potential contribution to the reduction of nonrenewable energy consumption. We also will discuss some proposals for improving the energy efficiency of agriculture in general and of organic agriculture in particular.

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Materials and methods

To compare the NREE (ratio of the final output and the NRE used) and the NRE consumption we analyzed 160 cases in Spain: 80 organic and 80 conventional farms (comparison by pairs). The selection of comparable cases was based on three basic criteria: history, proximity and similarity. The organic farmers were chosen at random according to how long they had been producing organically, as it takes time to establish management practices and to overcome a possible downward turn in production following the switch to organic farming. These farmers had all been operating for between 4 to 17 years. Conventional farms were chosen according to their proximity and similarity to organic ones, usually those with neighbouring plots (in order to ensure similar agro-climatic conditions) and/or with other similar characteristics (dry land or irrigated land, varieties used…). Certain aspects of management were also discussed and verified with technicians from the zones. The organic and conventional farmers were interviewed in person to obtain detailed information on management techniques, types of machinery and inputs used. The interviews were conducted from March to July 2006.

For the purposes of calculating energy efficiency, input refers to those sources of energy brought in that have an opportunity cost in an economic sense. The energy value of agricultural inputs takes into consideration both the energy used in the transformation of the products into the state in which they are used by farmers and inherent energy. Energy output refers to the energy content of the material produced from the agricultural activity. The main references used for the energy conversion are Ausdley *et al.* (1997), Fluck (1992), González de Molina & Guzmán (2006), Green (1987) and Mataix & Mañas (1998). The unit of analysis for the comparisons is the hectare.

Results and discussion

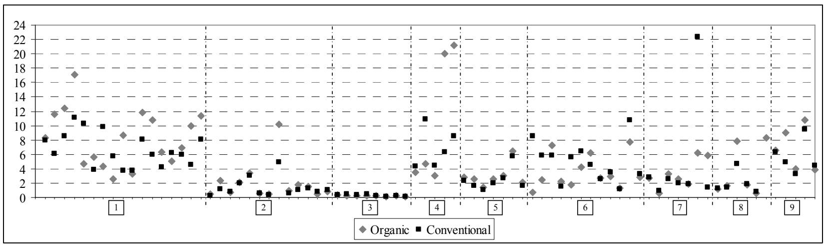

Figure 1: Non-Renewable Energy Efficiency in organic and conventional crops

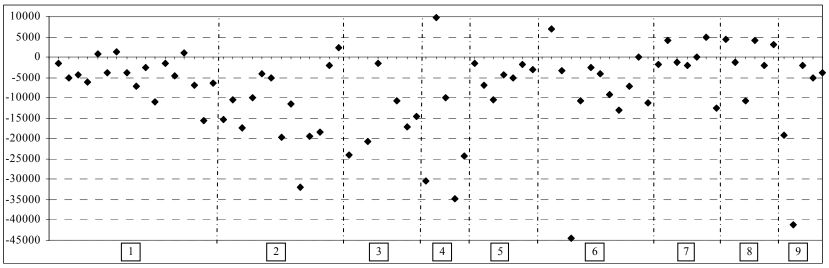

Figure 2: Differences of Non-Renewable Energy consumption: organic minus conventional crops (MJ/ha)

Note: 1 = Cereals and legumes; 2 = Vegetables; 3 = Greenhouse vegetables; 4 = Citrus trees; 5 = Olive trees; 6 = Fruit trees; 7 = Vineyard; 8 = Nuts; 9 = Tropical fruits

Figure 1 shows the NREE in organic and conventional crops. In most of the cases this indicator is higher in organic systems. Figure 2 shows the differences in NRE consumption between organic and conventional crops. Only 11 conventional cases (of the total of 80) have a lower use of NRE.

The main causes of these results are the use of machinery and chemical inputs. In general, the practice that uses more energy in organic production than in the conventional system is mechanical weed control, which in conventional production is partially replaced by the use of herbicides. Some organic farms use more energy because greater quantities of compost are incorporated into the soil without the use of adequate machinery, or because too high amounts of industrial inputs (copper, fertilizers, etc.) are used. However, organic production saves much more energy on pesticide and herbicide treatments and on chemical fertilizers (especially nitrogen, which has a very high transformation and inherent energy).

On the other hand, there are two factors that contribute to reducing the NREE of the agricultural systems: the greenhouse structure (metals, plastics, concrete, etc.) and the irrigation system. As we can see in the Figure 1, all the greenhouse cases (organic and conventional crops) have a NREE less than one; this means that energy input is greater than energy output. The influence of the irrigation system can be seen in vegetables, the majority of which have am NREE under 2; some cases are energy-inefficient.

Conclusions

Based on the results obtained, it could be concluded that organic farming is contributing effectively to improving NRE efficiency and to saving NRE in Spain. Nevertheless, there is room for further improvement in the sustainability of organic farming through greater self sufficiency within the territory it occupies and, consequently, lower flow of imported energy originating from other ecosystems. The use of local resources such as compost and temporary plant covers (mainly in trees) is a strategy that helps to reduce non-renewable energy consumption. Moreover, it is feasible to cut down further on the unnecessary use of machinery for soil preparation and weed control. This should be limited to those occasions when it is strictly necessary.

Acknowledgments

This research was supported by the Department of Rural Development of the Spanish Ministry of Agriculture, Fisheries and Food.

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The Comparative Energy Efficiency of Organic Farming

Azeez, G.S.E & Hewlett, K.L.[1]

Key words: organic farming, energy, climate change, agriculture, food

Abstract

Organic farming is generally a more energy efficient system of food production. Comparative analyses of fifteen crop and livestock sectors indicate that UK organic farming uses around 26% less energy per tonne of output on average. The main energy saving is from the non-use of industrially produced inorganic nitrogen fertiliser. Organic farming is more energy efficient for wheat, most field vegetables, milk, red meat and pigs, but it is less efficient for poultry production.

Energy use in agriculture

Agricultural fossil fuel energy use is important for its contribution to climate change via carbon dioxide emissions and is the only global warming factor which has been fully measured for several organic and non-organic farming sectors in one country. It also has important socio-economic implications due to the predicted long-term decline in global supplies of oil and gas and the associated rise in energy prices. This is expected to increase the cost of food and may increasingly affect food availability and security in some cases, adding to the problems for future food supplies that are likely to arise from climate change and population increase.

In UK, most of farming has been industrialised. This means that most of the energy used in agriculture is now used *before* the farm in the manufacture of inputs such as fertilisers, pesticides, farm machinery, animal feed grain, and veterinary drugs. On the farm, energy is used in the form of transport fuel for machinery and heating glasshouses, for operations such as crop drying and milking, and for heating, lighting and ventilating the 'factory' farms that rear indoor pigs and chicken.

Organic farming aims to replace industrial processes with natural processes, as far as possible. It is intended to be a more sustainable system, so it is important to know to what extent this is true for energy. The UK Government has funded 'Life Cycle Analyses' of ten organic and non-organic sectors. These were carried out by Cranfield University (Williams *et al*, 2006) and updated recently (Williams, 2007). An earlier government-funded desk-study had also looked at organic energy use for five vegetables (carrots, onions, calabrese, cabbage and leeks) that were not analysed by Williams *et al.* (MAFF, 2000). These findings are analysed in this paper.

The results of the two studies are shown in the table below, columns 3 and 4, and from these a comparative energy efficiency figure was derived for organic production in each sector and on average. To determine the significance of these findings, we multiplied the energy use/t by the annual national production of each of the sectors. This enabled us to establish the total energy use for each sector and to assess the energy reductions that could be achieved if the whole national production of these sectors were organic. However, we excluded tomatoes from our calculation of the

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average energy use of organic farming on the grounds that the energy data is only for 'long-season' tomato production in heated glasshouses. This is little used in the UK organic sector

Results

Table summarising the findings of UK Government studies on non-organic and organic farming energy use and of the further analysis by the Soil Association:

Sector	Organic energy use/t as % of non-organic	Non-organic energy use/t, GJ	Organic energy use/t, GJ	UK production t/yr, 2006 (Defra, 2006, 2007)	Total UK energy use, GJx10^6	Total UK energy use if all organic, GJx10^6	Change in energy use if all organic, GJx10^6
Milling wheat	84%	2.40	2.02	6,115,000	14.67	12.35	- 2.33
Oilseed rape	103%	4.85	4.99	1,870,000	9.07	9.33	0.26
Potatoes	114%	1.49	1.71	5,684,000	8.49	9.70	0.21
Carrots	75%	0.60	0.45	718,500	0.43	0.32	-0.11
Cabbage	28%	0.90	0.25	262,700	0.24	0.66	-0.17
Onion	84%	1.25	1.05	404,500	0.51	0.42	-0.08
Calabrese	51%	3.70	1.90	86,900	0.32	0.17	-0.16
Leeks	42%	0.95	0.40	49,800	0.05	0.02	-0.03
Beef	59%	26.54	15.56	869,000	23.06	13.52	-9.54
Sheep	43%	24.99	10.79	333,000	8.32	3.59	-4.73
Pigmeat	65%	21.97	14.28	670,000	14.72	9.57	-5.15
Milk (unit =1 m^3)	72%	2.55	1.83	13,720,000	34.99	25.13	-9.86
Eggs (unit=20,000 eggs)	110%	13.66	15.00	443,000	6.05	6.64	0.59
Poultrymeat	111%	15.17	16.89	1,500,000	23.40	26.04	2.57
Long season glasshouse tomatoes	130%	122.00	159.00	82,684 (for all tomatoes)	10.09	13.15	3.06
Average (excluding tomatoes)	74%						-27.51 (-19%)

Results: how the agricultural sectors compare in their energy use

Of the fifteen sectors, the results of the studies show that cabbages, leeks, carrots and onions, i.e. traditional British vegetables, are the least energy demanding foods (using less than or around 1GJ/t). Arable crops and milk are next (using a few GJ/t). Then come meat and eggs (10-30 GJ/t). Finally, heated glasshouse vegetables are highly energy intensive (using over 100 GJ/t). This is an order of magnitude greater than other foods.

However, the real significance of the energy use/t figures depends on the comparative production of each food, as a food with a low energy use/t can still have a significant impact nationally if it is produced and consumed in large quantities. Despite its relatively low energy use per unit volume, the single largest user of energy among the food sectors is milk because of the large quantity produced.

Results: organic farming energy use

According to these studies, UK organic farming is more energy efficient than non-organic production in nine sectors, similar in one, and less efficient in four sectors Organic farming is more energy efficient for the production of wheat, green vegetables (calabrese, leeks, cabbage), carrots, onions, milk, red meat (beef and sheep) and pigs. On average, these sectors used 40% less energy/t when produced organically, with the biggest energy savings in green vegetables and red meat. Energy use for oilseed rape was similar in both systems, while organic farming was found to be less energy efficient for: potatoes (using 14% more energy); poultrymeat (11% more); eggs (10% more); and 'long season' heated glasshouse tomatoes (30% more).

On average (excluding data for tomatoes), UK organic farming is about 26% more energy efficient per tonne. When total national energy use is considered, it can be seen that switching current UK production to organic farming would reduce agricultural fossil energy use by around 20%. Organic farming offers the greatest contribution to reducing national energy use in the milk and beef sectors, also with significant energy savings for sheep and pigs, and smaller savings for wheat.

Discussion: factors in organic energy use

The main reason for the energy efficiency of organic farming is because it does not use inorganic nitrogen fertiliser. Nitrogen (N) fertiliser is the single main use of energy in farming, accounting for 37% of the total energy use (Defra, 2005). N fertiliser is extremely energy intensive, because the raw material is fossil fuels (usually natural gas) and also due to the high energy demands of the manufacturing process - each kg of N in fertiliser requires 41MJ of energy to produce (Mortimer, 2003). UK farmers use about 1 million tonnes of N in the form of fertiliser each year (AIC, 2005). More broadly, organic farming is energy efficient because it does not rely on industrial inputs, instead harnessing natural ecological and biological processes to carry out the functions that farmers need.

In North West Europe, lower yields are the main weakness of organic farming for energy efficiency. However, this is not true for the rest of the world, where organic yields are similar or higher in comparison to non-organic yields. Contrary to perceptions, organic and non-organic field crops use a similar amount of machinery per hectare: there is more use of mechanical weeding for some crops, but less use of machinery for spraying agro-chemicals. The yield differential between the systems is likely largely due to the disproportionate R&D investment into non-organic crop development over the last 60 years. As the development of organic systems progresses, yields and thus energy efficiency should continue to increase. An exception is poultry. Non-organic poultry production is very energy efficient because of the high 'animal feed to meat' conversion rates of factory farmed chickens. However, the organic movement does not believe that continued factory farming is a valid option due to its unacceptable standards of animal welfare and reliance on antibiotic drugs.

There are several concerns about the farm management data used in Cranfield University's study, according to an independent critique (Watson, 2007), suggesting that more accurate data would yield figures even more favourable for organic farming.

Recommendations for reducing energy use

In conclusion, the harnessing of natural biological and ecological processes employed by organic farming is more energy efficient than using industrially manufactured farm inputs. Policymakers should therefore promote a wider uptake of organic farming to reduce agricultural energy use. Food choices are important too; for an energy-efficient and climate-friendly diet it is recommended that people and businesses buy food that is: organic, seasonal, local, unprocessed, and with less meat.

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Impact of different Agricultural Systems and Patterns of Consumption on Greenhouse-Gas Emissions in Austria

Freyer, B.[1] & Weik, S.[2]

Key words: greenhouse-gas emissions, CO_2-equivalents, organic farming, nutrition patters, scenarios

Abstract

Agricultural systems as well as consumer patterns influence the green house gas emissions. Therefore, we analysed different farming systems, consumption patterns and seasonal oriented food consumption. Whereas conventional production and the current meat oriented nutrition patterns lead to high green house gas emissions, there is a tremendous reduction potential, if products are organically produced and if there is a shift to vegetarian-based diets.. Nevertheless, there is a need for research in terms of data quality, and a differentiation of farming systems as well as nutrition patterns.

Introduction

Agricultural systems follow different approaches in their energy budget. Conventional crop rotation systems uses plants with a low capacity for potential carbon sequestration in soils, e.g. with cropping systems like – winter wheat - winter barley - rape, where the root mass of the rotation is on average 0.8-1.5t DM $ha^{-1}a^{-1}$. In the contrary, organic cropping systems have the following rotation patter:– red clover - red clover - winter wheat - green manure – potatoes - grain legumes - green manure - winter rye - green manure - summer barley. The biomass output of the root system in organic crop production is 2.5-3.5t DM $ha^{-1}a^{-1}$ (Freyer 2003), which is more than double the conventional output. Additionally the organic system fixes between 50-90 kg N $ha^{-1}a^{-1}$. Several authors outline that the organic system has a high potential to reduce greenhouse-gas emissions (Dalgaard et al. 2003, Haas et al. 2001, Bockisch 2000, Haas et al. 1995). Furthermore, animal husbandry systems, where the whole fodder is organic, the fodder input and livestock per hectare are limited, and serve to impact positively on the reduction of greenhouse gas emissions (Koerber and Kretschmer 2000).

Agriculture is responsible for 14% of the global greenhouse-gas emissions (Stern 2006). Rough estimations state that nutrition and all related processes are responsible for 15 to 20% of the current energy consumption in developed countries (Jungbluth 2000). The most important factor in the food chain is animal production as well as consumption patters with a high share of meat (Taylor 2000). There is no doubt that consumer nutrition habits influence the green house gas emissions, especially if they prefer vegetable instead of meat. Besides these positive effects, the adoption of nutrition would reduce human diseases, which are a result of malnutrition and super-nutrition (Elmadfa et al. 2003; Kiefer et al. 2002).

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Objectives

The aim of the study was to investigate the impact of agricultural production systems and different nutrition patterns on greenhouse-gas emissions in Austria.

Methods

The potency of the individual greenhouse gases is taken into account by the concept of the global warming potential (CO_2-equivalents). Based on this indicator we compared the current status quo with three scenarios to make a total of four scenarios:

- Scenario 1: Status quo: conv. agriculture/nutrition-average: average of Austrian nutrition pattern with conventional products.
- Scenario 2: org. agriculture/nutrition-average: average of Austrian nutrition pattern with bio-products.
- Scenario 3: conv. agriculture/nutrition-opt.: optimised nutrition pattern with conventional products.
- Scenario 4: org. agriculture/nutrition-opt.: optimised nutrition pattern with bio- products.

The average nutrition pattern of adult Austrians (S1) was derived from Austrian consumption statistics (Statistik Austria 2003). These we compared with standard nutritional science recommendations (DGE 2004). Data on greenhouse gas emissions for the production cycle of foods from the databank GEMIS 4.2 and from literature were used to calculate and compare the annual per capita emissions of the different nutrition patterns. Greenhouse-gas emissions for agricultural production and processing of foodstuff were calculated. Some simplifications and estimations were necessary because of lack of data on organic drinks, coffee, tea, cocoa, nuts, alcohol, processed organic foods among others. The food life cycle phases at transportation, trade and at household levels, which take place after agricultural production were not part of the analysis. Also in this sector we assumed, that if we account for these effects, the organic result would be better than conventional, because of regional oriented consumption patterns.

Results and discussions

There is a higher consumption of bread, vegetable and fruits in the recommended nutrition level. As a result of this, the fresh matter (FM) of recommended food consumption increased from 644.4 kg $capita^{-1}$ a^{-1} in the average to 723.0 kg $capita^{-1}$ a^{-1} in the recommended nutrition levels (Table 1). The analyses showed that greenhouse gas emissions caused by the current Austrian nutritional pattern can be reduced fundamentally. The change of products from conventional (S1) to organic production (S2) reduces the emissions by 30%. A change of nutritional pattern from the average (S1) to the recommended level of conventional products (S3)results in a reduction of the emissions by 16%, but the emission further reduces to 39% if there is change to the recommended level of bio-products (S4). The realisation of scenario 4 means a tremendous change in nutritional style; the food quality change (to organic products) as well as the daily food consumption pattern (to recommended levels). Based on a total of 10.6t CO_2-equivalents per capita and year, the adaptation contributes to a reduction of 4.7% (the last statement is not in the table).

Tab. 1: Scenarios on greenhouse-gas emissions based on agriculture system and nutrition patterns

Agriculture and Nutrition Pattern	Total Food Consumption	CO_2-Equivalents (E)	Savings versus Scenario 1	
Scenarios (S)	kg FM capita^{-1} yr^{-1}	kg capita^{-1} yr^{-1}	kg CO_2-E	%
1 Conv. Agriculture (S1)	644	1230	-	-
2 Org. agriculture (S2)	644	856	374	30.4
3 S1+recomm. Conv. Nutrition (S3)	723	1031	199	16.2
4 S2+recomm. organic nutrition (S4)	723	742	489	39.7

Source: own

Our results further indicated that the most important effects is realised with a change of meat, milk and cheese production and consumption to vegetable-based diet (Figure 1).

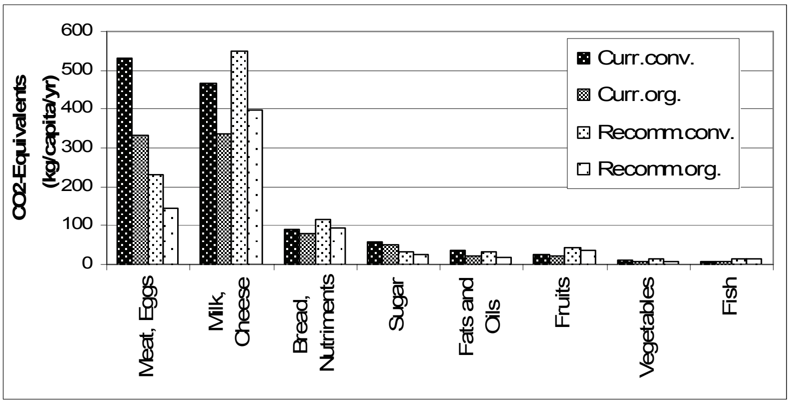

Figure 1: Greenhouse-gas emissions for product groups and nutrition patterns

Source: own

The most important effect is realised with a change of meat, milk and cheese production and consumption (Figure 1). There is a slightly increase of CO_2-equivalents with organic products and recommended nutrition pattern in terms of bread, nutriments, fruits, vegetables and fish, but not essential for the total emissions.

Conclusions

The calculations have shown that there is a high potential to reduce greenhouse-gas emissions by changing the agricultural system as well as the nutrition pattern towards a healthy nutrition. Several data of the organic production are over estimated in the estimation process, because of a lack of data on organic production. Both the conversion to organic agriculture as well as in nutritional patterns imply a high challenge for society. Additional costs are common arguments against the purchase of organic products, but the change in nutritional patterns implies the possibility to reduce costs because of lower meat consumption. In contrast to this, the change in consumption of milk products to the recommended levels, which could an increase of cost for the consumer, does not change the carbon emissions, Further investigations are needed for a detailed analysis of different nutrition patterns and their effect on both greenhouse-gas emissions as well as food costs. The production potential of organic products also need to be studied.

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Emission of Climate-Relevant Gases in Organic and Conventional Cropping Systems

Küstermann, B.[1] & Hülsbergen, K.J.[2]

Key words: greenhouse gas emission, carbon cycle, C sequestration, farming system

Abstract

In 81 commercial farms in Germany, emissions of the greenhouse gases CO_2, CH_4 and N_2O from crop production have been computed by model-based analyses. The considered influence factors comprise farm structure, mass and energy inputs as well as cultivation methods. A linear correlation was found between energy input and greenhouse gas potential. Due to lower N and energy inputs and also higher C sequestration as a result of humus restoration, the organic farms revealed area-related emissions (785 kg CO_2 eq ha^{-1} a^{-1}) that were 2.75 times lower than the emissions from conventional farms (2165 kg CO_2 eq ha^{-1} a^{-1}).

Introduction

According to the latest IPCC report, the mean global temperature is going to increase by 1.0 to 6.3 °C by the end of the 21st century, if greenhouse gas emissions continue to rise unhampered. Rainfall intensity and flood hazards will increase just as the duration of drought and heat periods, with other words: extreme weather situations will occur more frequently. In all spheres of the society, especially in agriculture, strategies have to be developed for an adaptation to the climatic changes, but also for the protection of the global climate. Is organic farming able to render an effective contribution to the protection of the atmosphere? Which level reach greenhouse gas emissions in organic farming compared to other forms of land use? Are there mitigation potentials and if so, how efficient can they be used? Statements to these questions will be made below using results from model-supported analyses of the greenhouse gas emissions from organic and conventional farms in Germany.

Materials and methods

In recent years, a model program has been developed by us that allows to estimate the emission of the greenhouse gases CO_2, N_2O und CH_4 on the level of farm systems in form of energy and mass balances. The emissions are converted into CO_2-equivalents [CO_2 eq]. Depending on the radiation absorption and the retention time in the atmosphere, the greenhouse potential of CH_4 amounts to 23, that of N_2O to 296, related to the efficiency of CO_2 (= 1).

The following balancing methods have been integrated into the model:

- Balancing of energy fluxes. Consideration is made of direct (diesel fuel, electricity, solid fuels) and indirect energy input (manufacturing and transport of

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fertilizers, pesticides, machines). The energy input is the basis for deriving CO_2 emissions (Küstermann et al. 2007).

- Balancing of nitrogen fluxes in the system soil – plant – animal – environment. Our model program includes methods for estimating N flows and N pools by means of management data like N_2 fixation efficiency, manure N production, N turnover in the soil (Küstermann et al. 2007). N_2O emissions from the soil are calculated with regard to the N Input.
- Balancing of carbon fluxes in the system soil – plant – animal – environment (Küstermann et al. 2007a). We estimate the C sequestration in soils depending on crop rotation, fertilization and tillage (humus accumulation and depletion). In livestock keeping, metabolic CH_4 emissions are calculated with consideration of feeding.

The model software has been applied in 33 organic (org) and 48 conventional farms (con) located in different soil and climatic regions of Germany. To ensure comparability, only emissions from crop production have been demonstrated.

Results

Between organic and conventional farms, grave differences were dislosed concerning structure, mass and energy inputs, yields, C-sequestration and greenhouse potentials (Table 1), but also among organic as well as conventional farms deviations are enormous. The mean energy input in organic farms reaches 5.6 GJ ha^{-1} a^{-1}. Due to differences in cropping structure und intensity, some farms exceed this level by up to 100 %. In the conventional farms, mineral fertilizer and pesticide application cause markedly higher energy inputs (12.6 GJ ha^{-1} a^{-1}). Yields and energy fixation in the ecofarms (28 to 192 GJ ha^{-1} a^{-1}) reveal a wider variation than the corresponding values of the conventional farms (51 to 192 GJ ha^{-1} a^{-1}). Energy fixation depends on the cropping system, site specific yield potentials and the use of the produced biomass. High energy fixation is achieved with a high harvest index, for example when the byproducts and also catch crops are used. Organic farming consumes clearly less energy per unit area and reaches higher efficiency levels per unit product (output/input ratio, Table 1). C sequestration in the soil organic matter varies broadly. On average, organic farms accumulate humus (+ 110 kg C ha^{-1} a^{-1} = reduction of the greenhouse potential by 415 kg CO_2 eq ha^{-1} a^{-1}), whereas conventional farms have depleting humus contents (-40 kg C ha^{-1} a^{-1} = 150 kg CO_2 eq ha^{-1} a^{-1}). This can be explained by differences in crop rotations (high legume share (org) vs. high root crop and cereal proportion (con)) as well as in quantity and quality of the supplied organic matter.

Due to lower N and energy inputs, clearly lower N_2O and CO_2 emissions were computed for the organic farms than for the conventional counterparts. The conventional farms emitted 2165 kg CO_2 eq ha^{-1} a^{-1} on average. This exceeds the calculated emissions from the organic farms (785 kg CO_2 eq ha^{-1} a^{-1}) by the 2.75 fold. The product-related differences (per GJ) are smaller on grounds of much lower energy fixation on organic farms.

Tab. 1: Farm structure, mass and energy budget as well as greenhouse gas emissions in crop production. Analysis of 81 commercial farms in Germany

Parameter	Measuring unit	org (n = 33)		con (n = 48)	
		Mean	(Min – Max)	**Mean**	(Min – Max)
Farm structure					
Livestock density	LSU ha^{-1}	**0.3**	0 – 1.5	**0.6**	0 – 2.7
Cereal proportion	% of AA	**48**	14 – 67	**57**	30 – 77
Legume proportion	% of AA	**33**	15 – 46	**7**	0 – 18
Inputs and Outputs					
Energy input	GJ ha^{-1}	**5.6**	3.6 – 11.3	**12.6**	6.8 – 17.8
N input	kg N ha^{-1}	**149**	69 – 285	**236**	116 – 339
Energy fixation	GJ ha^{-1}	**75**	28 – 192	**127**	51 – 192
Output/Input ratio	GJ GJ^{-1}	**12.6**	5.6 – 24.4	**9.9**	6.4 – 13.6
Greenhouse gas potential					
CO_2 emission, (energy input)	kg CO_2 eq ha^{-1}	**349**	215 – 526	**707**	337 – 1023
C sequestration in humus*	kg CO_2 eq ha^{-1}	**-415**	-575 – 1766	**150**	-915 – 1255
N_2O emission	kg CO_2 eq ha^{-1}	**852**	387 – 1552	**1307**	643 – 1865
Greenhouse potential	kg CO_2 eq ha^{-1}	**785**	-155 – 1709	**2165**	937 – 4109
Greenhouse potential	kg CO_2 eq GJ^{-1}	**12.6**	-1.1 – 28.7	**17.4**	10.7 – 27.4

* Positive values indicate humus reduction and release of soil-bound C to the atmosphere, negative value indicate humus accumulation and recovery/return of C from the atmosphere into the soil.

There is a linear relationship between energy input and greenhouse potential; with increasing input of mineral N and energy rise the area-related N_2O and CO_2 emissions (Fig. 1). Calculations of greenhouse potentials take into account also C sequestration, symbiotic N_2 fixation, energy inputs with the use of machines and fuel. This explains the enormous variability of CO_2 emissions from organic and conventional farms.

Discussion

The statements made here agree basically with the results obtained by use of the same method in a spatially more limited agricultural region, the Tertiary hills in Bavaria (Küstermann et al. 2007). The increased number of investigated farms (81 vs. 28) makes the results presented in this paper more reliable. Moreover, farm-specific and site-related effects on greenhouse gas emissions can be analysed more profoundly because of the widely differing farm systems involved in this study.

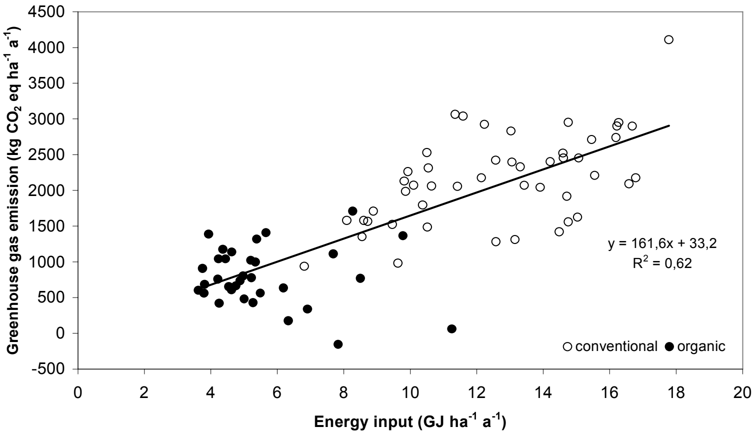

Figure 1: Greenhouse gas emissions in dependence on the energy input

At present, major uncertainties exist in modelling N_2O emissions; our model as well can only estimate potential emissions. This is problematic because of the high specific greenhouse gas potential of N_2O. Therefore, additional N_2O measurements have to be made in order to survey site and management effects, to mark the scope of error and to improve the model software.

Conclusions

Our investigations allow to draw conclusions on management optimization and mitigation of greenhouse gas emissions. The farm enterprise lies in the focus of our analyses, because on this level management decisions have to be taken, which have impacts on environment and climate. The mitigation of emissions requires to identify problematic sectors in farms and to derive coordinated measures and strategies.

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Can Organic Farming Contribute to Carbon Sequestration? A Survey in a Pear Orchard in Emilia-Romagna Region, Italy

Ciavatta C.[1], Gioacchini P.[2], & Montecchio D.[3]

Key words: Organic Carbon Sequestration, Organic farming, Pear orchard

Abstract

The effect of organic fertilisation on the level of total organic carbon (TOC) in an 18-years old pear orchard (cv. Abate Fetel) was evaluated vs. a conventional pear orchard mineral fertilized (control). In both orchards soil samples (Typic Udochrept loamy soil) were taken at two depths (0-15 and 30-50 cm) along the row (tilled and mainly amended with compost) and in the inter-row space (grassed with different Graminaceae species in the organic orchard, bare in the conventional orchard). The area (elevation 20 m), located in Bologna province, Emilia-Romagna Region (Italy), is characterised by mean annual temperature 13.1 °C and rainfall around 750 mm.

In the horizon 0-15 cm of the row an increase of about 14 tons ha-1 of TOC has been calculated after 18-years of cultivation and amendment compared to the control soil, which had received just mineral fertilisation. A significant increase of TOC (about 6.3 tons ha-1) was also measured in the top layer (0-15 cm) in the grassed inter-row, where this C sink is exclusively due to the cover crop. A survey of the role of organic vs. conventional farming on soil C sink/source is started in 2007 in 8 typical organic orchard farms located in Emilia-Romagna Region and it is still running.

Introduction

Soil organic carbon (C) preservation in agro-ecosystems is a crucial point to maintain soil fertility and productivity and to reduce losses of CO_2 in the atmosphere. The use of different soil management can contribute to the soil carbon sequestration and its distribution in the soil profile (Lal, 2002) to mitigate the greenhouse effect (Lal, 2003).

Organic farming has been reported to have a positive effect on C sequestration as a result of increased root yields, higher humification rate constant and the direct application of organic matter through organic amendments (Ciavatta et al., 1997; Francioso et al., 2000; 2005; Kundu et al., 2007; Bhattacharyya et al., 2007). In order to increase the level of organic C in the top layer of soil, perennial grass species are often used in organic orchards.

Aim of this study was to determine the contribution of organic amendment to the soil carbon sink in an 18-years old pear orchard (cv. Abate Fetel) *vs.* a conventional pear orchard mineral fertilized (control).

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Materials and methods

Soil samples (Typic Udochrept loamy soil) were taken from an 18-years old, organically fertilised pear orchard (cv. Abate Fetel) of a certified organic farm located in San Matteo della Decima (Bologna), Emilia-Romagna Region (Italy) and from a mineral fertilised pear orchard of a conventional orchard (control) located about 100 m far away. The area (elevation 20 m) is characterised by the following mean climate conditions (1921-2004): mean annual temperature 13.1 °C and rainfall around 750 mm. Along the 18-years the main organic fertilisation was done with 4-6 tons ha^{-1} of compost (28% organic C, 2.5% total N, 2.3 organic N, P_2O_5 1.4%, K_2O 1.7%). Compost was prepared by composting (130 days period) a blend of 70% (v/v) plant trimming (mowing and pruning) and 30% (v/v) sewage sludge (50% waste waters and 50% food processing). The yearly nitrogen mineral fertilisation was around 90 kg N ha^{-1} (ammonium sulphate and urea).

In both orchards soil samples (4 samples per plot) were collected at the end of April 2006 from four plots at two depths (0-15 and 30-50 cm) along the row (tilled and mainly amended with compost) and in the inter-row space (grassed with different perennial Graminaceae species in the organic orchard, bare in the conventional orchard). The choice of the two sampling layers was related to the tillage depths (around 20 cm): the top layer (0-15 cm) was annually tilled, while the deep layer (30-50 cm) did not undergo any tillage. After sampling soil samples were air dried, crushed to pass a 2 mm sieve and stored in sealed bags, according to Italian Official Methods of Soil Analysis (2000).

The main physical-chemical characteristics of the organic orchard soil were: pH (in water) 7.98; Texture: sand 30%, silt 48%, clay 22%; Total carbonates ($CaCO_3$) 14%; Bicarbonates (HCO_3^-) 5.1%; Cation exchange capacity 23 $cmol_c$ kg^{-1}; Total organic carbon (TOC) 9.5 g kg^{-1}; Total Kjeldahl nitrogen (TKN) 1.3 g kg^{-1}; those of the control soil were: pH (in water) 8.00; Texture: sand 32%, silt 49%, clay 19%; Total carbonates ($CaCO_3$) 16% g kg^{-1}; Bicarbonates (HCO_3^-) 4.8%; Cation exchange capacity 21 $cmol_c$ kg^{-1}; TOC 8.4 g kg^{-1}; TKN 0.9 g kg^{-1}.

Results and discussion

Total organic carbon (TOC) content of soil samples of the organic and conventional pear orchard taken at two depths (0-15 and 30-50 cm) along the row is shown in Fig. 1. The top layer of the organic orchard was significantly richer in TOC compared to the conventional one. These differences disappeared in the deep layer, indicating that the effect of the amendment was not distributed along the soil profile. The inter-row zone showed a similar trend with a significantly higher content of TOC in the upper layer of the organic orchard compared to the conventional one (Fig. 2). In this case the greater amount of TOC was due to the C released from grasses as rhyzodepositions. However, even in the inter-row, the deep layer of the two orchards had similar TOC content suggesting that any C contribution to soil only affects the upper part of the soil profile.

From a quantitative point of view, it can be calculated that a concentration of 1 g kg^{-1} of soil TOC corresponds to 1.875 tons ha^{-1}, assuming a soil depth of 15 cm and a density of 1.25 kg dm^{-3}. Applying this assumption, it can be estimated that in the horizon 0-15 cm of the row there was an increase of about 14 tons ha^{-1} of TOC after 18-years of cultivation and amendment *vs.* the control that has received just mineral fertilisation (Fig. 1). On the same basis, the presence of grasses in the top layer of the inter-row caused a significant increase in TOC that could be quantify in about 6.3 tons ha^{-1} and that was due to the accumulation of their rhizodeposits.

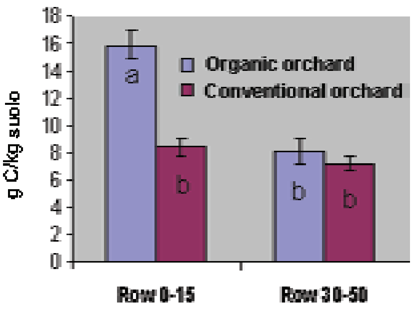

Figure 1: Total organic carbon (TOC) content in soil samples taken at two depths (0-15 and 30-50 cm) in the row. Tukey-HSD test: similar letters are not significantly different at ***p* ≤0.05.**

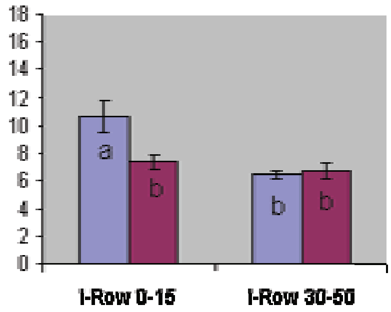

Figure 2: Total organic carbon (TOC) content in soil samples taken at two depths (0-15 and 30-50 cm) in the inter-row. Tukey-HSD test: similar letters are not significantly different at *p ≤0.05.*

Conclusions

The management of the organic orchard with the annual addition of compost over 18-years and the presence of grasses was able to significantly increase the amount of TOC in the 0-15 cm layer compared to the conventional orchard used as control. These increases were equal to 14 and 6.3 tons ha^{-1} in the row and in the inter-row respectively.

In order to confirm these preliminary results, a survey of the role of organic *vs.* conventional farming on soil carbon sink/source is started in 2007 in Emilia-Romagna Region. Eight typical organic orchard farms and eight conventional orchard farms (control), located in different provinces of the Region, have been sampled and results will be available in 2008.

Acknowledgments

Activity carried out within the project co-ordinated by CRPV (Vegetal Production Research Center, Italy) in collaboration with ProBER (Organic Producers of Emilia-Romagna Region, Italy), funded by Emilia-Romagna Region (L.R. 28/98). Authors gratefully thank Dr. P. Schiatti (ProBER) and S. Scagliarini (Agriculture and Environment Centre) for technical support and soil sampling.

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Energy efficiency of biomass production in managed versus natural temperate forest and grassland ecosystems

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Key words: net primary production (NPP), natural ecosystems, harvested biomass, carbon storage, energy balance

Abstract

In a conceptual model study based on literature data from Danish ecosystems, energy yield from biomass production was compared in two semi-natural ecosystems (broadleaved forest and grassland) and their managed counterparts. The highest net energy yield of harvested biomass was obtained in the managed grassland system. The energy efficiency in terms of output:input ratios were about 190:1 in the managed beech forest and 6:1 in the managed grassland. This is discussed in relation to nitrogen cycling, carbon storage and energy efficiency of biomass production.

Introduction

Biomass (natural and cultivated) is globally a limited resource since available land is limited and the inputs which are needed for cultivation are costly in terms of energy input, e.g. fertiliser (organic or non-organic), fuel, machinery and human labour. Global total terrestrial net primary production (NPP), of which 50% is carbon (C), has been estimated to 56.8 Pg C y^{-1} (1 Pg is 10^{15} g) and humans are exploiting this resource very intensively; the current human consumption is estimated to 15-25% of this amount (Imhoff and Bounoua, 2006).

Net primary production is a quantitative measure of ecosystem productivity (yield) reflecting the influence of soil and site conditions and the level of cultivation among others. In comparison with natural ecosystems, such as forests and permanent grasslands, cultivated land may yield higher annual NPP with the aid of plant breeding and cultivation technologies. However, most land cultivation methods require inputs of fossil energy and irrigation water which are increasingly scarce resources (Scanlon et al., 2007, Pimentel and Pimentel, 2006). Use of these limited resources may be well-argued if high quality food crops or valuable materials are produced but less so if primary biomass is considered for bioenergy production.

Nitrogen (N) is the nutrient that generally limits plant growth, and the global cycling of biologically available N has been doubled by humans. The elevated N cycling has caused eutrophication, acidification, emissions of nitrous oxides (strong green house gas) and higher species extinction rates (Vitousek et al., 1997). The extension of fertilised cropland areas for biomass production will aggravate this trend.

To meet multifunctional goals of landscape management, ecosystems may be managed to act as a sink for green house gases, preserve habitat quality, and offer recreation and aesthetic pleasure; this includes securing the functional integrity of energy, water and nutrient cycles observed in natural ecosystems. Over long ranges

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of time, the production of biomass in undisturbed ecosystems balances the decomposition and mineralisation carried out by the organisms that feed on living and dead biomass. Utilization of biomass (i.e. harvest for food, feed, fibre and fuel) is a spatial and temporal decoupling of the carbon, nutrient and energy cycles of natural ecosystems. Here, we investigate the energy use efficiency of biomass production in Danish (humid temperate) ecosystems by comparing biomass utilisation from organic/nature-friendly managed and semi-natural forest and grassland. The results are discussed in relation to nitrogen cycling, green house gas storage and biomass production for human utilisation.

Materials and methods

Humid temperate nemoral forest and grassland on nutrient rich sandy loam soils were selected to compare a managed biomass utilisation system with the semi-natural ecosystem counterpart as a reference: 1) a broadleaved, deciduous forest reserve (site Suserup, Vesterdal and Christensen, 2007) versus a managed beech forest in continuous cyclic management (harvest of mature stems by target diameter according to the target dimension principle, considered a fundamental principle in close-to-nature forest management), and 2) a grassland mixture (70-50% *Lolium sp.*, and 30-50% *Trifolium sp.*) managed according to organic agriculture principles (14 t/ha manure (pig slurry) and 1 t/ha lime per year (i.e. 4 t/ha every 4 years), 4x harvest per year for silage (Danish Agricultural Advisory Service, 2007)) versus permanent grasslands assuming no harvest and only wildlife grazing (Statistics Denmark, 2007). A comparison of energy balances was made. We focused on carbon storage in above-ground biomass (g dry matter m^{-2}), energy yield per year (EY) of above-ground NPP (g dry matter m^{-2} y^{-1} and converted to MJ m^{-2} y^{-1} by the lower heating value at 0% water content) and the energy input (EI) required to harvest this yield (MJ m^{-2} y^{-1}). Energy input data were collected from national statistics and literature (see references in Table). The net energy yield was found by correcting for the harvested biomass as (EY-EI) multiplied by harvest %. Finally, the energy output:input ratio was calculated from the energy yield.

Results and discussion

The net primary production (NPP) in dry matter above ground ranged from 310 to 860 g m^{-2} y^{-1} corresponding to energy yield of 5.1 to 15.6 MJ m^{-2} y^{-1} (1 MJ m^{-2} is 10 GJ ha^{-1}); the highest energy yield was obtained in the grassland mixture. In the managed beech forest the net energy yield was 6.7 MJ m^{-2} y^{-1} with an energy input of 0.05 MJ m^{-2} y^{-1} for harvesting of stems. In comparison with the forest reserve, the production (above-ground NPP) in the managed forest was higher since trees are younger and more vital. In conclusion, the management of the forest lead to an increase in NPP and energy yield with an energy output:input ratio (EY:EI) of 190:1. In the grassland mixture, the net energy yield was 11.9 MJ m^{-2} y^{-1} and the energy input 2.3 MJ m^{-2} y^{-1}. The main energy input came from animal manure calculated as the energy needed to produce the manure without allocating energy to the meat production. Manure application to grassland increased the NPP, but may also increase the nitrogen status of the ecosystem and cause N losses (as well as phosphorus, potassium and micro nutrient levels). In conclusion, the management of the grass land lead to an increase in NPP and energy yield with an energy output:input ratio of 6:1 due to the annual inputs of fuel and fertiliser. Multifunctional land use is linked with the green house gas issue, since production system, material inputs, biomass products, standing biomass, and ecosystem gas exchange are intertwined. The higher biomass storage in the forest ecosystems measured as above-ground biomass after harvest (about 150-fold in managed forest and 300-fold in forest reserve in comparison with the grassland mixture) demonstrated a large storage potential for carbon dioxide in above-ground biomass. Carbon storage in trees provides flexibility in the biomass utilisation: NPP can be stored in living biomass to be utilised at a later stage or be a permanent reservoir (Kirschbaum, 2003, Righelato and Sprackeln, 2007). Soil organic matter incl. forest floor constituted about 50% of the total biomass in the two forest types (above- and below-ground) indicating a soil C storage potential in forest reserves (Vesterdal and Christensen, 2007).

Tab. 1: Above-ground biomass production and energy inputs and outputs of two pairs of Danish semi-natural and managed temperate ecosystems

Ecosystem	Forest reserve Suserup[a]	Managed beech forest[b]	Semi-natural grassland[c]	Grass-land mixture[d]
Standing living biomass		**g dry matter m^{-2}**		
Above-ground biomass after harvest[g]	25000	13000	<310	<80
Production		**g dry matter m^{-2} y^{-1}**		
Above-ground annual NPP[g]	400	530	310	860
Harvest (% of NPP)[g]	0 (0)	350 (67)	0 (0)	780 (91)
		MJ m^{-2} y^{-1}		
Energy yield (EY) of NPP[e]	**7.4**	**10.1**	**5.1**	**15.6**
Energy input[f]				
Fuel		0.04		0.80
Machines		0.01		0.09
Seeds				0.01
Manure				1.41
Liming				0.02
Total energy input (EI)	**0**	**0.05**	**0**	**2.3**
Net energy yield	**n.a.**	**6.7**	**n.a.**	**11.9**
EY:EI	n.a.	190:1	n.a.	6:1

a. Vesterdal and Christensen, 2007, **b**. Larsen and Johannsen, 2000, **c.** NPP adapted from permanent grasslands out of rotation, assuming no harvest (Statistics Denmark, 2007) **d.** Danish Agricultural Advisory Service, 2007, **e**. Lower heating values adapted from www.biolex.dk. Grass and grassland mixture heating values assumed similar to straw~18,2 MJ kg^{-1} d.m., **f.** Based on Dalgaard et al., 2001. **g.** Own calculations based on references mentioned. **n.a.** ~ not applicable.

Conclusions

Based on literature data, a few specific ecosystems were chosen to demonstrate the kind of assessments needed to evaluate consequences of different land use and potentials for primary biomass production. We calculated that cultivation increased the NPP in both forest and grassland in comparison with the semi-natural counterparts. The biomass production potential (above-ground NPP) versus the carbon storage potential in standing living biomass showed a potential sink for carbon in forest. Biomass production from close-to-nature beech forest management required much less input energy to extract NPP per ha than organically grown grassland mixtures, which was reflected in much higher energy efficiency of the former. Further, the manure application in grassland mixtures may cause N-losses to the atmosphere (GHG emissions) and to aquifers, which also disfavours biomass from such systems. The flexibility of land use and its products should be considered in a multifaceted evaluation, since primary biomass may be used for food, feed, fibre and fuel. Forest cover is a long term land use that can not be changed annually, whereas grass can enter a crop rotation. Hardwood is a non-food commodity whereas grass can be used in a sequence of food and non-food purposes, e.g. animal feed and biofuels. Altogether, land use type and cultivation intensity influences the utilities provided.

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Wood Chips from Hedgerows – Biomass Potential for On-Farm Mulching and Bioenergy?

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Key words: agro-eco-systems, soil protection, landscape, bioenergy

Abstract

Hedgerows are landscape features with ecological value and agricultural benefits which are appreciated in organic farming. Biomass from periodical cutting down of hedgerows is often unutilized litter. The study assesses different ways how to use wood chips from hedgerows, and quantifies the biomass potential for either mulching arable land with wood chips or, alternatively, for bioenergy use. The calculations are based on experiments at the experimental station for organic farming Kleinhohenheim and on literature. The yield of wood chips was clearly too low to mulch the total arable land of the model farm. Hedgerows on an area equal to 1% of the farm area yielded wood chips for 0.05 ha if 160 m^3 ha^{-1} were applied. This layer significantly reduced weeds. Hedgerows covering 5% or 20% of the farmland would provide wood chips for about 0.2 or 1 ha for mulching or, used as firewood, they would cover the corresponding fuel oil demand of more than one average household. Compared to poplars in short rotation coppice on the same area, the energy output is low. Since an energy use of wood chips is ecological and economical inefficient, mulching seems a reasonable way to use wood chips from cutting hedgerow, in spite of low yields. Wood chips should be applied to thoroughly selected areas, such as slopes (protection from soil erosion), crops with wide inter-row-distance or to perennial, high-value crops.

Introduction

Hedgerows have many functions and benefits in agricultural systems (Baudry *et al.* 2000). Organic Farming standards explicitly state the relevance of hedgerows for a sound agro-ecosystem. From time to time, usually in a period of 10–15 years, hedgerows have to be cut back to maintain the functions of a hedgerow. The material is mostly chopped to wood chips, and then often left on site unutilized. Safeguarding hedgerows would be facilitated if the "by-product" wood chips would produce some profit. Since the majority of the material is twigs and small stems with a high proportion of bark and moisture, the efficiency of wood fuel from hedgerows seems to be low. An alternative is mulching, e.g. for weed control, as presently done in ornamental gardening, in orchards or urban landscapes (Ferguson *et al.* 2004; Rathinasabapathi *et al*. 2005). Very little is known about the use of wood chips for mulch on arable land, and about the amount of biomass which can be produced by semi-natural hedgerows on a farm. The University of Hohenheim has established a long-term experiment to examine effects of wood chips mulch from hedgerows in an organic cropping system. Among multiple aspects of the experiment, the current paper focuses on productivity and should 1. assess the size of the hedgerow area which is needed to produce sufficient quantities of biomass for mulching a certain area of arable land; 2. discuss the alternative use of wood chips for bioenergy instead for mulching; 3. exemplarily

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contrast the productivity (biomass and energy yield) of hedgerows with the productivity from short rotation coppice (SRC). Simple linear scenarios based on the experimental station Kleinhohenheim as a case study should assess the biomass potential of hedgerows both for mulch and bioenergy, and point out approaches how to use wood chips from hedgerows best.

Materials and methods

Size and structure of the experimental station for organic farming Kleinhohenheim, Stuttgart, Germany, were adopted for this study, completed by additional data from literature for scenario calculations. The farmland is structured with hedgerows along the main field lanes, and at some field boundaries. Hedgerows are composed of autochthonous hardwood species. A section of the hedgerows is routinely cut down every year in a rotation of about 10 years, and the stems and twigs < 5 cm diameter are chopped by a disc wheel chopper. A part of the wood chips is then used in a field trial for mulching, and the rest is left on site. The total farmland is 60 ha, 40 ha of which is arable land. Wood chips were applied on arable land in an amount 80 m^3 ha^{-1} and 160 m^3 ha^{-1}. Several characteristics of the wood chips were determined in own experiments (Tab. 1). Further data on productivity of hedgerows and SRC were taken from literature. Simple scenarios were calculated to describe the productivity of hedgerows and of SRC from a calculative area. Wood chips would be used for energy only outside the farm, and the ash would not be returned to the fields.

Tab. 1: Basic data for calculation and discussion

Data from own experiments [1)]		Literature data [2) 3) 4)]	
1 m^3 wood chips	= 0.4 t FM	Mean biomass production by hedgerows	5 t FM ha^{-1} a^{-1}
Water content of wood chips	36%	Mean biomass production by short rotation coppice	13 t DM ha^{-1}*a
C:N ratio of w. chips	47	Width of hedgerows	4 m
Bark weight of wood chips	25% of FM	Caloric value of wood chips from hedgerows	12.6 MJ kg^{-1} DM
Wood chips mulch applied	80 or 160 m^3 ha^{-1} a^{-1}	Caloric value of wood chips from SRC	18.5 MJ kg^{-1} DM
Application of N_t by mulch	4 kg m^{-3}	Caloric value of fuel oil	11.4 kWh l^{-1}
Application of C_t by mulch	189 kg m^{-3}	Energy consumption /household	3000 l fuel oil

[1)] Gruber et al. (2008), [2)] Rösch 1996 (annual mean), [3)] Boelcke (2006): 3-years rotation; FM: fresh matter, [4)] calculated after Kaltschmitt et al. (2000); DM: dry matter, FM: fresh matter.

Results

A percentage of 1% hedgerows (Scenario 1, Tab. 2) on the total model farm area would equal to 0.6 ha, or a hedgerow length of 1.5 km. The wood yield from these hedgerows would be sufficient to mulch a maximum of 0.05 ha of arable land (recipient area) each year if 160 m^3 wood chips ha^{-1} were applied. The recipient area would be twice as much if 80 m^3 ha^{-1} were applied. Scenario 2 with 3 ha of hedgerows (7.5 km) would produce wood chips for a maximum of 0.23 ha recipient area, and in scenario 3, hedgerows on 12 ha land (30 km) produced biomass for mulching 0.94 ha. As a comparison, the annual energy yield of the same hedgerows ranged from 7 to 134 MWh, corresponding to a fuel oil equivalent of approximately 600–12,000 l. If the same area would be planted with poplars in SRC instead of hedgerows, the energy yield ranged from 35 to 700 MWh, corresponding to 3,000 to 60,000 l fuel oil.

Tab. 2: Maximum area per year for mulch application (recipient area) and annual energy yield of wood chips produced from hedgerows in three scenarios, in comparison to poplars in short rotation coppice (SRC) on the same calculative area of land; mulch application: 160 m^3 ha^{-1}.

		Mulch	Bioenergy			
Scenarios % of farm area for hedgerows	Hedgerow area (ha) or length (km)	Recipient area (ha)	Energy yield (MWh)		Fuel oil equivalent (l)	
		Wood chips	Wood chips	SRC	Wood chips	SRC
Scenario 1: 1%	0.6 (1.5)	0.05	7	35	590	3,000
Scenario 2: 5%	3.0 (7.5)	0.23	33	174	2,900	15,200
Scenario 3: 20%	12.0 (30.0)	0.94	134	696	11,700	60,100

Discussion

The annual biomass yield of hedgerows is not enough to mulch all arable land, independently from whether 80 m^3 ha^{-1} or 160 m^3 ha^{-1} are applied. Since only an application of 160 m^3 mulch ha^{-1} was significantly weed-suppressing (Gruber *et al.* 2008), planting semi-natural hedgerows specifically for mulch production is not useful. Though the biomass produced in scenario 2 and 3 is enough for the energy supply of one to three households, using the hedgerow area alternatively for SRC would result in a 5-fold higher production of bioenergy. Poplars are fast-growing trees and genotypes are used which are specifically selected for SRC thus explaining the higher yield of SRC compared to hedgerows. Semi-natural hedgerows are mainly composed of autochthonous shrub species with low capacity for biomass production and often grow on marginal land, e.g. field clearing cairns which additionally reduces yield. The biomass production of hedgerows may highly vary by the composition of species and the management, but at present, little reliable information is available about yields. However, today’s primary purpose of hedgerows is to provide ecological benefits (Baudry *et al.* 2000). Under this assumption, wood chips are a by-product that emerges if the ecological value of a hedgerow is maintained by periodical cutting. Using wood chips from hedgerows for combustion seems not reasonable due to high proportions of bark (Tab. 1), which means a high ash content of more than the 6-fold than from pure wood (Hartmann 2005), so that combustion could cause technical difficulties. Recycling of nutrients, input of C_{org} and soil cover by mulch promise to be more beneficial for the agro-ecosystem. Therefore, in spite of low biomass production, the by-product wood chips should be used for mulch rather than for combustion in organic farming. The area and the crops the mulch is applied to have to be selected thoroughly. Wood chips should be applied with decreasing priority to: 1. erodible areas (slopes, silty soils) 2. crops with wide inter-row distance (faba beans) 3. perennials with high economic value (raspberries, black currant). As an alternative, farms could offer organic wood chips for sale to private consumers for gardening. Though this means an export of nutrients, a direct profit from hedgerows is provided. All scenarios and alternative uses have to be evaluated economically in detail in further approaches. Basically, a semi-mechanised process of harvesting and chopping, as usual for cutting hedgerows, causes twice as much costs as a wood combine harvester used in SRC (Textor 2008). Presuming the ecological value is high at low cutting intensity and in wood with diverse structure as recommended by Hinsley & Bellamy (2000) for protecting birds, hedgerows cut in a rotation of ca. 10 years would be more beneficial than SRC in a 3-years-rotation.

Conclusions

To safeguard hedgerows and their ecological benefits, possible economical incentives should be considered and used. The amount of wood chips produced from hedgerows is only sufficient to mulch a very small area of arable land. A use for energy is possible but not efficient in comparison to SRC, and in terms of possible technical difficulties. Co-combustion with other fuels could be taken into consideration. The best solution seems to be the application of wood chips mulch on sensitive areas or to specific crops. Another solution to make economical use of the hedgerows could be the production of “Organic Wood Chips” for sale to private consumers. Though a replacement of hedgerows by SRC is not intended, the ecological effects of both should be compared directly in further studies. To maintain ecological values of hedgerows, only a part of it should be cut back per year.

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Does Organic Farming have Greater Potential to Adapt to Climate Change?

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Climate change, adaptation, resilience, organic agriculture

Abstract

Organic agriculture are highly resilient systems based on sustainable soil fertility management, on the maintenance of diversity on landscape, farm, field and crop level and on a combination of indigenous, locally adapted knowledge with innovative technology. Such agro-ecosystems might be very adaptive to climate change scenarios.

Introduction

Agricultural production worldwide will face less predictable weather conditions than experienced during the intensification of agriculture. Weather extremes will become predominant. Lobell et al. (2008) expect severe humanitarian, environmental, and security implications. Specific, regionally adapted investment in order to improve adaptation of agricultural production will be necessary. In this context it is important to improve technical measures like irrigation or breeding programs on drought or heat tolerant crops, but even more important is the design of highly adaptive and resilient production systems. Organic farming might be a starting point worth to study in detail.

Traditional knowledge as a key to adaptation to climate change

Traditional skills and knowledge have been abandoned in intensive agriculture. Organic agriculture, on the other hand, has always been based on practical farming skills, observation, personal experience and tacit knowledge. Knowledge and experience are the conditions *sine qua non* to use natural processes and reduce dependence on external inputs (Boron, 2006). This knowledge is a 'reservoir of adaptations' as it provides the skills for manipulating complex agro-ecosystems.

Improved soil fertility as a key to adaptation to climate change

Soil fertility is a corner stone for resilient agro-ecosystems. Nonetheless, intensive agriculture neglects sustainable land use. Pimentel et al. (1995) calculated a loss of nearly a third of the World's arable land to erosion within the last 40 years with an on-going loss of more than 10 million ha per year.

Organic farming consists of different soil fertility-building and soil conserving techniques such as i) the on-farm flux of manure from livestock production to cropland,

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ii) the use of composts, iii) the use of leguminous crops and green manure in rotations, iv) diversified crop sequences with permanent soil cover and different rooting depths as well as v) minimum or shallow tillage. These practices bring organic farming in a good position to maintain productivity in the event of drought, irregular rainfall events with floods, and rising temperatures.

The most important findings concerning soil improvement by organic farming are:

- Reganold et al. (1987), found that humus rich topsoil layers of organic fields were 16 cm thicker than the ones of neighboured conventional fields in Washington, USA. This resulted in reduced erodibility.
- The DOK trial, a long-term Swiss field experiment on loess soil that began in 1978 (Mäder et al., 2002) showed that organic yields were only 20 % lower than in conventional. Soil microbial biomass and the physiological functions of soils as well as plant-microbe interactions were enhanced by organic agriculture. Furthermore, the aggregate and percolation stability of both bio-dynamic and organic plots were significantly higher (10 to 60 percent) than conventionally farmed plots. This also affected the water retention potential of these soils in a positive way and reduced their susceptibility to erosion. Soil aggregate stability was strongly correlated to earthworm and microbial biomass. Other soil macrofauna, such as carabides, spiders and staphylinides were more abundant in the organic fields than in the conventional ones (Pfiffner and Niggli, 1996; Pfiffner and Mäder 1997) with positive effects on soil structure, water infiltration, drainage, water-holding capacity and soil aeration.
- The Rodale farming trial that began in 1981 in Pennsylvania, USA, compared manure and legume-based organic agriculture systems to a conventional one based on mineral fertilizers (Pimentel et al., 2005). Whilst the long-term results show similar soybean and maize yields in organic and conventional systems, soil carbon increased in the organic system. The amount of water percolating through the top 36 cm was 15–20% greater in the organic systems indicating an increase in groundwater recharge and reduced run-off. In dry years, the organic plots yielded 28 to 34 % more corn and 56 to 100 more soybean. It was also found that water capture in organic plots was twice as high as in conventional plots during torrential rains. This may significantly reduce flood risk when practised on large areas.
- Marriott and Wander (2006) analyzed soil samples from nine farming system trials that were started in the USA between 1981 and 2000. The soil organic carbon concentrations were 14 percent higher in organic systems than in conventional ones. The labile fraction of the soil organic matter – a source of mineralizable C and N with important implications for plant nutrition – showed 30 to 40 percent higher values in organic soils.
- In the Netherlands, an investigation was done on farms that had been under organic and conventional management for 70 years on a polder soil (Pulleman, et al., 2003). The percentage of water stable macro-aggregates on organically farmed sites was 72 percent higher compared to conventional. The higher physical stability was linked to significantly increased soil organic matter content and to a larger volume percentage of worm-worked soil (organic 28 percent and conventional 8 percent).
- A study of organic cotton production in India found yield levels similar to a modern cultivation technique, however, soil organic matter, water stable aggregates and mean weight diameter showed advantages for organic (Eyhorn et al. 2007).
- In the Tigray province of Ethiopia, agricultural productivity was enhanced by compost application and introduction of leguminous plants into the crop sequence.

By restoring soil fertility, yields were increased to a much greater extent than by using purchase mineral fertilizers under summer drought conditions (Edwards, 2007).

Water retention and water quality in organically managed soils

Currently, 70 percent of the available water is used for agriculture. As water becomes increasingly scarce in certain regions of the world, it will be important to increase water use efficiency in irrigation and rain-fed agriculture. *Per se*, organic agriculture is not designed to use water as efficient as possible. Nonetheless, some agricultural techniques such as shallow tillage, disruption of capillarity by superficial mechanical weeding, soil residue management, improved of soil cover and structure may have positive effects on soil moisture, water infiltration, water use efficiency and soil surface temperature in organic crops. It can be assumed that organic systems are quite good in terms of water and soil erosion management, but that in combination with elements of minimum tillage, it would be most powerful.

In addition to maximizing water use efficiency in agriculture, it is important to reduce water pollution for the sake of drinking water and aquatic biodiversity. Organic practices reduce pollution in water effluents since pesticides and inorganic fertilizers – major pollutants of the aquatic environment – are prohibited. Organic agriculture has demonstrated 40 to 64 percent reduced nitrate leaching rates compared to conventional in different soil types in Europe (Stolze et al., 2000).

Diversity enhances farm resilience

An additional strength of organic farming systems is their diversity – including the diversity of crops, fields, rotations, landscapes and farm activities (mix of various farm enterprises). The high level of diversity on organic farms provides ecological services that significantly enhance farm resilience (Bengtsson et al., 2005; Hole et al., 2005). Biodiversity is an important driving factor for system stability. Organic agriculture has been shown to harbour more species at higher abundance of organism groups than conventional farming.

Positive effects of enhanced biodiversity on pest prevention have been shown by Zehnder et al. 2007, and similar effects of diversified agro-ecosystems on diseases and better utilization of soil nutrients and water are likely. The establishment of an organic production system needs to consider aspects such as landscape complexity to ensure that sufficient semi-natural landscape elements are present to serve as natural and attractive refuges for enemies and predators (e.g. planting hedges, sowing weed strips, installing beetle banks). In other words, biodiversity in organic agriculture has a distinct function, a functional biodiversity that stabilizes the agricultural systems.

The potential of genetic diversity at the crop level for stabilization of low-input farming systems and for adaptation to environmental changes is considerable (Kotschi, 2006). There are many small initiatives by plant and animal breeders in the context of organic farms scattered around the world. As resistance and robustness to environmental stress are characteristics encoded by multiple genes, the in situ conservation and on-farm breeding are likely to be more successful than genetic engineering.

In conclusion, organic farmers strive for the protection of a diverse landscape with habitats managed to host and attract beneficial organisms. This biodiversity-driven stability leads to a more stable food supply even under less favourable or less predictable whether conditions.

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Biogas in Organic Agriculture

Effects of Biogas Digestion of Slurry, Cover Crops and Crop Residues on Nitrogen Cycles and Crop Rotation Productivity of a Mixed Organic Farming System

Möller, K.[1], Stinner, W. & Leithold, G.

Key words: nitrogen, nutrient management, digestion, renewable energies

Abstract

Manures and crop residues can be utilised for digestion, without any significant losses of nutrients. This paper presents the results of field trials about the effects of biogas digestion in a mixed organic cropping systems on nutrient cycling and yield of a whole crop rotation. Digestion of slurry affected yields and N uptake only after soil incorporation. The inclusion of crop residues for digestion increased the amounts of "mobile" manure. N uptake and yield of non-leguminous main crops increased about 10%, due to a more adapted allocation of nutrients within the whole cropping system by reallocation of N towards the crops with higher N needs. Additionally, removing the cover crops in autumn and their digestion increased the fertilizing efficiency of N, lowering the risk of leaching losses.

Introduction

Nitrogen (N) is frequently considered to be one of the key limiting factors responsible for the limited productivity of organic farming systems (e.g. Berry et al., 2002). The supply of N from organic resources is difficult to synchronize with crop N demand (Pang and Letey, 2000). Crops under organic farming management are almost exclusively dependent on soil biological processes which provide nutrients by mineralization of applied organic matter like animal manure, crop residues, or green manuring. Improved agricultural management practices to meet crop N demand while avoiding N losses to the environment is a challenge, particularly for organic farming systems. During the anaerobic digestion, slurry dry matter is degraded. The elevated NH_4^+-N concentration in the digested material indicates its special suitability as plant-available N manure, making the nitrogen readily available for the crops. Commonly it was assumed, that digestion was connected with an enhanced N availability of applied slurry-N. The objectives of the trials presented were (i) to measure the impact of digestion of slurry on N uptake and yields within a whole eight year crop rotation, (ii) to determine the effect of digestion of crop residues (CR) like straw and of cover crops (CC) (iii) and of additionally introduced external substrates (equivalent to 40 kg N ha^{-1}) on fluxes of N, N uptake and yields within the rotation.

Materials and methods

The experiments were carried out between 2002/03 and 2004/05 at the research station for organic farming "Gladbacherhof" of the University of Giessen, situated 17 km east of Limburg in Hessen. The research station is located 140 - 230 m above sea level. The average annual temperature is 9.3 °C and the mean annual precipitation is

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682 mm (1960-2000). The soils are of a silty loam texture derived from loess with pH values of 6.6 - 6.9 and are classified as Calcic Luvisols with a field capacity of 330-370 mm m^{-1}. The field experiments were designed as a mixed system with crops on arable land (70%) and on grassland (30%). The designed arable crop rotation comprises eight years. It includes: 1-2. Clover/grass-ley (2 years); 3. Winter wheat+CC; 4. Maize (at 80% of the area) and potatoes (at 20% of the area); 5. Winter rye+CC; 6. Peas+CC; 7. Spelt+CC, and 8. Spring wheat. The CC mixture consisted of summer vetch (*Vicia sativa*) at 90 kg ha^{-1} and oil radish (*Raphanus sativus*) at 5 kg ha^{-1}. The plots were set at fixed places. All field experiments were carried out fourfold in a completely randomised design.

A common farmyard manure (FYM) and undigested slurry (US) system were compared to three manuring systems in which the cattle slurry and other substrates were digested in a biogas plant prior to field application In DS only slurry was digested. In DS+FR slurry and all kind of CR and CC were digested, the effluents of the percolation digester producing solid and liquid effluents were reallocated within crop rotation. DS+FER was similar to DS+FER, additionally purchased substrates at 40 kg N ha^{-1} were digested. More details: Möller et al. (2006).

Results

Comparing digested and undigested cattle slurry showed that total N content did not differ after digestion. However, the ammonia content in the slurry arose through digestion from 43 to 53% of the total N. The organic dry matter content (ODM) decreases significantly, as well as the C/N ratio decreased by about 25% due to slurry digestion. The pH arose 0.8 points, which means, that the concentration of protons due to digestion decreased by the factor of 6.3. Also, the mineral nutrient content in DM arose due to the concentration process of the partly decomposed dry matter in the digester. Digestion of CR and CC produced solid residues very similar to farmyard manure. The liquid residues of digestion in the percolation digester showed very similar properties than dung water obtained from farmyard manure staple in all relevant parameters, showing very high K and N contents, and a narrow C/N ratio.

No differences in total available manure N were registered in the three systems US, DS and DS+FR. In systems without CR and CC digestion (FYM, US, DS) ca. one half of total manure N was available as manure N and the other half as immobile green manure N. As far as additional digestion of CC and CR are concerned similar amounts of N were available as in US and DS. However, 87% of the total available N was mobile as effluents of the digester. The higher amounts of N in manures allowed a reallocation of nutrients within crop rotation towards crops with a higher N demand (winter wheat), at the cost of crops with a lower N demand like peas or spelt.

Differences yields were caused mainly by differences in the yields of the high N demanding non-legume cash crops (winter and spring wheat) within the crop rotation. No differences in total biomass yields were measured in crops with a lower crop N demand (rye, spelt and the three legume main crops). The cereals with lower N demand (rye and spelt) showed in DS+FR and DS+FER a strong tendency to lodging, which results in serious damage to the crop during the main growing period (Tab. 1).

Tab. 1: Crop dry matter yield (t ha^{-1}) and total N uptake main crops (kg N ha^{-1})

DM yields:	FYM	US	DS	DS+FR	DS+FER
Clover/grass-ley 1	13.3	13.7	13.7	13.8	13.9
Clover/grass-ley 2	12.1	12.2	11.9	12.3	12.5
Winter wheat	5.25a	5.73b	5.67b	6.09c	6.21c
Root crops:					
Potatoes (0.2 parts)	6.42	6.36	6.72	6.88	6.65
Maize (0.8 parts)	14.7	14.9	15.2	15.9	15.9
Rye	5.02	4.69	4.66	4.26	4.48
Peas	2.88	2.84	2.74	2.82	2.62
Spelt	3.57	3.60	3.52	3.40	3.23
Spring wheat	3.83a	3.76a	4.17b	4.33b	4.93c
MV Crop rotation	7.38a	7.47a	7.48a	7.63b	7.74b
MV non-legumes	6.15a	6.19ab	6.30ab	6.44bc	6.58c
MV legumes	9.43	9.59	9.44	9.62	9.66
Crop N uptake:					
Clover/grass-ley 1	414	423	422	427	433
Clover/grass-ley 2	375	378	364	372	381
Winter wheat	112a	129b	129b	152c	170d
Root crops:					
Potatoes (0.2 parts)	98	97	103	103	103
Maize (0.8 parts)	143a	150ab	149ab	173b	176b
Rye	113a	113a	112a	120ab	126b
Peas	151	152	146	147	140
Spelt	114	128	120	116	121
Spring wheat	98a	111ab	119b	145c	166d
MV Crop rotation	189a	197b	194b	205c	212c
MV non-legumes	114a	124b	124b	139c	149d
MV legumes	313	318	311	315	318

Values with the same letter are not different at $P \leq 0.05$

The lowest N yields were obtained in FYM (Tab. 1). US and DS showed significant higher N uptakes as a sum of whole crop rotation as FYM. The inclusion of CR and CC in digestion process (DS+FR) caused a further substantial increase of N yields. In legumes the N uptake and yields didn't differ in any way. The main differences in crop N uptake were related to the non-legumes within the crop rotation. Non-legumes were able to take much more N in US than in FYM, whereas digestion of slurry did not influence N uptake of non-legumes. Digestion and reallocation of nutrients of CC and CR (DS+FR) resulted in a further increase of N uptake of non-legumes, without any adverse effect on N uptake of leguminous crops such peas. The highest N yields were obtained by inclusion of external substrates in digestion process (DS+FER).

Further effects of digestion were a strong reduction of the balance of emissions of greenhouse gases and the replacement of fossil fuels due to the production of heat and power energy. Harvest and digestion of CR and CC reduced furthermore the nitrate leaching risk (for more details: Möller et al. (2006).

Discussion

Digestion of slurry had only small effects on the overall yields and the N use efficiency of the whole arable crop rotation. Probable causes are: (i) Higher ammonia losses after spreading digested slurry (not shown), or (ii) the organically bound N of undigested slurry seems to have enough time, for example in long cycle crops like maize to become mineralized and available to crops. The higher yields of the manuring system which includes CC and CR in digestion process (DS+FR) are strongly related to a higher N use efficiency of the system. In the system similar amounts of nitrogen circulated than in US and DS (Table 5), but the non-legume main crops yielded significant higher amounts of nitrogen, and grains with higher nitrogen content (not shown). The harvest of CC in autumn and posterior digestion and application directly to the following main crop enhances N use efficiency significantly. Including not only CR, but also external substrates in the system (DS+FER), led only to a small further increase in yields on the arable land in comparison to DS+FR, in spite of the high amounts of N introduced into the system by the purchased substrates. The causes are strong lodging of less N demanding cereal crops and a higher weed infestation through *Gallium aparine*.

Conclusions

Biogas plants may act as nutrient bank where the nutrient harvested from crop residues and cover crops can be released and used as manure on high-value crops. Digestion of CC and CR will increase the amounts of mobile manures, allowing a more pronounced manuring of high N demanding crops. Furthermore, N use efficiency of manuring was higher if the biomass is digested and reallocated within the same crop rotation in comparison to direct soil incorporation. However, digestion is only a first step towards a higher efficiency of the N cycle in organic farming systems. Digestion can constitute an important key technology for implementation of more appropriate techniques for manure application by reducing solid concentration and by having a significant effect on particle size distribution. A subsequent solid-liquid separation of the residues combined with slurry injection techniques might allow further improvement of organic manuring systems.

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Biogas in stockless organic Farming: Effects of Digestion of Clover/grass, Cover Crops and Crop Residues on Nitrogen Cycles and Crop Rotation Productivity

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Key words: nitrogen, nutrient management, digestion, renewable energies, stockless farming system

Abstract

A common practice in stockless organic farming systems is to leave the biomass from clover/grass-ley and crop residues in the field for their residual fertility effect. No farmyard manures for transfer of nutrients within the system are available. Clover/grass-ley biomass and crop residues represents an unexploited energy potential that could be harnessed by the digestion in biogas plants for production of methane, thus replacing ruminants by the biogas digester. In field trials by implementing a whole crop rotation comprehending six crops were carried out in 2002-2005 to evaluate whether the use of N could be improved by processing biomass described above in a biogas digester and using the effluents as a fertilizer, compared to general practice.

Results indicate that digestion of crop residues resulted in more efficient manuring systems, not only by the implementation of an additional "product" (power energy), but also by getting more efficient cropping systems with higher DM and N yields of most of the non-legume crops, combined with a reduction of N losses due to denitrification and a reduction of the nitrate leaching risk. The causes were a better and more evenly allocation of nutrients within the whole crop rotation, a higher N input via N_2 fixation, lower N losses and probably a higher N availability of digested in comparison to the same amounts of nutrients in undigested organic manures.

Introduction

In stockless organic farming systems clover/grass biomass, cover crops (CC) and crop residues (CR) represent a large unexploited energy potential that could be harnessed by the anaerobic digestion in biogas plants for production of methane. Some authors assumed that simultaneously, the availability of the nitrogen of the effluents would be increased due to reduced emissions to the air and water and enhanced nitrogen mineralization. The digestion of legume-grass leys, a fundamental component in those crop rotations due to N_2 fixation and weed suppressing effect, would create a mobile fertilizer.

The experimental evidence for beneficial effects of using green manure crops for biogas digestion is very scarce. There is a need for a system approach which includes measurement of all N loss pathways from management clover/grass-ley crops as either by traditional green manure or by removing for methane production with recycling of the digested residues to the same crop rotation. The complex interactions connected with described changes in manuring system need to be quantified in order

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to evaluate the whole-chain differentiation of N use efficiency and other effects on crop productivity and environmental impact of farming systems. The objectives of the presented trials were (i) to measure the impact of digestion of residues like clover/grass-leys, straw and cover crop biomass (ii) and of additionally introduced external substrates (equivalent to 40 kg N ha^{-1}) on N fluxes, N uptake and yields within a whole crop rotation. A further objective are (iii) to assess the impact on nitrate leaching risk and soilborne nitrous oxide emissions.

Materials and methods

A field trial with a block design were carried out between 2002 and 2005 on the research station Gladbacherhof. Soils are silty loams derived from loess (calcic Luvisols). The cropping system consisted of a six-field crop rotation including: 1. Clover/grass-ley; 2. Potatoes; 3. Winter wheat+CC; 4. Peas+CC; 5. Winter wheat+CC, and 6. Spring wheat. The CC consisted of summer vetch (*Vicia sativa*) at 90 kg ha^{-1} and oil radish (*Raphanus sativus*) at 5 kg ha^{-1}. The plots were set stationary. Field experiments were carried out fourfold with experimental plots of 72 m^2 (6 m x 12 m). All crops were cropped in each year. In the trials the common mulching practice in organic agriculture without livestock was compared with two strategies of biogas digestion (Tab. 1). Further informations can be seen in MÖLLER et al. 2006.

Tab. 1: Manuring treatments

Manuring treatment	Abbre-viation	Management of clover/grass ley, crop residues and cover crops
Usual stockless management	wL	Remained on field (ploughed in, mulched)
Stockless management with digestion of field residues	wL-FR	Harvested, digested, effluents reallocated as manure within crop rotation
Stockless management with digestion of field residues, and external substrates at 40 kg N ha^{-1}	wL-FER	Harvested, digested, effluents reallocated as manure within crop rotation

Results

The total amounts of N in manures didn't differ between wL and wL-FR (approx. 127 kg N ha^{-1}). However, in wL-FR more than 80% of N circulating within the system were transferred by the biogas effluents (104 kg N ha^{-1}), and was applied more evenly through the whole crop cropping system, mainly on non-legume crops (not shown). In spring the measured soil mineral content differed only slightly as a mean of the whole crop rotation. However, in the non-legume crops the soil mineral N was higher in both biogas variants than in wL, disadvantaging legume crops.

The yield of saleable non-legume main products was highest in wL-FR with 5.24 t DM ha^{-1} and lowest in wL with 4.78 t DM ha^{-1}, a difference of c. 10%. The average yield of winter wheat in both positions within crop rotation was significant higher in wL-FR than in wL, with grain yield differences of 13%. Simultaneously, the yield variation of non-leguminous crops in different position of the crop rotation differed in a lesser degree in wL-FR than in wL, as showed by a lower coefficient of variation. The winter wheat crops in wL-FER were affected by lodging and by a strong development of *Gallium* *aparine*. No differences in DM yield were measured in legume main crops (clover/grass-ley and peas) between the different manuring systems (Tab. 2).

Tab. 2: Dry matter yields (t DM ha^{-1}) and N uptake (kg N ha^{-1}), including straw

	Yields			Total N uptake		
	wL	wL-FR	wL-FER	wL	wL-FR	wL-FER
CG ley	12.9	13.7	13.3	368	383	383
Potatoes	7.43	7.48	6.77	97.5b	98.3b	82.0a
WW 3	12.7	14.1	13.0	133	156	143
Peas	6.99b	5.92a	7.07b	160	147	159
WW 5	11.3a	13.8b	12.6ab	97.4a	126b	115b
SW	5,83a	6,84b	75,3b	62.0a	72.3a	85.6b
MV non-legumes	9.30a	10.5b	9.95b	97.5a	113b	106b
MV winter wheat	12.0a	13.9b	12.8ab	115a	141b	129ab
MV crop rotation	9.54a	10.3b	10.0b	153a	164b	161b

The system wL-FR showed higher (+16%) mean N uptake by non-legumes (113.2 kg N ha^{-1}) comparing to wL (97.5 kg N ha^{-1}). Highest differences were measured in winter wheat: digestion of crop residues (wL-FR) increased N uptake at 23% in comparison to wL.

Soilborne nitrous oxide emissions from the common stockless system accounted for 2.914 kg N_2O-N ha^{-1}. Main source were the mulched clover/grass-ley and autumn incorporated CC. Digestion of field residues decreased this emissions to 1818 kg N_2O-N ha^{-1}, which corresponds to a reduction of about 38% (results not shown).

In autumn the measured soil mineral content in 0-90 cm differed significantly as a mean of the whole crop rotation. A significant reduction of ca. 20% were measured in wL-FR (43,4 kg N ha^{-1}) due to harvesting the residues including clover/grass-ley and CC in comparison to wL (52,4 kg N ha^{-1}). The values of wL-FER were intermediate (48,2 kg N ha^{-1}). The highest effects were measured after incorporation of CC in autumn prior to a winter cereal crop and in the clover/grass-ley. Differences were measured meanly on the upper soil layer (data not shown).

Discussion

Harvesting by removing clover/grass-ley, CR and CC for digestion in a biogas plant not only avoid the concentration of high amounts of N in certain segments of the crop rotation prone to get loss, but also it resulted in the build up of considerably amounts of mobile manures, able to apply to different crops, i.e. reallocating the available nitrogen more evenly within crop rotation. The higher yields of the systems with digestion of the crop residues resulted probably due to the combined effect of at least four factors: (i) A higher N Input via di-nitrogen fixation of the harvested clover/grass-ley: Mulching, leaving the clover/grass biomass on the field induced negative feed-back effects through enhancing soil N supply of the legumes (Heuwinkel et al., 2005). (ii) A higher allocation of the main growth limiting nutrient N on the non-leguminous crops. (iii) A more evenly allocation of the available nutrients across the different non-leguminous crops within crop rotation. Due to the law of “the diminishing response of yield to increasing N supply”, yield improvements are possible by a reduction of N supply of previously high supplied crops, providing the nutrients to crops former very low in N. And, (iv) a further possible cause for higher DM and N yields could be the C losses due to digestion and a related reduction of processes resulting in N immobilization related to the supply of C.

An improved N availability of the systems with digestion of residues can be deducted from the higher N uptake, the higher grain and straw N content obtained in both systems with digestion and the higher weed infestation with *Gallium aparine*. The higher N availability as a consequence of digestion and reallocation of nutrients resulted also in lodging of the winter wheat, mainly in wL-FER. Lodging and weed infestation probably counteracts to some extend the yield improving effects of the improved N availability due to the digestion and reallocation of nutrients within the system.

Conclusions

Digestion of crop residues like clover/grass-ley and CC is an instrument to get more efficient organic stockless systems, not only by the implementation of an additional "product" (power energy) replacing fossil fuels, but also by getting more efficient cropping systems with higher DM and N yields, combined with a reduction of the risk of N losses due to leaving a lot of organic residues on the fields in autumn. The causes of the described effects were a more evenly allocation of nutrients within the crop rotation, a better matching of crop N demand and soil N supply by application of manures just at the beginning of the most N demanding period, a higher N inputs via N_2 fixation, lower N losses due to emissions and probably a higher N availability of digested in comparison to undigested organic manures due to a reduction in C returned to the soil.

In the ley/arable system, livestock, particularly ruminant livestock, plays an important role in utilising the leys, and are also important as a source of manure for transferring fertility to priority crops around the farm. Livestock also fulfil an additional role through their utilisation of arable CR. Implementation of biogas digesters in stockless organic farming systems replaced to a some extend the function of ruminant animal husbandry, by exploiting the residues and the biomass produced by clover/grass-leys, CC and CR. By harvesting the crop residues and CC the nitrogen gets free to be used wherever and whenever desired, instead of a location-bound and time-bound amount of organic manures, increasing the "state of freedom" for organic manuring. A feature common to the new technologies is the increased scope for N application at a time and place when needed by the crop, as opposed to the necessity of incorporating untreated material during the normal ploughing season.

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Energy balance of different organic biogas farming systems

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Key words: biogas, energy balance, energy crop, farming system

Abstract

The ecological impact of biogas plants depends on their integration into a given farming system. Therefore only farm-specific and no general statements are possible. In this paper, two different concepts of biogas production for an organic cash crop farm have been energetically balanced using a model software. The analysis of input and efficient use of fossil energy carriers provides information on the environmental relevance of the farm operations. Apart from this, renewable energy production in the farming systems is compared to food production, and changes in the farm output are described. It turns out that organically run cash crop farms can benefit from a reasonable integration of a biogas plant, both in food crop and energy production. An increased orientation on the growing of energy crops, however, leads to worse utilization of fossil energy carriers and reduced food production.

Introduction

Striving for largely closed nutrient cycles and the conservation and improvement of soil fertility are intrinsic to organic farming systems. Reaching these aims, organic cash crop farms are faced with limits due to the absence of livestock. However, these limits can be overcome by integrating a biogas plant (BGP) into the farm system. The ecological consequences of integrating a biogas plant into a farm are complex and farm-specific. A model program for energy balancing on different technological levels (from crop cultivation to energy production) has been developed that not only allows one to analyse both existing and planned biogas systems, but also to estimate the effects prior to the erection of a plant. The paper describes the application of the model to an organic cash-crop farm, for which two management scenarios with different biogas intensity were elaborated. The input of fossil energy carriers is compared with the output in form of utilizable energy and food crops.

Materials and methods

Energy balancing includes the whole technological chain from the field (growing and harvest of food and energy plants) through storage (preservation) to the biogas plant (conversion) and the CHPP (combined heat and power plant). The energy input in the form of electricity and fuel (direct energy input) as well as the upstream energy input for the manufacturing of machines, equipment, and other expendables (indirect energy input) is considered. The energy output as well is described throughout the whole technological chain (yield of food crops / yield of energy plants – preserves – biogas – power and heat) with consideration of loss paths (storage and preservation losses, conversion losses, technical losses). To estimate the resource efficiency, the output/input ratio is computed. Energy balancing of crop production is performed according to Hülsbergen et al. (2001) on the basis of farm-related operational and

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yield data. The gas-forming potential of the substrates is calculated according to Keymer (2007), power and heat quantities correspond to those of a modern Otto gas engine with an efficiency up to 40 $\%_{el}$ and 53 $\%_{therm}$ (FNR 2005). To test its suitability for scenario calculations, the new energy balancing approach has been applied on the Experimental Farm Viehhausen. The results are taken into account in the current planning of an experimental biogas station in the investigated farm. The tested experimental farm (80 hectares) is located about 35 km north of Munich in the Bavarian Tertiary hills (480 m above see level, 780 mm, 7.8°C). In the farm, data records from field trials on yield potentials of cereals and energy crops and also on the development of grass/clover crops in biogas crop rotations were used to cover the computed model results. The five-field crop rotation of the stockless ecofarm (Sc REAL) is dominated by cereals (Table 1). The grass/clover gets mulched; cereals and grain legumes are sold. For the farm, two experimental management systems were designed representing different strategies of how to integrate a biogas plant into an organically run cash crop system. The extensive biogas system (Sc BGe) maintains the cash-crop-dominated crop rotation of Sc REAL, except grass/clover is used for energy production instead of being mulched (Table 1). The yield increase of grass/clover has been ascribed to cutting management, and that of cereals to increased N-supply and the high N use rate of the biogas slurry (about 60 % soluble N in the total N (FNR 2005)). The second scenario shows an intensive four-field rotation with mainly biogas crops (BGi). The acreage of cash crop growing declined from 80 % (Sc REAL and Sc BGe) to 25 %. Yield and quality levels of grass/clover and cereals correspond to those cutting in Sc BGe (Table 1).

Table 1: Crop rotation, yield and use of the products on the real farm (Sc REAL) and in the two experimental farming systems (Sc BGe and Sc BGi)

Sc REAL crop rotation	dt DM	use	Sc BGe crop rotation	dt DM	use	Sc BGi crop rotation	dt DM	use
grass clover 50*	80	mulch	grass clover 70*	120	biogas	grass clover 70*	120	biogas
winter wheat	34	sale	winter wheat	45	sale	winter wheat	45	sale
triticale + wcc	34	sale	triticale + wcc	45	sale	silage maize	154	biogas
pea + scc	23	sale	pea + scc	23	sale	+ rye for silage	27	biogas
winter wheat	34	sale	winter wheat	45	sale	cereal for silage	69	biogas

* proportion of clover 50 and 70 % respectively; wcc - winter catch crop; scc - summer catch crop

Results

A total farm analysis of the three systems and a comparison among the food crop and the energy production chains in each variant is given in Table 2. In the biogas scenarios, energy input in cash crop production rises vis-à-vis Sc REAL due to the spreading of biogas slurry. The yield increase involves an enhanced energy output per hectare of cropping area of 28 % (BGe) and 37 % (BGi), respectively. The output/input ratio in food crop production differs little among the scenarios (Table 2). Although the area-related energy output of cash cropping increases in both biogas scenarios, only in Sc BGe does food production really increase (58 GJ ha^{-1}; 46 GJ ha^{-1} in Sc REAL) due to a constant cropping structure. In Sc BGi, food production decreases (20 GJ ha^{-1}) owing to the drastically reduced cropping area in favour of the cultivation of energy crops.

Power generation on the basis of biomass fermentation involves several conversion steps; each involving energy losses (Fig. 1). Correspondingly lower is the output/input ratio (6 to 7) compared with food cropping (15) (Table 2). Table 2: Total farm and product related (food crops, power/heat) energy balance in the cash crop farm and under the two biogas scenarios

		Sc REAL		Sc BGe			Sc BGi		
		farm	food	farm	food	energy	farm	food	energy
	hectare	**80**	**64**	**40**	**32**	**8**	**40**	**10**	**30**
field	direct	2.5	2.2	3.7	2.8	6.5	5.3	3.,0	6.1
field	indirect	1.7	1.8	2.3	1.9	3.5	3.4	2.,4	3.7
field	**Input** fossil energy	**4.2**	**4.0**	**5.9**	**4.7**	**10.0**	**8.76**	**5.3**	**9.8**
field	**Output** energy crops	-	-	43.8	-	219.1	169.7	-	226.3
field	**Output** food	**46.4**	**58.0**	**58.0**	**72.5**	-	**20.1**	**80.4**	-
field	**Output/Input-ratio** food production	**-**	**14.6**	**-**	**15.5**	**-**	**-**	**15.3**	**-**
store	**Output** preserved energy crops	-	-	36.8	-	184.2	141.0	-	188.0
BGP	**Input** fossil energy			**0.7**		**3.7**	**3.3**		**4.4**
BGP	**Output** biogas			18.5		92.7	82.3		109.7
CHPP*	**Output**								
CHPP*	power			7.4		37.1	32.9		43.9
CHPP*	heat			9.8		49.1	43.6		58.1
CHPP*	power + heat			**17.2**		**86.2**	**76.5**		**102.0**
CHPP*	**Output/Input-ratio** energy production			-		**6.3**	**-**		**7.2**
CHPP*	heat					3.6			4.1
CHPP*	power					2.7			3.1
farm	**Input**	**4.2**		**6.7**			**12.0**		
farm	**Output** farm	**46.4**		**75.2**			**96.6**		
farm	food	**46.4**		**58.0**			**20.1**		
farm	energy	**-**		**17.2**			**76.5**		
farm	**Output/Input-ratio** farm production	**11.0**		**11.2**			**8.1**		

*CHPP - combined heat and power plant

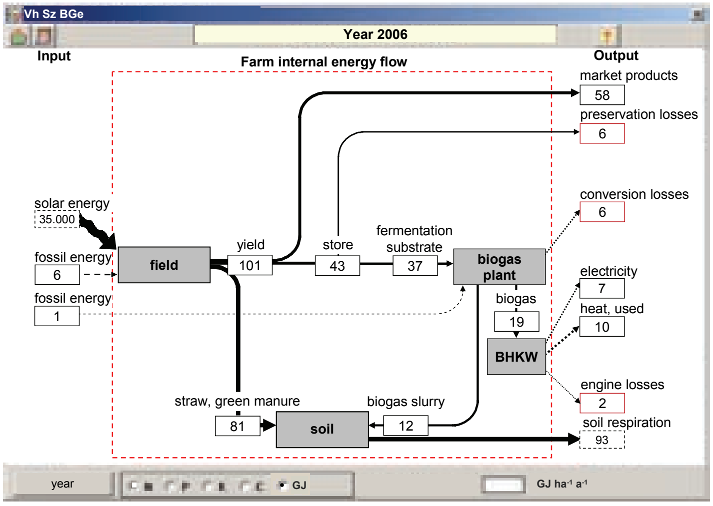

Figure 1: Energy flow in an organic cash crop farm with biogas plant: fossil energy input, energy fixation in the biomass, energy output (food products, electricity, heat) and energy loss paths in Sc BGe. Screenshot from the REPRO model (Hülsbergen 2003).

In the biogas scenarios, apart from cash crops, utilizable renewable energy in the form of electricity and heat is generated by fermentation of by-products (BGe) or energy crops (BGi). This entails an increase in the total energy output of the farm in both biogas scenarios (75 and 97 GJ ha^{-1} in BGe and BGi; 46 GJ ha^{-1} in Sc REAL) (Table 2). In Sc BGi the output/input ratio deteriorates markedly: more fossil energy carriers are consumed (12 GJ ha^{-1}; 4 and 7 GJ ha^{-1} in Sc REAL and Sc BGe) with reduced use efficiency.

Discussion

The main argument for an expansion of renewable energy sources is the CO_2-neutral energy provision. Energy balances allow one to draw conclusions on the utilization efficiency of fossil energy carriers and the resulting CO_2-emissions. Reliable information, however, can only be obtained from farm-specific analyses over the entire farm production chain. Such an approach has also been called for by Berglund & Börjesson (2006). Producing bioenergy may also entail changes in cropping structure and yields. Rising yields of cash crops increase food production only when the cropping area is kept constant; a decline in the cash crop area in favour of energy plants may reduce food production despite enhanced yields per hectare.

Conclusions

Apart from biogas generation, there are further possibilities for providing energy by using agricultural biomass, which may turn a farm enterprise into a net energy producer already at a low proportion of energetically converted biomass. However, not only is the highest possible energy gain required for complying with the principle of sustainability; the objective must also be maximum utilization of the input of fossil resources. In this connection, power generation on the basis of biogas turns out to be more energy efficient than, for example, RME or bioethanol production (output/input ratio 1 to 6) (Venendaal et al. 1997).

Acknowledgments

The research activities were funded by Deutsche Bundesstiftung Umwelt (DBU).

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Biogas and Organic Farming: Empirical evidence on production structure and economics in Germany

Anspach, V.[1] & Möller, D.[2]

Key words: economics, energy, biogas plants, modelling, internal benefits

Abstract

Biogas production has an increasing importance on organic farms in Germany. Biogas plants have the possibility to produce energy, soil fertility and positive returns on capital. Yet previously no studies on the structure, economic outcomes and internal benefits of biogas production on organic farms existed. Therefore in 2006 and 2007 an empirical study, designed as a census, has been carried out to investigate these questions. Based on the empirical study a simulation model was built to analyse the economic potential. The highest economic potential, particularly if organic food and energy production are to be accomplished, was found for biogas plants which are mainly residual-based and on a farm scale size. The construction of small but also low priced biogas plants for organic farms will be a challenge.

Introduction

Biogas is one out of a set of new biomass based technologies intended to reduce the use of fossil fuels. In addition to the discussion on the potential, costs and energy efficiency of bio-energy in general, especially biogas seems to have the chance to play a major role in future energy scenarios. Farmers have already adapted to the given situation and started to grow energy crops for biogas. In organic farming the discussion has even more complex aspects. Due to the ideas and regulations of organic farming the material flows and economics are much more complex. Farmers and consultants are facing an information gap which has to be closed to offer realistic decision support for future farms investments.

The study presented here consists of two parts. First, an empirical study ("BioBiogas-Monitoring 2006-2007" at the University of Kassel, Germany) was conducted to investigate the structure of biogas production on organic farms and to get insights into technology specifics, use of heat and slurry and on the selection of substrates. Based on the results of the empirical study a simulation model was built and used to analyse the economic potential of biogas in organic farms.

The hypothesis is that organic farms can produce energy (electricity) from biogas in an economic way because of three typical characteristics. First, many farms face a surplus of grass-clover mixtures, which are needed to maintain soil fertility. Especially farms without or with low livestock are looking for reasonable usage of clover instead of mulching. Second, the diverse structure of organic farms in Germany often gives the opportunity to use the waste heat from combined heat and power plants (in stables, dairies, residences, etc.). Finally, the use of slurry coming from the biogas

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plants can improve the on-farm nitrogen cycles significantly. The economic value of a time and spatially flexible fertiliser on organic farms is – due to the overall low nitrogen level – considerably higher than on conventional farms. In fact, biogas production may enhance the "on-farm production" of soil fertility (ANSPACH AND MÖLLER 2007).

Materials and methods

The empirical study was designed as a census instead of sampling. The database consists of 120 notably known organic farms with a biogas plant (experts assume at least 150 biogas plants). A semi-structured questionnaire was sent together with known farm specific data and a paper summing up previous results of the BioBiogas-Monitoring 2006. Around 80% of farmers where contacted by a follow-up call to improve the quantity and quality of answers. 100 out of the 120 farms answered the questionnaire, a 83% response rate.

Due to the challenge that the empirical data does not contain satisfactory information on the economics of biogas production on the farm level a cost and performance accounting model was developed and used as a simulation model. The full cost approach follows the standard set by the German Agricultural Association (DLG) (see MÖLLER 2006). The assumptions of the model, based on real farm examples, are a medium sized biogas plant with an engine power of 200 kW_{el} (electricity) and investment costs of 4000 €/kW_{el}. On average, 50% of waste heat is used, which can be sold for 4 cent/kW_{therm} (thermal). For the monetary value of using biogas slurry as a fertiliser, 6€/m³ are assumed to coincide with a value of at least 1€/kg nitrogen. The substrate production of organic maize and cereal silage is calculated with full costs, grass and clover only with the harvesting costs, the acquisition of conventional maize with 1400€/ha. One third of the daily substrate ration on all three types of biogas farms is liquid manure.

Results

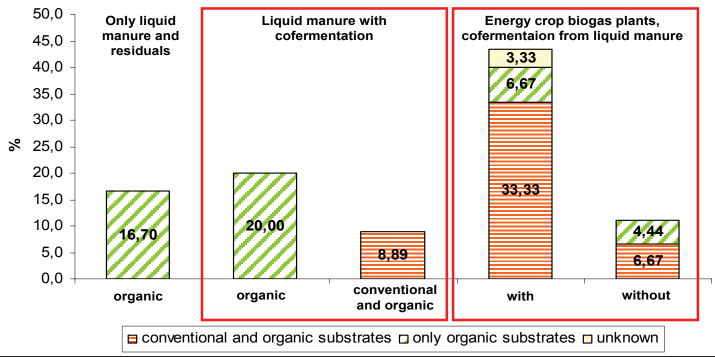
Organic farmers belong to the group of pioneers in the biogas sector and the relevance of biogas on organic farms is still increasing. Today at least 150 biogas plants with an electrical capacity of 15-20 MW_{el} are installed. Since 2005 the number of biogas plants has increased by about 50%, the electrical capacity by about 30%. The plant size ranges between 15 kW_{el} and 700 kW_{el}.

Today around 5% of all biogas plants in Germany can be found on organic farms. Most of the plants are located on feed growing and crop growing farms, but currently more and more so-called "biogas farms" have come into existence. Biogas farms are mostly cooperations of farmers to share a plant and collect the needed substrates together. Most of the biogas plants are really well integrated in the agricultural circuit of the farms. This means that the technological and biological handling of plants is mostly under control and most of the waste heat can be used reasonably for heating houses, intra-farm use like heating stables or the dairy, drying or selling it via small local heat pipes in the neighbourhood. The average use of waste heat from biogas plants on organic farms is about 50%, in comparison with newly constructed conventional biogas plants with a waste heat utilization of about 30% (SCHOLWIN AND FRITSCHE 2007).

The main reasons for producing biogas – beside generation income from electricity sales - are positive effects on crop production, upgrading of organic fertilisers and a profitable use of grass/clover and grassland. We could find very strong internal benefits by using the biogas slurry as an organic fertiliser, especially, but not only, on crop growing farms. The investigated biogas farms show yield increases between 10 and 30%, especially in grain production as well as higher backing quality in grain production and better fodder quality and efficiency of grass silage (see also MÖLLER ET AL. 2006).

Regarding the composition of substrates, we can differentiate three types of biogas farms. The first type is a small plant that uses liquid manure and some fodder residuals only. Second are biogas plants based on liquid manure with more than 50% of the ration; the remainder are co ferments from energy plants. The third type describes biogas plants based on energy crops with and without cofermentation of liquid manure (Fig. 1). The acquisition of conventional substrates has a great importance; about 50% of the farms are using those substrates, mostly maize and cereal silage.

Fig.1: Composition of substrates in biogas plants on organic farms (n = 90)



The economics of biogas production on organic farms can be characterised as follows: The use of "waste" heat and the consideration of intra-farm benefits improve the overall profitability significantly (Tab. 1).

Tab.1: Return of capital of different Types of Biogas-Farms in %

	Type of Biogas Farm 1 (Utilisation of residuals)	**Type of Biogas Farm 2 (Energy crop grower)**	**Type of Biogas Farm 3 (Conventional acquisition)**
Substrate	Clover, grassland, liquid manure	Clover, cereal silage, maize silage, liquid manure	Clover, conventional maize silage, liquid manure
Base (only sold power)	**0,5**	**- 4,3**	**0,2**
incl. use of heat	**4,3**	**- 0,7**	**3,9**
incl. internal effects	**4,5**	**- 1,2**	**3,1**
incl. internal effects and use of heat	**8,3**	**2,3**	**6,8**

The production of energy crops (maize and cereal silage) on organic farms is not profitable under the current framework. Highest profitability is reached when low-cost residual materials (clover and mixtures, intercrops, straw, etc.) are used as a basis for energy production. Many organic farming associations and the EU-regulations on organic farming allow the purchase of additional input material (e.g. maize and cereal silage) originating from conventional farms. Especially larger biogas plants are often dependent on that source, the economic performance can thus be stabilised significantly.

Discussion

The empirical data source can be considered as very good because of the high share of German organic biogas farmers interviewed. The reliability of the data could be improved by personal interviews (as the follow-up calls showed), but the overall picture can be considered as quite realistic. However the gained data is not in itself sufficient for detailed economic modelling exercises. The presented results of model simulation runs are very dependent on the underlying assumptions, but the use of up-to-date data and the congruence with other result and farmers estimates generate meaningful outcomes. Further research is needed with real farm data e.g. of 10-20 examples.

Conclusions

We found a strong interest for biogas plants on organic farms; the importance is equal to conventional farms. Today, positive returns on capital are possible. New capital investments are or could be profitable, if the biogas plants are imbedded into reasonable integrated concepts. Biogas plants have to be adapted to the flow of materials on the farms and their business environment. The main factors of success are high waste heat usage, internal benefits like positive effects on crop production. These are created by the improvement of liquid manure and the use of cost effective substrates such as residuals or by-products of crop production. Currently exclusive production of energy crops is uneconomic, because of the high production costs of organic substrates. Therefore the acquisition of conventional substrates, especially maize, is feasible from an economic point of view. However, this depends on future developments of substrate prices. Also the growing demand for conventional substrates is very critically observed by organic farming associations.

If the aim is to accomplish the production of both organic food and energy, an adequate biogas plant should be mainly residual-based and in a farm scaled size. The construction of small but also low priced biogas plants for organic farms is an important challenge for engineers. Additional research is particularly needed into the internal benefits of biogas slurry and improved heat use concepts.

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A New Lease on Life for Marginal Farmland: Convergence of Prairie Restoration with Biofuel Production

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Key words: biofuels, biomass, organic agriculture, tallgrass prairie, sustainability.

Abstract

The prairie ecosystem that occupied most of the North American continent has been mostly converted into agricultural farmland. The looming global scarcity of fossil fuels has spurred interest in producing ethanol from corn (Zea mays) but legitimate objections remain to the idea of supporting this vision. The purpose of this study was to initiate a prairie restoration on marginal soil of a 16.2 ha. farm in southeastern Minnesota and to determine which restoration procedure (only native grass species versus a mixture of grasses and forbes) was most effective for the establishment of prairie on the land that may yield biomass for biofuels. We planted 11.4Kg./ha. of grasses on 4.7 ha. and 0.70Kg./ha. of forbs on 3.2 ha., in June 2007. An evaluation of species richness was conducted after 90 days in the 5 restored plots. The mean percent cover in the grass plots was 0.935, whereas the one in the grass-and-forbs plots was 0.944. A t-test with two independent samples complemented the computation of the diversity index and indicated that there was not a statistically significant difference in species diversity among the plots. This paper postulates a model of prairie rehabilitation in synergy with renewable energy production from native prairies. This could inspire agriculture in the Midwest of the U.S. to a vision of ecological restoration and sustainability.

Introduction

The fertile tallgrass prairie of North America stretched through 68 million hectares before European settlement (Smith 2001) and since then, the development of large scale agriculture, aided by mechanization and cheap fossil fuels, enhanced monoculture and an extirpation of prairies (Jackson 2002). Despite restoration efforts, a looming global scarcity of fossil fuels has spurred interest in renewable energy, especially ethanol from corn (*Zea mays*). However, legitimate objections remain to the idea of diverting significant quantities of corn into ethanol as corn remains a major food and thus increases in food prices could become inevitable. Its cultivation is best on fertile land and expanding its production to marginal soils may require ever-increasing off-farm inputs. The arguments sketched out above have recently been supported by the work of Tilman *et al*. (2006). They showed that low-input high-diversity (LIHD) mixtures of native grassland perennials are superior to corn or soybean in terms of usable energy, greenhouse gas reductions and agrichemical pollution. Even though the study was conducted on small plots its outcome inspired the authors to verify the applicability of these findings on a real-farm situation.

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Materials and methods

We have initiated a restoration effort in 2007 over a larger area in an effort to further validate the findings of Tilman *et al.* (2006), and to demonstrate the synergism that can exist between biofuel production and prairie restoration. The work consisted in restoring prairie on marginal soil of a 16.2 hectare farm in south eastern Minnesota to verify on a landscape scale how biomass production for biofuel can be combined with grass and restoration. Additionally, we intended to learn which restoration procedure (only native grass species, versus a mixture of grasses and forbs) was most effective for the establishment of prairie perennials on the land that may yield viable stalks to be pelletized and used, on-site, for heating purposes. The study area (Pork & Plants Farm) is located in the Whitewater watershed in Winona county, southeastern Minnesota, U.S.. To reduce reliance on the costly corn, 7.9 hectares were planted (4.7 ha of mixed grasses and 3.2 ha of mixed grasses and forbs) in June 2007 (Table 1).

Tab.1: Prairie plant species that were sown at Pork & Plants Farm.

Native grasses **Scientific name**	**Pure live seed, kg**	**Native forbs** **Scientific name**	**Pure live seed, kg**
Big Bluestem *Andropogon gerardii*	22.7	Long Head Coneflower *Ratibida columnifera*	0.3
Indian Grass *Sorghastrum nutans*	16.3	Maximilian Sunflower *Helianthus maximilianii*	0.3
Little Bluestem *Schizachyrium scoparium*	4.7	Partridge Pea *Chamaecrista fasciculata*	0.3
Side Oats Grama *Bouteloua curtipendula*	7.9	Black-eyed Susan *Rudbeckia hirta*	0.31
Blue Grama *Bouteloua hirsuta*	4.5	White Prairie Clover *Dalea candida*	0.42
Green Needle Grass *Stipa viridula*	9.0	Oxeye Sunflower *Heliopsis helianthoides*	0.42
Switch Grass *Panicum virgatum*	7.2	Purple Prairie Clover *Dalea purpurea*	0.25
Slender Wheatgrass *Agropyron trachycaulum*	9.0		
Virginia Wild Rye *Elymus canadensis*	9.0		
Total:	90.8		2.3

With the above mentioned mixes and hectarage, the plantings came down to an average of 11.4 kg./ha of grasses on 4.7 ha and 0.70 kg/ha. of forbs on 3.2 ha, as recommended by the local soil and water conservation district office that donated the seed. An evaluation analysis of the vegetation in the 5 restored plots was conducted after 90 days (August 2007). Random quarter meter quadrats were used to assess plant cover (n=10), along a west-east transect of each of the five restored plots. Our interest focused primarily on measuring diversity (species richness) and plant cover (percentage) within the sampled areas. Species richness was evaluated by considering the Margalef's index of diversity (diversity = s-1/log N), where s is the number of species and N is the total number of individuals (Longino *et al.,* 2002). Data collection occurred on August 25, 2007, when the plants had emerged from the soil (which had been disked prior to planting), and were already at a 'rosette' stage.

This allowed for an easy identification and measurement of the percent of plant cover in each sample quadrat.

Results

All five plots were uniformly covered by herbaceous vegetation and this included primarily unwanted weeds that infest corn crops. The mean percent cover in the grass plots was 0.935, whereas the one in the grass and forbs plots was 0.944. In the grass only samples we identified 2 prairie species, which occurred in 12 of the 30 samples (*S. scoparium* and *P. virgatum*). The mixed samples had a total of 4 prairie species in 11 of the 20 samples (*S. scoparium*, *P. virgatum* , *C. fasciculata*, *R. hirta*). A number of annual, early succession species were also found in all the samples. A count of the prairie plant species was accomplished in the 10 samples along each transect, for each plot. The mean number of prairie and non-prairie species and their respective Margalef's index are reported (Tab. 2). The Margalef's index of diversity may not be the best value to consider because it does not include the evenness of the individual plants distribution in the system. Despite its limitations however, the Margalef's Index provided a preliminary indication that diversity (species richness) in the grass and forbs plots was slightly higher than in the grass only plots (Table 2).

Tab. 2: Descriptive statistics and Margalef's Index of species richness for the grass and grass + forbs plots at Pork &Plants Farm in August 2007.

Sample number	Mean spp. # (grass plots)	Percent cover (grass plots)	Margalef's Index (grass plots)	Mean spp. # (grass & forbs)	Percent cover (grass & forbs)	Margalef's Index (grass & forbs)
1	1.0	0.92	0.5	6.0	0.96	5.0
2	2.0	0.95	0.5	4.0	0.95	1.5
3	2.0	0.95	1.0	5.0	0.92	2.5
4	3.0	0.94	1.0	6.0	0.92	2.5
5	3.0	0.98	1.0	4.0	0.96	1.5
6	4.0	0.96	1.5	7.0	0.94	3.5
7	3.0	0.90	1.0	3.0	0.94	1.5
8	3.0	0.93	0.5	4.0	0.94	1.5
9	4.0	0.91	1.5	4.0	0.95	3.5
10	1.0	0.91	0.5	7.0	0.96	3.5

A t-test with two independent samples complemented the computation of the diversity index and indicated that there was not a statistically significant difference in species diversity between the grass only and the grass and forbs plots ($t = (48) = 1.76$, $p>0.05$, two-tails).

Discussion and Conclusion

The restoration effort at Pork & Plants farm was limited in its first year as the vegetation may take a few more years (2-3) before it establishes a diverse community (Reichman 1987). The restoration technique (seed drilling) may be inexpensive and fast to accomplish but not as effective as transplanting seedlings that are capable of competing more aggressively against non prairie plants. This is evident in that non-prairie species covered most of the surface in all the sample quadrats indicating the challenge for the native seedlings to emerge when the soil might have had a conspicuous seed bank community of common agricultural weeds in place, before the restoration took place. However, more research is needed in order to discover what specific prairie establishment might produce a specific prairie type, e.g., mainly grasses versus mainly forbs. Our effort demonstrates a feasible approach to a reestablishment of ecological services in our bioregion that is sustainable and supportive of organic farming practices. The pellets produced from the prairie plots that were restored at Pork & Plants Farm will be used as biofuel to heat one of the farm greenhouses. A pelletizer is a needed equipment to mince the dry biomass, at the end of the growing season. Questions concerning with costs, social and environmental benefits, energy ratio and carbon footprint remain unanswered at the moment. However, we remain convinced that prairie restoration has potential to reshape the design of farms and restore a sustainable agrarian culture in our bioregion. To this end, there is a need to educate farmers, ranchers and land owners about these and similar opportunities. More importantly there is a need to inspire students and educate them (Borsari and Vidrine 2005) to remediate to the impacts of disturbance upon the environment, which is inexorably caused by human activities. Thus, synergizing prairie restoration with biofuel production may become a promising model for the future of agriculture in the Midwest region of the U.S. and supportive of a vision of sustainability in modern agroecosystems.

Acknowledgements

We are grateful to Eric Kreidermacher for setting aside land at his farm and to Darryl Buck and Timothy Terrill for their assistance with this project.

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Food safety and quality management

Effect of cultivar and soil characteristics on nutritional value in organic and conventional wheat

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Key words: micronutrients, soil organic matter, quality, organic wheat cultivars, soil pH

Abstract

Evidence of greater nutritional value in organic crops is currently a subject of intense debate. Our objectives in this study were to test for grain mineral concentration in 35 winter wheat cultivars in paired organic and conventional systems, and to determine the influence of cultivar, soil characteristics and farming system on mineral concentration. Here we report preliminary results that show that the grain mineral concentration in organic wheat was higher for copper (Cu), magnesium (Mg), manganese (Mn), phosphorus (P) and zinc (Zn) and lower in calcium (Ca), than the grain mineral concentration in conventional wheat. No difference was found between systems for iron (Fe) concentration. Cultivar was significant in determining mineral concentration for Ca, Cu, Mg, Mn and P. Soil mineral concentration was not responsible for grain mineral concentration, with the exception of P. The organic wheat farming systems had higher grain mineral concentrations of Cu, Mg, Mn, P and Zn than the conventional systems, possibly due in part to increased soil organic matter and pH in the organic systems. Growing specific cultivars capable of exploiting particular soil conditions may be necessary in order to optimize the nutritional value in organic farming systems.

Introduction

While global cereal grain yields have increased dramatically since the Green Revolution (Borlaug 1983), global food systems are not providing sufficient micronutrients to consumers (Welch 2002). Over 40% of the world's population is currently micronutrient deficient, resulting in numerous health problems, inflated economic costs borne by society, and learning disabilities for children (Sanchez and Swaminathan 2005). Though a diversification of diet to include micronutrient rich traditional foods is a preferred solution to these challenges, staple cereal grains are the primary dietary source of micronutrients for much of the world's population without access to varied food crops (Bouis 2003).

Genetic variation among wheat cultivars have been shown to be responsible for considerable differences in both mineral content and grain yield (Garvin et al. 2006, Murphy et al. in review). Cropping system can also have an impact on grain mineral

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concentration and yield among wheat cultivars (L-Baeckström et al. 2006; Murphy et al. 2007). We are conducting a study that compares the mineral nutrient concentration of calcium (Ca), copper (Cu), iron (Fe), magnesium (Mg), manganese (Mn), phosphorus, (P), and zinc (Zn) among 35 wheat cultivars grown in both organic and conventional systems. The objectives of this study are to compare the mineral concentration of wheat in organic and conventional systems and to estimate the variation in mineral content due to cultivar, soil characteristics and cropping system.

Materials and methods

Thirty-five soft white winter wheat cultivars were grown in side-by-side organic and conventional fields in Pullman, Washington (latitude 46º73'N, longitude 117º18'W) in the 2004-2005 and 2005-2006 growing seasons on a Palouse silt loam soil. Annual precipitation is approximately 500 mm/year. The organic and conventional fields were separated by buffer strips (7m minimum), though otherwise located in similar microclimatic conditions with comparable soil properties. Cultivars were grown in a randomized complete block design with four replicates. Samples were analyzed simultaneously for Ca, Cu, Fe, Mg, Mn, P, and Zn using Inductively Coupled Argon Plasma techniques. Four NIST (National Institute of Standards and Technology, Gaithersburg, MD, USA) durum wheat standards and four acid blanks were run with each batch of samples. Twenty soil samples from each field in each system were randomly collected to a depth of 18-cm and pooled for analysis. Soil organic matter, pH, and available Cu, Fe, Mg, P and Zn were determined by the University of Idaho soil lab (additional replicates of soil samples are currently being analyzed). This study was expanded to two locations in 2006-2007 and 2007-2008 (results not yet available) to strengthen the statistical power of the data and increase the geographical scope of the results to include a larger area of the wheat growing region of the Pacific Northwest (PNW) in the US.

The organic fields in Pullman have been certified organic since 2002. The two-year rotation in the organic systems was winter wheat/winter pea plowdown. The organic fields were fertilized with ~40 kg/ha of N from the winter pea plowdown and supplemented with certified organic PerfectBlend® fertilizer at the rate of 6 kg/ha each of N, P, and K, drilled with the seed at planting. This management practice was intended to reflect low-input, organic soft white winter wheat production in the PNW. The conventional fields were fertilized with 100, 23 and 17 kg/ha of nitrogen, phosphate and sulphur, respectively, and managed as a 2-year winter wheat/fallow rotation. Seed was treated with fungicide and insecticide before planting and weed control was accomplished with herbicide and hand weeding throughout the growing season in the conventional systems. All plots were harvested with a Hege plot combine with stainless steel sieves and cleaned with a Hege seed cleaner with stainless steel sieves.

Results

Grain grown in the organic system had significantly higher levels of Cu, Mg, Mn, P and Zn than grain grown in the conventional system. In an analysis of variance for each mineral, only P had a significant cultivar x system interaction. Grain Ca concentration was significantly higher in the conventional system than in the organic systems; no significant difference between systems was found for grain Fe concentration (Tab. 1). Cultivar was a highly significant source of variation for Ca and Mg ($P<0.001$) and Cu, Mn and P ($P<0.01$). There were no significant genotypic differences for Fe or Zn.

Tab. 1: Mean mineral concentration (mg/kg) between organic and conventional systems

System	*Ca*	*Cu*	*Fe*	*Mg*	*Mn*	*P*	*Zn*
Organic	339	2.78*	28.6	971*	45.1*	2845*	17.1*
Conventional	349*	2.40	29.2	929	43.6	2650	15.8

* significantly higher value (P<0.05)

Soil organic matter, pH, and available soil P and N (nitrate + nitrite) were greater in the organic systems. Available N (ammonia) Cu, Fe, Mn and Zn were greater in the conventional system (Tab. 2). Cation exchange capacity was similar in both systems.

Tab. 2: Soil characteristics between organic and conventional systems

System	Organic Matter	Cation Exchange Capacity	pH	N (Ammonia)	N (Nitrate + Nitrite)	Cu	Fe	Mn	P	Zn
	(%)	cmol(+)/kg					(ug/g)			
Organic	3.4	24	6.1	14	12	2	54	61	11	0.8
Conventional	2.4	23	5.2	32	9	2.4	81	81	6	1.7

Discussion

The organic grain had slight, though statistically significant, increases in the levels of Cu, Mn and Zn over the conventional grain, despite lower concentration of these minerals in the organic soil. Only P had greater concentration in both the grain and the soil. Concentrations of available Cu, Mn, Zn, and Fe in the soil were greater in the conventional system. Micronutrient availability in the soil has been shown to increase in more acidic soils (Fageria et al. 2002). The lower soil pH in the conventional fields may be due to the higher applications of inorganic N fertilizer and higher levels of available soil N in the form of ammonia.

How then does the lower soil micronutrient availability in organic soils translate into higher micronutrient concentration in organic grain? Organic matter has been shown to positively influence available soil micronutrients (Fageria et al. 2002; Wei et al. 2006) and the organic matter was 1.0% higher in the organic systems. Additionally, root colonization by mycorrhizal fungi can improve acquisition of Cu, Zn, Mn, and Fe (Marshner and Dell 1994), and has been found to be greater in organic as compared to conventional wheat cropping systems (Ryan et al. 2004). Both the increased organic matter and the potential for greater root colonization by mycorrhizal fungi may have played a role in the greater nutrient concentrations in grain from the organic system.

All cultivars used in this study were in the soft white market class. Soft white wheat represents the most important market class in the PNW and is typically used for products where high protein content is unnecessary, including steamed bread, cookies and sponge cakes. Within each system, cultivar was important in determining Ca, Cu, Mg, Mn and P concentrations. This suggests that certain cultivars may be optimally adapted to organic farming systems in a way that allows for higher grain mineral concentration. These cultivars are likely capable of exploiting the higher organic matter in the organic systems to achieve higher nutritional value.

Our previous results have shown that a biological trade-off between yield and mineral concentration likely does not exist (Murphy et al. in review). Our preliminary results from this study show several cultivars with both high yields and high concentrations of minerals, which suggests the potential for simultaneous selection of both grain yield and nutritional value.

Conclusions

Grain mineral concentration was higher in organic systems than conventional systems for Cu, Mg, Mn, P and Zn. Only Ca had a higher grain concentration in conventional systems than in organic systems. It is plausible that increased root colonization by the mycorrhizal fungi present in organic fields with higher percent organic matter may have resulted in enhanced uptake of soil nutrients and higher grain nutrient concentration. This hypothesis is currently being tested. Of further interest is the apparent ability of certain cultivars to achieve both high yields and increased nutritional value specifically within organic fields. Mechanisms for this evident adaptation to organic systems will be explored in greater detain in an expanded, multi-location, multi-year continuation of this trial.

Acknowledgments

We thank the Center for Sustaining Agriculture and Natural Resources at Washington State University, the Organic Farming Research Foundation and the United States Department of Agriculture's Integrated Organic Program (USDA-CSREES) for their generous support of this research. We especially thank Meg Gollnick, Kerry Balow and Steve Lyon for their invaluable assistance in this project.

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A multidisciplinary approach to improve the quality of organic wheat-bread chain

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Key words: organic wheat, flour, bread, nutritional quality, baking quality, taste, flavour

Abstract

The main challenge for organic farmers, millers and bakers is to fulfill consumers' expectations of providing healthy and safe products. The quality of organic grain can be modulated by agronomic modifications on genotypes, crop management, crop rotation and soil fertility, but the milling process and finally the baking process are also key factors in producing bread of high baking quality, nutritional value, taste and flavour. Nitrogen (N) is a key nutrient in achieving acceptable yield levels of sufficient bread-making quality, but previous results have shown that organic wheat tends to have lower protein content, dough mixing tolerance and loaf volume. The selection of genotypes with high N use efficiency, weed competitiveness and disease resistance allowed improving the agronomic performance. Besides protein content and protein composition, the baking performance of organic wheat bread also depended on flour starch damage, amylase activity, ash content and particle size distribution. The milling technique had a critical effect on both baking performance and nutritional value whereas the baking process may improve the bioavailability of minerals through acidification process (sourdough). Finally, this programme allowed to better characterize stakes and constraints of the whole organic wheat-flour-bread chain due to a multidisciplinary approach.

Introduction

Nowadays, the protein content is frequently used as the (unique) predicator of the bread making quality of organic wheat grain. Nonetheless, bread making quality is determined by several factors, namely wheat quality, flour properties and baking process. Previous results have shown that, compared to non-organic wheat, organic wheat has lower protein content, dough mixing tolerance and loaf volume (Gooding et al., 1993). Häglung et al. (1998) emphasised that flour with a protein content of less than 12g per 100g of grains required a longer mixing time for optimum dough development. Furthermore, they noticed that baking bread with an acceptable bread volume was difficult to obtain when flour protein content was lower than 8 g per 100g. As a consequence, artisan bakers adapt their baking processes to organically-grown flours with low protein content while others still request highly standardized flour with high protein content.

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The quality value of organic bread can also be expressed by nutritional value and sensory attributes (flavour and taste). Previous results have shown that nutritional value could be improved through the milling process (Chaurand et al., 2005). The nutritional value of whole-meal is generally considered higher to that of refined flour. Therefore, the sensory attributes depends on flour starch damage, amylase activity, ash content and particle size distribution (Kihlberg et al, 2004). Following recommendations of nutritionists, the future trend for the milling industry will be to produce flours richer in micronutrients and fibres.
This paper looks different ways to improve the baking quality, the nutritional value and the sensory attributes of organic bread through agronomical and food processing ways.

Materials and methods

A French national research programme on *Organic Wheat-Bread* was carried out in 2003-2007 to assess and to adapt crop management and processing methods to improve baking quality, nutritional value and sensory attributes of organic bread (Taupier-Letage et al., 2007). Different methodologies were set up in order (1) to evaluate the influence of crop management (genotype, fertilization management, others…) and environmental conditions on grain protein content and bread making quality, (2) to analyse the effect of the milling technique on the nutritional value and baking properties, (3) to improve the fermentation process of flour with yeast or surdough and, (4) finally, to optimise bread production recipes according to the consumers demand. Then, interviews and focus group provided new knowledge on stakes, requirements and constraints of the different actors (producers, collectors, millers, bakers and consumers) in the *organic wheat-flour-bread* chain.

Results and discussion

Consumer's preferences and attitudes

Sensory test had been realised from two focus groups with usual and occasional consumers (120 panellists in total). Four prototypes and two controls of organic bread differing from the type (French baguette *vs* unsliced bread) and from the milling yield (more or less refined) were tested to evaluate consumers attitudes and preferences. The preference of organic bread consumers is strongly explained by authenticity and healthy dimension in relation with ethical and ecological values of organic production. Usual consumers are stressed by safety and nutritional values linked with ecological principles guarantee by organic certification. Occasional consumers mentioned the need for better consumer information, especially on nutritional value, a better availability of organic bread, a strong authenticity but also a wider diversity. The major contraints for increasing consumption of organic bread are the high consumer price and the poor availability in the mass distribution.

The incidence of crop management on bread making quality

The relationship between grain protein content and baking test appears strongly determined by the genotype. Following the work of Goyer et al. (2005), a new criteria was defined to identify genotypes suitable for organic and low-input conditions as (1) weed competitiveness, (2) quality index with grain protein content and Zeleny reference and (3) yield performance obtained in low-input and organic conditions. Accordingly, a national network of experimental assays has been set up in France to develop a breeding programme for organic wheat. David et al (2005) mentioned that organic wheat yield and grain protein content (GPC) are strongly influenced by environmental and agronomic conditions. Grain filling of organic wheat varied according to water stress, temperature and soil compaction. Number of kernels was determined by N-deficiency and weed density. The weed density had a negative effect on kernel number leads to nitrogen concentration in grains, increasing GPC. Moreover our data demonstrated the incidence of the cropping system on yield and GPC performance. Arable systems with diversified crop rotation (including cereals, grain legumes and spring crops), regular N fertilization and weeding operations obtained higher results compared to mixed farming systems and extensive arable systems with low N fertilization and no weeding operations. This program provided a better understanding of the interactions of crop rotation, crop management and climatic conditions on yield and grain protein content performance.

The incidence of the milling technique

Flour obtained with stone milling exhibited a higher rate of starch damage compared to roller milling. This result is in accordance with those of Gélinas et al., (2006) who demonstrated that stones tightening reduced flour granulation, increased both starch damage and water absorption but did not change dough mixing stability of whole-meal flour. Conversely, the higher flexibility of the roller milling system allows separating all the parameters which can influence the nutritional value and the functional properties of flours, rate of starch damage, fiber and minerals content as well as the flour granulation. According to our results, at the same milling yield the baking performance of stone-milled flour was inferior to roller-milled flour. Indeed, stone milling is not as much efficient as roller milling to eliminate outer layers accurately. However this less efficiency results in a higher nutritional value for a given flour yield. According to these results, new milling diagrammes were developped to improve the baking quality of flour obtained with stone-milling and to improve the nutritionnal quality of flour originated from roller milling. All the resulting flours answer to the nutritionnal recommendations of the French national programme of health and nutrition (PNNS program).

Increasing fiber content in flour may result in a lower assimilation of minerals complexed by phytates. An optimisation of the fermentation step with surdough allowed to improve both the bioavailability of minerals as well as the sensory attributes of the resulted bread.

Stakes and constraints of the different actors in the wheat-bread chain

Finally, this programme allows us to characterise stakes and constraints of the whole cereal supply chain. Although the grain price is essentially determined by the grain protein content, collectors and millers noticed that the major obstacles for quality improvement are weevils and weeds contamination. Co-operation between organic cereal producers should be encouraged to allow better cleaning & storage, and bulking to create larger quantities for sale. Therefore, co-operation between producers, millers and distributors should be enhanced to fulfill consumer’s expectations through innovations and quality improvement.

Conclusions

This program allowed to gather a wide scientific and technical partnership. This multidisciplinary approach resulted in a significant headway in the field of the agronomy and the cereal processing:

- Protein content is not enough by itself to assess and guarantee the baking quality, it is more important to consider the interaction genotype-protein content to develop a grading system for wheat storage and to prepare milling batches. As a consequence, the cropping system appears as a key management tool.
- New milling diagrammes were developped to combine a high milling yield with good nutritional and sensory attributes either on roller milling and stone milling. In these conditions, the fermentation step must be adjusted to increase the micronutrient bioavailability.

Combining all these data leads to propose a range of nutritional and tasty breads well accepted by consumers. Further research should focus to support the following main points: (1) create a national field network to develop technical references and advices, (2) develop innovative methods to assess organic flour and bread and (3) support the development of the organic wheat-bread chain

Acknowledgment

The authors gratefully acknowledge funding from the French National Institute for Agricultural Research and the Technical institutes for Agricultural and Food industry. The results are based on the joint effort of the following research teams: Arvalis Institut du Végétal, AERIAL, ADIV, ENITIAA, INRA, ISARA Lyon and ITAB.

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Organic vs Conventional Suckling Lamb Production: Product Quality and Consumer Acceptance

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Key words: suckling lamb, physico-chemical composition, fatty acids, eating quality, consumer preference.

Abstract

Samples of suckling lambs (n=40) of two breeds reared under conventional and organic conditions were analysed to asses physico-chemical characteristics, including instrumental texture, and nutritional quality in terms of fatty acid composition. Consumer acceptance was also studied using the home-use test. Results revealed that organic suckling lamb meat is healthier as shown by the lower saturated fatty acid levels, the higher polyunsaturated fatty acid contents and the higher $\omega 6/\omega 3$ ratiko. The organic meat had lower instrumental hardness, received higher scores in all sensory parameters, and had statistically better fat sensation and higher ratings for overall liking. These results lend support to the notion among consumers that organic products are healthier and tastier.

Introduction

In recent decades world meat consumption has increased, but the economic, ecological and ethical sustainability of meat production is being questioned. However, organic meat production based on natural pastures, by-products and feed produced without artificial fertilisers and chemical pesticides might be more sustainable than conventional meat productions, because it can be produced on land where pasture and grass improve fertility, using by-products of vegetable crops or even wastes from the forest industry (Kum, 2002). It is true that production cost are usually higher in organic than conventional systems, and the higher meat price is the major reason given by consumers for not buying organic products (Angood et al., 2007). However, regular purchasers of organic foods believe they are healthier and taste better than conventional foods (Heaney, 2001).

Although there is a growing volume of literature comparing conventionally and organically produced meat, there have been few studies investigating the nutritional and eating quality of lamb (Nurnberg et al., 2006). Angood et al. (2007) found that organic lamb had better eating quality than conventional lamb in terms of juiciness, flavour, and overall appeal, thus providing some evidence for the perception among

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consumers that organic products “taste better”, but in suckling lamb there are no studies on this question. In the Mediterranean area, and more specifically in the “Castilla y León” region of Spain, fresh suckling lamb meat is a typical and traditional product, regarded by consumers as having high eating quality. Taking that into account, the aim of this work was to compare the two production systems for suckling lambs in terms of physico-chemical composition, including fatty acid composition, and sensory properties as perceived by consumers.

Materials and methods

The material included 40 suckling lambs, ten animals per production system (organic or conventional) and breed, of two Spanish sheep breeds, all from the same production area (Fariza, Zamora, Spain). Suckling lambs did not receive any kind of feed and were raised exclusively on maternal milk from birth to slaughter. The suckling lambs reared under organic conditions spent the day on pasture with their dams. The organic ewes’ diet (pasture of fresh oats) was supplemented (30% of the ration) with a certified organic mixture (17% oats, 13% barley, 10% sunflower seeds, 25% peas, 35% alfalfa forage). Suckling lambs reared under conventional conditions remained in a dry lot where their dams were fed with commercial concentrate (18% beetroot pulp, 26% alfalfa, 22% barley, 12% corn, 12% soy, 10% cotton). The animals were slaughtered at 11 kg ($\pm$0.5) live weight (20-25 days) in abattoirs licensed, inspected and certified by the Castilla y León Organic Agriculture Council (CAECYL). Carcasses were chilled under commercial conditions at 4ºC and 80% RH for 24 hours.

Meat pH was measured on fresh meat 24 h after slaughter in the muscle *Longissimus dorsi* by means of a pH-meter HI8314 (Hanna Instruments) equipped with a penetrating electrode. Intramuscular fat (ether-extractable), was determined according to standard AOAC (1990) procedures. Water-holding capacity (WHC), expressed as the proportion of expressible juice was measured as described by Pla (2000). Lipids were extracted from meat using a standard chloroform/methanol procedure. Fatty acid composition of lipids was methylated and analysed by gas chromatography according to the method described by Revilla et al. (2005). Fatty acids were expressed as a fraction of total weight. Analyses were performed in triplicate. For instrumental texture analysis *L. dorsi* (9^{th}-12^{th} rib level) were grilled on a pre-heated double hot plate grill at 200ºC until the internal temperature reached 70ºC. The internal temperature was measured using a digital thermometer Checktemp1 (Hanna Instruments). Six rectangular parallelepipeds, 1x1 cm across and 2-3 cm long, were then cut parallel to the muscle fibres. A TX-T2i*plus* (Stable Micro Systems) equipped with Warner-Bratzler probe was used. The crosshead speed was 1 mm/s and maximum peak force was recorded.

The sensory analysis was carried out using a home-use test (Lawless & Haymann, 1998) involving 35 families (4 to 5 members) from the province of Zamora. Three-day mature half carcasses were delivered to each family with the instructions that the samples should be prepared by roasting at 175ºC for two hours, with only salt added. Consumers were asked to taste the samples in a quiet setting, with no consumption of alcohol. Assessment characteristics of meat were collected from individual questionnaires delivered to each consumer. A 9-point hedonic scale, in which 1 corresponded to “I don’t like it at all” and 9 corresponded to “I like it a lot” was used to measure the global relative preferences for the colour, taste, aroma, hardness, juiciness, fat sensation and overall appreciation.

Data of each variable were analysed by one-way analysis of variance (ANOVA). The statistical significance of a factor was calculated at the α=0.05 level using the *F*-test. In tables and figures, different letters ([a,b]) mean statistically significant differences.

Results and discussion

The results showed no statistically significant differences between conventional and organic meat for pH, intramuscular fat, or water holding capacity (Table 1). This is in agreement with results previously reported for Churra and Castellana suckling lambs. The organic meat has lower Warner-Bratzler Shear Force (WBSF), indicating the higher tenderness of this meat. Organic production implies more mobility, and it may produce greater muscle volume and greater tenderness because of the higher ratio of myofibrillar protein to total collagen (Aalhus et al., 1991).

Statistically significant differences were observed between production system for fatty acid composition. The organic meat showed lower values for the sum of saturated fatty acids (SFA), and higher values for the sum of mono and polyunsaturated acids (PUFA); the differences were significant for SFA and PUFA. The ratio polyunsaturated/saturated acids (P/S), which was relatively low for both meat types (ideally >0.4), did not show statistical differences, although it was higher for the organic meat. Finally, the ratio ω6/ω3 was lower than 5 (maximum recommended value) for both conventional and organic meat, and significantly lower for organic meat. These results indicate that the intramuscular fat from organic meat was healthier. In lambs reared on pasture, as with organic ewes, the percentage of PUFA, especially of the n-3 series, increased compared with lambs fed the concentrate diet. There is a correlation between fatty acid composition of suckling lambs and the ewes' diet, so that the intramuscular fat of suckling lambs also had higher levels of these compounds.

Tab. 1: Mean and (SD) of meat quality characteristics and fatty acid composition

	Conventional	Organic	p-value
pH	5.6 (0.2)a	5.6 (0.1)a	0.661
Intramuscular fat %	5.8 (2.5)a	6.5 (2.2)a	0.582
WHC %	15.8 (2.7)a	15.3 (1.7)a	0.325
WBSF (k)	2.02 (0.61)b	1.65 (0.48)a	0.000
Saturated fatty acids	68.54 (6.12)b	63.53 (6.93) a	0.001
Monounsaturated fatty acids	23.97 (5.47)a	25.96 (3.69)a	0.060
Polyunsaturated fatty acids	7.48 (2.27)a	9.25 (2.91)b	0.003
P/S	0.11 (0.04)a	0.15 (0.05)b	0.000
ω6/ω3	3.35 (0.92)b	3.47 (1.62)a	0.709

Regarding consumer appreciation, organic meat showed higher values for all the evaluated parameters, and the differences were statistically significant for fat sensation due to the higher unsaturation of the fat. As the fat unsaturation increases, the melting point decreases, improving the mouthfeel of the product. The hardness of organic meat received higher scores by consumers, although the difference was not statistically significant. Spanish consumers prefer pale, tender and less intense lamb flavor. The results for hardness indicated that consumers found this meat tenderer, which correlated with the lower WBSF of this meat. Finally, the scores for overall appreciation were significantly higher for organic meat.

Conclusions

Organic meat is healthier as showed by the lower saturated fatty acid levels, the higher polyunsaturated fatty acid contents and the higher ω6/ω3 ratio. Indeed, it had lower instrumental hardness, received higher scores in all sensory parameters and had statistically better fat sensation and had higher ratings for overall appreciation. These results lend support for the notion among consumers that organic products are healthier and tastier.

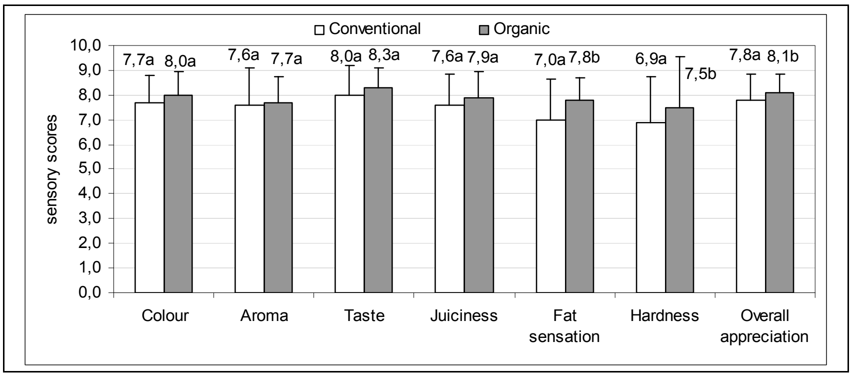

Figure 1: Sensory scores for the parameters evaluated by consumers

Acknowledgments

Authors are grateful to Junta de Castilla y León and to Caja Rural for financial support.

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Animal welfare and food safety: danger, risk and the distribution of responsibility

Kijlstra, A.[1] & Bos, A.P.

Key words: animal welfare, food safety, dioxins, paratuberculosis, toxoplasma

Abstract

Increased animal welfare may pose risks for public health, such as increased bacterial, viral or parasitic infections or an increased level of environmental contaminants in the food product. Examples include Campylobacter in organic boilers, Toxoplasma in pigs and poultry meat and Mycobacterium paratuberculosis in milk. Concerning environmental contaminants it is known that free-foraging laying hens will produce eggs that contain higher dioxin levels than hens kept in cages. Furthermore, outdoor chickens are considered to play an important role in the case of Avian flu outbreaks. This review indicates that it is possible to tackle each of the issues mentioned. Risk management is not only a responsibility of the government, but also should be divided amongst the participants in the food chain, including the consumer. To this end it is important that transparency about risks be maintained and optimal communication employed.

Introduction

Animal friendly production systems may create new or reintroduce old risks in relation to public health. There is a great deal of differentiation between the possible adverse public health aspects that have been described with animal friendly production systems, of which some are related to food safety of the product and others to direct transfer of microbial agents between farm animals and humans. Some of the risks are due to poorly designed systems and therefore can be prevented, whereas others reflect a fundamental conflict between an attitude of zero tolerance towards public health risks and the wish to keep animals under natural and high welfare conditions that are inherently less controllable from a hygienic point of view. Other risks arise because the environment is no longer "natural", for instance due to historic pollution (dioxins).

To date, food safety issues associated with organic farming have been considered as a delicate issue and little attention has been paid to methods dealing with such dilemmas. In this paper we intend to highlight possible solutions and will illustrate this with recently described examples.

Materials and methods

We identified food safety issues related to organic animal farming by assessing a number of databases. The Web of Science was assessed using the key words "organic", "animal friendly" and "food safety", using the advanced search option. Papers related to animal husbandry were selected and specific food safety issues

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were isolated. Subsequently repositories such as “Organic Eprints” or the “EFSA Journal” were studied for further papers related to the identified food safety issues.

Food safety issues were tabulated and type and source of risks were described. A proposed responsibility towards management of risks in the food chain were assigned to various players in the food chain.

Results

Tab. 1: Public health concerns associated with animal friendly production systems

Type	Animal Husbandry	Source	Risk Management
Campylobacter	Poultry, pigs	Outdoor run, contact with wild fauna	Monitoring, decontamination, consumer education
Avian influenza	Poultry	Contact with wild birds, humans (farm hygiene)	Monitoring, temporary indoor keeping, vaccination
Toxoplasma	Pigs, poultry	Outdoor run, farm cats, rodents	Monitoring, farm management, post harvest decontamination, consumer education
Mycobacterium paratuberculosis	Dairy cattle	Faeces infected cows, pasture	Monitoring, farm management
Dioxins	Poultry (eggs)	Polluted outdoor run	Monitoring, farm management

The literature search revealed several issues where concerns were expressed regarding public health. Food safety in relation to animal welfare has not yet received much attention in the peer reviewed literature, and for each subject often no more than a few references were found. Examples of concerns that were identified are shown in table 1. Concerns associated with *Trichinella*, *Salmonella* and *Yersinia*, for instance, were not included in the table. The types of dangers, source and management are depicted in the table and will be shortly described in the following paragraphs.

Providing chickens outdoor access may increase the risk of poultry becoming infected with *Campylobacter* because of contact with wild fauna, an infected stable or outdoor run. Once a *Campylobacter* infection has been established on a farm it is very difficult to eradicate it because of the nature of the environment, i.e. the outdoor run cannot be cleaned. Engvall (2001) showed that almost 100% of the organically farmed flocks in Sweden might be infected with Campylobacter, compared with only 10% of the conventionally reared flocks. Danish and Dutch studies confirmed these findings

(Heuer et al., 2001; Rodenburg et al., 2004). It should be noted that Campylobacter is not a direct health problem for chickens. Campylobacteriosis in humans is considered a serious food-borne disease and in past decades many actions have been taken to reduce *Campylobacter* in poultry production systems. Organic (broiler) chickens should be monitored at slaughter so that farmers can investigate whether intervention programs are able to decrease the infection rate. Postharvest decontamination (freezing, high pressure) of meat can be performed between slaughter and retail stages in the food chain. Consumers should be educated to properly cook their meat and maintain proper kitchen hygiene.

Avian influenza, especially the H5N1 type, is considered to be an important pathogen for humans. Mutations of the virus may cause a worldwide influenza epidemic. Migratory birds are thought to play a role in the transfer of disease to farmed poultry. Poultry that are partially housed outside are considered to be at high risk for contracting infection from infected migratory birds. Poor hygiene management on animal friendly farms may also play a role in transfer of viral infection. Regular on-farm monitoring, temporarily keeping chickens inside, and vaccination are possible measures to control avian flu.

Toxoplasmosis is a disease caused by the protozoan parasite *Toxoplasma gondii*. A primary infection with *T. gondii* during pregnancy can lead to serious and sometimes fatal disease of the fetus or newborn. Individuals with latent infection may develop chronic ocular toxoplasmosis leading to visual impairment. Undercooked meat has been considered the main source of infection. The great changes in animal production hygiene have resulted in a significant decrease of the rate of Toxoplasma infection of pork meat. However, the introduction of animal friendly production systems may lead to a reemergence of Toxoplasma infections in pigs (Kijlstra et al. 2004) and poultry. Monitoring of farms and adjustment of farm management can play an important role in the control of Toxoplasma infections. Farms with a known positive Toxoplasma status should have their meat decontaminated, e.g. by freezing. Consumers should be educated to properly cook their meat and prevent cross contamination during meat handling in the kitchen.

Mycobacterium avium subsp. *paratuberculosis* (MAP) is the cause of a severe incurable gastroenteritis in ruminants, also known as Johne`s disease. The mycobacterium responsible for paratuberculosis in ruminants has long been suspected to have a role in chronic inflammatory bowel disease in humans, especially Crohn`s disease. Transfer to humans is thought to occur via milk products, since the bacterium is resistant to pasteurization. Although the paratuberculosis situation in Dutch organic herds does not seem to differ from that found in conventional herds (Kijlstra 2005), it is mandatory to keep monitoring the prevalence so that measures can be taken if the seroprevalence starts to rise again. Consumers can do little about prevention of contact with the bacterium and therefore the responsibility lies with the farmers, milk factories, and government.

Dioxins are considered the most toxic substances in the human food chain. Exposure to dioxins occurs via the ingestion of animal products, including eggs. For dioxins in eggs a maximum limit has been set. It is forbidden to sell eggs when their dioxin level exceeds 3 pg TEQ/g egg fat. The dioxin content of eggs from free-foraging chickens is much higher than that observed in chickens kept in wire cages (Kijlstra et al. 2007). It is assumed that uptake of soil, insects and worms leads to bioaccumulation of dioxins in egg fat. A monitoring program in combination with farm management can prevent eggs with increased dioxin levels from entering the market. Responsibility lies with producers, egg packaging stations, and retailers to insist that only eggs participating in such control programs enter the market. Consumers should be aware of these quality assurance programs.

Discussion

In the transition to improved animal welfare systems it is necessary not only to make a good inventory of possible risks and to communicate them well, but also to differentiate them concerning responsibility. Some risks are inherent to the choice of keeping animals in a more natural environment and could be judged as an inherent responsibility of the consumer, whereas others may need a further refinement or adjustment of the housing or farm management system used.

Governments with an ambition to develop a transition to animal friendly farming systems should be aware of the fact that veterinary dogmas and zero risk tolerance for public health are implemented as a norm without any further differentiation. In this view, public health should not be seen as an exclusive responsibility of the government.

In the dilemma between animal welfare and food safety we should not simply deal with communication of food safety aspects to the consumer, but also should try to provide the relevant background of types and sources of the risks and relate them to the distribution of responsibility among the various players in the field.

Conclusions

Organic animal farming is associated with a number of concerns in relation to public health and food safety.

Responsibility with regard to food risk management depends on the type of danger and should be divided amongst the players in the food chain.

The ability to accept responsibility for the prevention of food-borne disease is important and communication of risks should be optimized.

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Biodiversity assessment and management

Impact of Organic Crop and Livestock Systems on Earthworm Population Dynamics

Kotcon, J.B.[1]

Key words: Long-Term Experiments, Farming systems, soil biodiversity, rotations.

Abstract

Earthworm population dynamics and diversity were evaluated in long-term farming systems experiments at the West Virginia University Organic Research Farm from 2000-2007. Farming systems included vegetable and field crop rotations, with versus without annual compost amendments. Field crop rotations with livestock included three years of clover-grassland. Earthworms were monitored by hand-sorting soil samples. Aporrectodea caliginosa and Lumbricus rubellus were the most common species observed. Cultivation adversely affected earthworm populations in all systems, while compost amendments either had no effect or increased earthworm populations. The population structure shifted toward younger age classes and lower biomass. Inclusion of clover-grassland in the rotation for pasture and hay production for sheep had no significant effects on populations in the field crop systems.

Introduction

Earthworms are generally considered to be important indicators of soil quality and provide well-known benefits through cycling of organic matter and improving soil porosity and aeration (Edwards, 1998). Earthworms are also known to be sensitive to synthetic pesticides, thus transition from conventional to organic practices is believed to enhance earthworm activity in soil. The West Virginia University Organic Research Farm project was initiated in 1999 as a long-term evaluation of organic farming systems. Prior to this time, the Farm had been in conventional horticultural production, primarily tree fruits and vegetables. Soils are silt-loam and slopes range from 0-24 %, typical of Appalachian hill top farms. The initial three years of the project involved a transition from conventional to organic management, with organic certification granted in 2003. Since that time, farming practices in this trial adhere to USDA organic certification requirements. The project was designed to evaluate the impact of several organic farming systems on crop and livestock productivity, soil quality, populations of pests and beneficial organisms, and farm profitability. This paper reports on the changes in earthworm populations in these farming systems.

Materials and methods

Two replicated farming systems experiments, market garden and field crop/livestock, were conducted. Each compared two treatments for managing soil quality during the transition from conventional to organic practices: a low input transition using cover crops only, and a high input treatment using off-farm compost amendments with cover crops. The field crop system also included two additional treatments, with- and

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without-livestock, arranged in a factorial design with the two transition (high vs low input) treatments. Prior to initiation of the experiment, all plots had been managed as permanent grassland or as a conventional apple orchard.

Low Input Treatment. Plots were cover cropped intensively beginning in Fall 1999 and throughout the 2000 growing season. Rye, sown in fall, 1999, was followed by clover in spring, 2000 and by rye and vetches in the fall of 2000. All cover crops were plowed in as green manure. This treatment was used to build soil quality and yielded no saleable product in 2000. Market garden plots were cropped, starting in 2001, with a 4-year rotation sequence of legumes, leafy vegetables (spinach and lettuce), solanaceous crops and cucurbits. Field crop plots in the without-livestock systems were cropped to wheat, potato, forage soybean, or Brussels sprouts. A rye-vetch winter cover was planted each year on all plots, except those with an established overwintering crop. Beginning in 2003, forage rape was substituted for brussels sprouts, and a summer cover crop of cowpea was inserted in the rotation. Field crop plots in the with-livestock systems followed a seven-year rotation, with cultivated crops for four years, followed by three years with orchard grass-red clover.

High Input Treatment. Following the rye cover crop planted in Fall 1999, plots were amended with a dairy manure compost at 10 T/acre in the spring of 2000. Crops in the field crop and market garden plots were the same rotation as for the Low Input system. Thus, the High Input treatment used off-farm compost to improve soil quality and produced saleable crops in the first year of transition. Compost was applied at 10 T.acre each year to High Input plots in the Market Garden and through 2003 in the Field Crop plots. Beginning in 2004, compost was applied at 20 T/acre in the potato and wheat crops, with no compost applied in the high input soybean, cowpea, or forage rape crops. The market garden had four replications of the two treatments and four crop families in all combinations (32 plots total). The field crop system had three replications of the low and high input systems with and without livestock, in all combinations (66 plots total). Sheep grazed the plots, with stocking density assigned at a level to minimize purchases of off-farm feed. Soil samples were collected to monitor soil earthworm fauna. Three soil cores (10-cm-diam by 15-cm-deep) were collected from each plot and eahrthworms were collected in the field by hand sorting. Worms were placed in vials on ice and returned to the lab where they were sorted by species and age class, and then oven-dried at 45 C to determine biomass. Worm fragments were counted as one-half of a worm, and fragments without an identifiable head were designated as unknown species. Worm populations were monitored in the Market Garden systems in spring of each year from 2000 through 2007 (except 2005), generally before the first tillage operations. Field crop systems and summer and fall populations in the Market Garden were also monitored through 2004.

Results

The dominant species in both field crop and market garden plots was *Aporrectodea caliginosa*, with *Lumbricus rubellus* also occurring frequently. *L. terrestris* was rare, and largely disappeared from the plots after a few years of cultivation. Although population densities increased during 2006 and 2007, the proportion of adults declined from 57 % of identified individuals in 2001, to only 26 % by 2007. Population density was significantly greater in market garden plots with high compost inputs on 6 of the 15 sample dates (Figures 1A and 1B). Similar trends in field crop plots were observed, but differences were statistically significant only for biomass at one date (Fig. 1 C and 1 D).

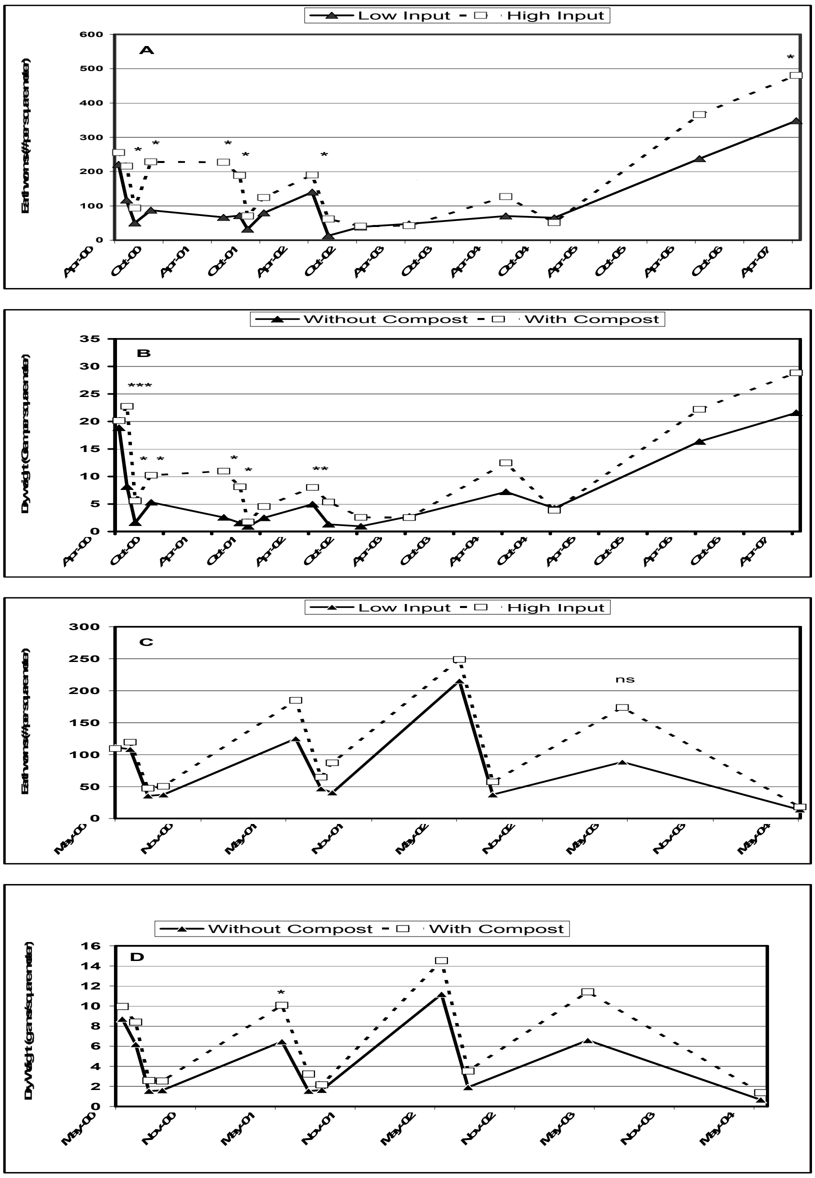

Figure 1: Earthworm population density (A) and biomass (B) in vegetable market garden systems and in Field Crop Systems (C and D) amended with 10 Tons Dairy manure compost per acre (High Input) or unamended (Low Input).

Discussion

Earthworm populations respond to agroecosystem management practices. Adverse effects of tillage on earthworm populations are well known (Edwards and Lofty, 1982; Rovira, et al. 1987). Anecic species such as *L. terrestris* are particularly sensitive, and largely disappeared from plots in this study after continuous cultivation began. The population age structure of the less sensitive species in our plots was also affected, as the majority of individuals collected in 2000 and 2001 were adults, but the populations became increasingly dominated by juveniles, with adults constituting only 26 % of the population by 2007. The declines observed in mid-summer may have been a direct result of spring tillage operations, or simply a sampling artefact due to earthworms moving during hot dry weather to soil layers deeper than the depth of our samples.

Other studies show that addition of organic substrates that serve as food sources can stimulate earthworm populations (Curry, 1976). In our study, population density and biomass were consistently greater in both field crop and market garden plots receiving dairy manure compost than in plots without compost, although differences were not always statistically significant. The host crop planted rarely had a significant or consistent effect, although there was a trend toward higher populations in market garden plots with tomato and pepper, and in field crop plots planted to orchard grass-red clover grasslands. The higher earthworm populations in tomato and pepper plots may have been due to the use of hay mulch for weed suppression, rather than a specific effect of these crops.

Few studies have examined the effects of livestock on earthworms. Hutchinson and King (1980) indicated that earthworm populations were greatest when the stocking rate of sheep was kept at levels associated with maximum productivity, however few other studies have found comparable effects. While the absence of cultivation may tend to promote earthworm populations, trampling has been shown to adversely affect earthworms living near the soil surface. In our plots, sheep grazed only for short periods, and no effects were discernible.

Acknowledgments

This research was supported by funding from the USDA-SARE and NRI programs, and by the West Virginia University Agricultural and Forestry Experiment Station.

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Eco-Regions: How to link organic farming with territorial development

Schermer, M.[1] & Kirchengast, Ch.[2]

Key words: Eco-Region, territorial development

Abstract

Organic farming in Austria has seen a rapid development as all over Europe. In some alpine regions over 50% of the farms have converted to organic. Thus the idea of forming "Eco-Regions" ("Bioregionen" in German), transforming organic farming values from a farm level to a regional scale, emerged. The paper presents the results of an action research based project to develop a model for the formation of Eco-Regions and to monitor the success in cross-sectoral networking. Besides a number of prerequisites also bottlenecks for the formation become apparent. The paper describes the model and the implementation in two distinct regions.

Introduction

Organic farming in Austria has seen a rapid development as all over Europe. According to official data in 2006 13,4% of the agricultural area of Austria have been farmed organically by 11,6% of all farms (BMLFUW 2007). Some regions however, most of them in the alpine area have reached significantly higher percentages up to over 50%. These high percentages provoked the idea of transforming organic farming from a farm level to a regional scale This is the basic meaning of "Eco-Region" ("Bioregion" in German), a concept which has entered the rural development debate since 2001 (Schermer & Kratochvil 2003). Thus the notion of "Eco-Region" in the Austrian context constitutes a sustainable territorial development approach based on local organic farming practices and products as ideational anchor points and on an active participation of organic farmers in such processes. This understanding of Eco-regions complies with the current shift from sectoral to territorial development policies. The CAP views rural spaces increasingly from a territorial perspective as opposed to the traditional sectoral view on rural development. It thus allocates partly funds under the measurements of the "second pillar" activities for integrated rural development, not only connected to agriculture. Organic farming is supposed to contribute to rural development more than other forms of farming, in particular due to the close ties between producers and consumers. The concept, building on the theory of neo-endogenous development (Ray 1998), provides benefits for organic farmers as well as for the region. For the organic sector the concept provides a possibility to reconnect production to a given territory and to focus on regional value chains as counterstrategy to the "conventionalisation trap" (Kratochvil & Leitner 2005) which is progressing with the increasing demand for organic products by consumers and the globalisation of trade relations. For rural development the concept provides the possibility to sharpen the notion of sustainability by providing a concrete example (Schermer, 2006).

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This contribution looks into the processes of formation, the preconditions and steps to link organic agriculture successfully with territorial development.

Material and Methods

As in the recent past a number of Austrian regions started to declare themselves Eco-Regions, the concerned stakeholders called for a systematisation and codification of the approach in order to prevent free riders. A participatory action research approach was chosen as the methodological project for a research and implantation oriented project. Action research builds on a cyclical process in four stages: planning, implementation, monitoring and evaluation and finally reflection to adjust planning (Zuber Skerrit, 2002).

The national funded project on Eco-Regions as a model for sustainable development was commissioned by the federal ministry of agriculture and implemented between beginning of 2004 and November 2007. During the first phase (2004 until March 2007) at least four participative workshops were held in each of four regions. The participants came from various stakeholder groups involved in Eco Region initiatives in different geographical areas and stages of Eco-Region development. These workshops aimed at reflecting on the concept in order to define a basic set of criteria for developing a general model. The participants furthermore designed concrete activities linking different actors in the region (tourism, commerce, culture etc.). The number and type of actors varied according to regional circumstances. The monitoring of the implementation of the designed activities, carried out in the frame of bi-monthly meetings, contributed to a general understanding of various difficulties rural actors may have in promoting territorial development. It also helped to derive guidelines for the sequence of stakeholder involvement and for the establishment of a coherent vision for regional development including concrete activities for implementation.

In the second phase (April to November 2007) concrete concepts were developed on the basis of the results of phase one in two of the four initial regions. The activities foreseen in these concepts will be implemented within the frame of the new LEADER program.

Results

The model, which was elaborated during the first project-phase, shows that Eco-Regions are conceptualised as an ongoing process rather than a fixed status. Therefore most of the criteria proposed are procedural. Minimum criteria as prerequisites include a clear delineation of the region, a percentage of organic farms above the national average and the setting up of a regional organisational structure for organic farming. The main instrument is the elaboration of a comprehensive development concept with concrete measures according to fixed obligatory development domains. These include measures on the further development of organic organisation, regional processing and marketing, cooperation with other sectors (gastronomy, tourism and commerce), internal and external communication, renewable energy, nature and cultural landscape. In addition to these compulsory topics the region is free to select further optional topics according to regional relevance.

The Eco-Region model postulates that the starting point is the local organic agriculture and their products. Different stakeholder groups (most often but not always organic farmers) start the process with an assessment on the potential fulfilment of the basic requirements. Preferably the elaboration of the Eco-Region concept goes in parallel with networking activities. First local organic farmers form a group, in a second stage this group networks along the supply chain and in the third stage with other territorial partners. This model is an ideal situation, which in the second phase was applied to two regions, where detailed development concepts were elaborated in a participatory process. These two regions differ largely according to the basic criteria, although in both cases the percentage of organic farmers is above the national average. The two regions also display different possible situations and paths in Eco-Region development:

The first region, the "Bio-Heu-Region Trumer Seenland" is organised by an organic cooperative with roughly 180 members. The delineation of the region follows cultural practices (silage free, hay based dairy farming, which was a base of the local dairy industry) and geographical boundaries provided by the watershed of a series of lakes. However, administratively the region touches two provinces (Salzburg and Upper Austria). The overlap with different administrative regions makes it difficult to link up with regional development organisations as for instance there are three LEADER regions involved. The proponents of the Bio-Heu-Region are very active in promoting the region, by e.g. electing a "hay queen" as a representative and organising all kinds of activities. However, links to other sectors remain rather weak, besides building up supply chains for niche products (like spelt) they have punctual co-operations with a cultural centre and local tourism offices, but so far they failed to involve the local dairy industry which is the backbone of agriculture. On the contrary the conventional dairies operate with the designation "region of delicacy – hay-milk cheese" declared by the federal ministry of agriculture.

The second region, the "Bioregion Murau", comprises one distinct district with clear administrative, geographical and culture-historical boundaries. Other than in the first case the initial idea of installing an Eco-Region was not primarily developed by organic and/or agricultural actors, but rather by local entrepreneurs. A core group, consisting of a baker, a plumbing entrepreneur, an organic farmer and a local rural development advisor, who is also a (conventional) farmer, proposed the Eco-Region concept. They formed a platform installing working groups in different sections (energy, agriculture, tourism and commerce). The organisational structure however is not very well developed. The local organic farmers are barely organised in a group, which makes it easy for market actors to appropriate the image of the Eco-Region for their ends. This happened when a big discounter, which is the major customer of the regional milk processing plant, launched a new strictly conventional brand, which plays with the natural image of the region and promotes the silage free traditional production methods. Most organic farmers go along with this as long as the milk price is increased.

Discussion

The most stunning result is that (so far) both Eco Regions, in spite of high percentages of organic farmers, did not defend their concept successfully against the conventional farming sector. The reasons are different in the two regions.

In the Bio-Heu-Region the distinction between the Eco-Region and the (conventional) hay-milk region is blurred in public although the president of the hay-milk region is an organic farmer himself and a member of the Bio-Heu-Region. Apparently, the organic farmers feel too weak to force the dairies, which operate both, conventional and organic processing lines, to market their cheese better and to pay a higher price to organic farmers. They started a number of activities which were raising the profile of the Eco-Region, but they are lacking strategic planning in order to take the lead in territorial development. It is probably asked too much from farmers to act as regional development agents, but without strategic planning to secure a larger part of the added value, the regional networking remains weak. The elaboration of an Eco-Region concept can be seen as a first step in the right direction.

In the Bioregion Murau the main focus of the proponents is on enhancing the regional added value. This aim can be achieved in various ways, the Eco-Region being only one of them. The new brand finds widely support, although it is a conventional brand. Organic farmers are not organised in a strong group and cannot defend their case against conventional farmers, who are particularly happy to participate in the new program as they could not in the frame of the Eco-Region. The underlying problem is that contrary to the sequence proposed in the model the actors in Murau started with regional networking before the organic farmers were organised.

Conclusions

Eco-Regions provide a frame which could allow organic stakeholders to play a key role for territorial development. The current experiences however show that their success has been limited so far, due to different reasons. In Murau one of the very prerequisites was and is missing: the formation of a group of organic farmers. Hence, the idea is weakly defended against usurpation by other actors. In the Bio-Heu-Region all prerequisites had been achieved, but strategic planning skills to build successful trans-sectoral cooperations is lacking.

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Effects of landscape agricultural intensification and management on weed species richness in the edges of dryland cereal fields.

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Key words: Landscape agricultural intensification, weed diversity, crop edges, dryland cereals.

Abstract

An extensive survey of weed vegetation was conducted in the crop edges of 180 organic and conventional dryland cereal fields in nine localities of NE Iberian Peninsula to assess the effect of landscape agricultural intensification and management on weed diversity.

This preliminary results show that averaged weed species richness per edge (alpha-diversity) and floristic homogeneity among edges are higher in organic than conventional fields. Only in conventionally managed fields, elevated landscape intensification is associated to higher weed alpha-diversities and floristic homogeneity among crop edges.

The expression of high-quality weed flora is higher in organic than in conventional crop edges but, conversely, it is only sensitive to landscape intensification in organic fields, being clearly favoured in low-intensified landscapes.

Introduction

Organic farming enhances weed diversity and abundance in dryland cereal fields (Hole et al., 2005) and facilitates the settling of characteristic segetal weeds –i.e. weed species which thrive almost exclusively in cereal fields. Within each management type (organic or conventional), the observed variability in weed diversity patterns among different cereal areas may be due to different farming intensity levels but also to landscape features such as agricultural intensification.

Several authors have studied the effect of landscape agricultural intensification on weed diversity of dryland cereal fields (Roschewitz et al., 2005). Landscape agricultural intensification, easily measured by the percentage of arable land, has been shown to be negatively correlated to other landscape features such as diversity, density of edges among patches or fragmentation of arable habitat. These features may differentially affect some aspects of weed populations' dynamics such as dispersion or survival through the distribution of safe-sites and connected patches, and consequently, may be related to diversity patterns at alpha, beta and gamma levels.

The aim of this work is to test the hypothesis that landscape complexity may modulate the effect of management system on weed species richness. To achieve it, an extensive weed survey was carried out in the field edges of 180 conventional and

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organic fields, in nine cereal localities of central Catalonia (NE Iberian Peninsula). As crop edges allow for a higher expression of weed diversity and are less dependent on management intensity than inner fields, they were considered especially appropriate to register landscape effects over farming intensity effects.

Materials and methods

In each locality a circular area of 12.57 km^2 was delimited. The nine studied localities shared brown lime soils and a Mediterranean climate. Between six and eight organically managed dryland cereal fields and between 12 and 14 conventionally managed ones were surveyed in each locality. Selection of fields was carried out *a priori* on orthophotographs and later in the field, those which were not sown with wheat or barley, or showed extreme values for aspect or size were discarded. In June of 2005, the weed vegetation of each field was surveyed in a rectangular sample of 20 x 5 m^2 set in the crop edge, half a meter inside the field from the cultivation limit and with the longest side of the rectangle parallel to the field margin. Each species in the sample was identified and its cover estimated by means of an ordinal scale which ranged from 1 to 5.

For each locality and management type, the averaged value of weed species richness per field (S_{α}) and the accumulated weed species richness across all the surveyed fields (S_{γ}) were obtained. The homogeneity of weed species distribution across the fields was computed as the ratio of the alpha to the gamma value, corrected for the different number of surveyed fields (Jost, 2006). Characteristic segetal species richness for each locality and management type was computed through the pooling of six fields (the minimum number of fields surveyed in a locality and a management type). Then, the pooling was randomly repeated until 1000 resamples were achieved and the average value was calculated.

Landscape agricultural intensification in each locality was estimated by the percentage of arable land in the 12.57 km^2 area, obtained from official habitat maps (Generalitat de Catalunya, 2005) worked at 1:25.000. This value showed highly significant correlations with landscape physiognomic diversity (r = -0.93, P< 0.001), density of edges among arable land and natural habitats (r = -0.78, P< 0.01) and arable habitat fragmentation (r = +0.77, P< 0.01).

To test the effect of landscape and management type on the aforementioned weed diversity descriptors, weighted lineal models were designed. For each combination of landscape intensification and management, the weight was proportional to the number of fields surveyed and the inverse of the variance of each weed diversity descriptor. Differences between management types were tested with paired t-tests. One locality was considered outlier for organic management and removed from analysis. Statistical analyses were carried out using R (R Development Core Team, 2006).

Results

Crop edges of organic fields sustained higher averaged weed species richness than conventional ones, and a marginal lineal positive relation with the ratio of arable land was only observed in conventional fields. Homogeneity of weed species richness distribution in a locality followed a similar pattern, as it was also higher in organic than conventional fields and was linearly related to landscape intensification in the latter ones (P< 0.05) (Tab. 1, Figure 1).

Tab. 1: Mean ± standard error of the weed diversity estimators studied.

	Conventional	Organic	
Averaged species richness per field	8.96 ± 1.062	15.45 ± 1.211	**
Homogeneity	0.19 ± 0.013	0.32 ± 0.021	***
Segetal species richness	3.16 ± 0.576	7.15 ± 1.345	*

* Significant for *P*<0.05, ** significant for *P*< 0.01, ***significant for *P*<0.001

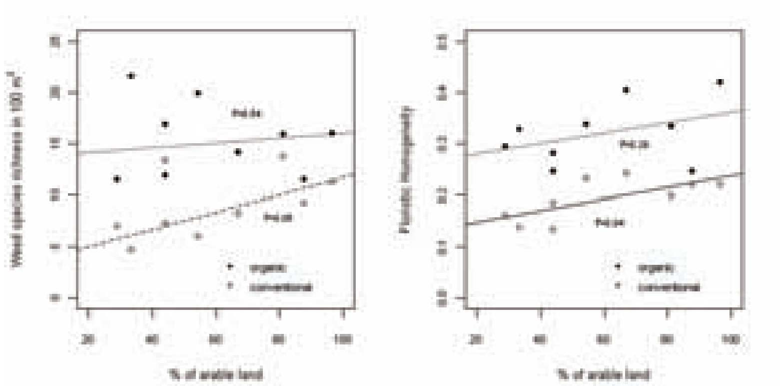

Figure 1: Mean species richness (left) and homogeneity of species richness distribution (right) of weeds with respect to landscape agricultural intensification. P-values of lineal models are next to each line.

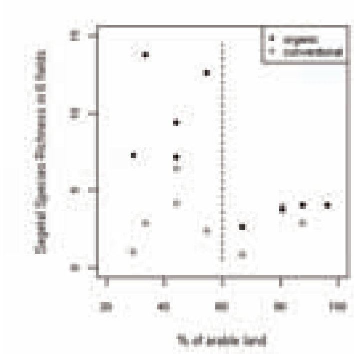

Figure 2: Segetal species richness accumulated across 6 fields with respect to landscape agricultural intensification. The vertical line remarks the change in the pattern for organic fields.

The pool of characteristic segetal weed species accumulated across six crop edges followed an interesting pattern. Differences in accumulated segetal species richness between management types were unappreciable in the four localities with the highest percentages of arable land but became clear in the less intensified landscapes, where organic fields displayed more elevated values (Figure 2).

Discussion and Conclusions

It is well-known that organic farming favours weed species richness. In this preliminary work we have shown that agriculturally intensified landscapes homogenize weed species distribution among dryland cereal crop edges only in conventionally managed fields. In intensified localities, dispersal and survival of ruderal/nitrophilous weed populations could be enhanced by the abundance of ruderal neighbouring habitats such as temporal fallows and highly disturbed roadsides. This hypothesis could also explain the increase in alpha weed species richness associated to landscape agricultural intensification in conventional crop edges. Though only marginally significant, this pattern does not seem to be consistent with other results obtained in central Europe (see Roschewitz et al., 2005). It is worth noting that this pattern was not observed in organic crop edges, probably because weed species richness is sufficiently high so that the contribution of neighbouring habitats cannot be detected.

Conversely, segetal species richness, which could be interpreted as high-quality diversity, seems to be negatively affected by landscape intensification (Figure 2), but only in organic fields. The high intensity of conventional management constitutes an unavoidable barrier to the presence of such specialist species that invalidates any possible landscape effect there, but organic farming seems to need low-intensified landscapes to achieve the highest levels. As an explanation, we propose that the pool of segetal species could have been lessened and substituted by a ruderal/nitrophilous species' one in intensified landscapes. Experimental studies should be conducted to determine the causes of the patterns highlighted in this work.

Acknowledgments

The authors thank the participating organic and conventional farmers. We also thank Albert Ferrer for his help with landscape data calculations. This research was partially funded by the Spanish Ministry of Education and Science with a fellowship to the first author, by the GDRE "Mediterranean and Mountain Ecosystems in a Changing World", and by the Science and Technology Department of the Spanish Government (project CGL2006-13190-c03-01/BOS).

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Comparative analysis of conventional and organic farming systems: Diversity and abundance of farmland birds

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Key words: Nature conservation, environmental sustainability, biodiversity, fauna, birds

Abstract

A comparative study of the abundance of breeding birds and wintering birds was carried out over the period 2005-2007 in conventionally and organically managed arable fields in Northern Germany. Birds were surveyed on 40 (breeding season) and 35 (non-breeding season) pairs of fields (conventional/organic), which were selected on similar field sizes, comparable boundary structures (hedges, shrubs) and representative crop rotations. Averaged over three years of investigation, skylarks (Alauda arvensis) and, less distinct, pheasants (Phasianus colchicus) occurred more often on organic fields. In contrast, yellow wagtails (Motacilla flava) showed higher abundances on conventional fields in one year. The diversity of farmland bird species was not affected by farming system (conventional/organic) neither during the breeding season nor during the non-breeding period. Over the winter, carnivore bird species occurred more often in organically managed fields while the total abundance of herbivore species was not affected by farming systems.

Introduction

Due to intensification in agriculture, populations of farmland birds have been declining in Europe during the last decades (Donald et al. 2001). Some factors which are responsible for the loss of breeding and foraging habitats are absent in organic farming. For instance, synthetic fertilizers, herbicides and pesticides are not permitted, and the diversity of field crops is usually higher in organic cropping systems (European Union Directive 2091/92). Despite these potential advantages of organic farming and the continuous increase of land area managed according to organic farming standards (Willer & Yussefi 2007), there are still surprisingly few scientific studies on the effects of organic agriculture on wild birds (Bengtsson et al. 2005; Hole et al. 2005; Piha et al. 2007). This paper presents the results of a three-year field study comparing breeding and winter bird communities in conventional and organic arable fields in Northwest Europe.

Materials and methods

The study was carried out on eight conventional and nine organic farms (managed organically for more than 10 years) located in the hedgerow-landscape of Schleswig-Holstein in Northern Germany. The experimental design consisted of 40 (breeding period) and 35 (non-breeding period) pairs of conventionally and organically cultivated arable fields. Each pair of fields was characterized by similar field sizes and

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comparable boundary structures (hedgerows, shrubs). The selection of representative pairs of fields also accounted for typical crop rotations of conventional and organic farms in the region. After pairs of representative fields had been selected in the first year of investigation, both the choice of crops and the way of cultivation of these fields during the following seasons were left to the farmers (Table 1, Table 2).

The survey of breeding birds was restricted to birds which are known to breed and forage directly on agricultural land (`true field species´). Birds were recorded by territory mapping, which is a method that accounts in particular for behaviour patterns indicating the breeding of birds (e.g., alerting pairs, singing males; Bibby et al. 2000). Over the non-breeding seasons (October-April) bird mapping was continued on a reduced sample of field pairs. Fields were crossed in transects at four dates (`line taxation´, see Bibby et al. 2000). Since both species diversity and total number of individuals were very low during winter, both parameters were analysed for the total non-breeding period (sum of four dates). Additionally, species were assigned to ecological groups, which were defined by food preferences of species during winter (primarily carnivore vs. primarily herbivore species; classification according to Bauer et al. 2005).

Statistical analyses were based on differences between conventional and organic agriculture. Pair-differences were analysed by a sign-test (probability of error 5%). Tests of abundances were restricted to species which were present in >10% of the fields. For a more detailed description of applied methods see Neumann et al. (2007).

Tab. 1: Management of the investigated pairs of arable fields during the breeding seasons 2005 to 2007 (n: number of fields, ha: total area)

Management	Breeding season 2005				Breeding season 2006				Breeding season 2007			
	Conventional		Organic		Conventional		Organic		Conventional		Organic	
	n	ha	n	ha	n	ha	n	ha	n	ha	n	ha
Maize[1]	12	80.4	1	11.0	11	53.5	2	14.1	11	46.8	2	4.1
Grass[1]	3	9.7			5	17.4			5	15.7		
Grass/clover[2]			12	93.1			14	80.6			13	104.7
Grain legumes[3]			7	35.7			4	23.3			5	32.7
Winter cereals	15	92.2	10	53.8	17	188.2	7	98.4	16	132.0	7	67.5
Winter rape	8	94.8	1	8.6	4	26.1			5	60.9		
Spring cereals	1	4.0	7	80.9	1	5.0	11	69.0	1	6.0	6	48.1
Root crops[4]	1	27.0			2	18.0	1	5.6	2	46.7	2	18.8
Seed production[5]			2	13.0			1	5.1			5	20.2
Crops total	40	308.1	40	296.1	40	308.1	40	296.1	40	308.1	40	296.1
Spring crops total	14	111.4	15	127.6	14	76.5	18	112.0	14	99.5	15	103.7
Spring crops %	35	36.2	37.5	43.1	35	24.8	45	37.8	35	32.3	37.5	35.0

[1] forage production; [2] forage production, green manure; [3] incl. mixtures; [4] sugar beet, potatoes; [5] oil seed radish, red clover, perennial ryegrass

Tab. 2: Management of the investigated pairs of arable fields during the non-breeding seasons 2005/06 and 2006/07 (reduced sample of fields compared to Tab. 1; n: number of fields, ha: total area)

Management	Non-breeding season 2005/06				Non-breeding season 2006/07			
	Conventional		Organic		Conventional		Organic	
	n	ha	n	ha	n	ha	n	ha
Intercrops[1]	1	8.5	7	27.2			1	11.6
Grass/clover after ploughing			8	42.4			15	74.2
Grass/clover undersown in pre-crop[1]			10	72.2			5	24.0
Grass	4	15.7	2	14.3	5	18.4	3	20.4
Winter cereals/rape after ploughing[2]	9	49.8	3	39.1	8	88.3	5	46.1
Winter cereals/rape direct drilling[1]	7	85.4			9	66.5		
Fallow land after ploughing	2	9.4	1	7.9			1	9.2
Fallow land not ploughed[1]	12	64.7	4	28.1	13	60.3	5	25.8
Fields total	35	233.5	35	231.2	35	233.5	35	231.2
Fields with crop residues total	20	158.6	21	127.5	22	126.8	11	81.3
Fields with crop residues %	57.1	67.9	60.0	55.2	62.9	54.3	31.4	35.2

[1] fields with crops residues, normally after stubble processing; [2] cultivation of winter rape only within conventional farming

Results

The diversity of breeding bird species was not affected by management type (conventional vs. organic, Table 1). Skylarks were more abundant in organically managed fields in all breeding seasons. The mean presence of pheasants was higher in organic crops even though significant effects could not be observed in the individual years. Yellow wagtails, however, occurred more often in conventional fields in one of the breeding periods.

The diversity of bird species was also not affected by farming type during the non-breeding seasons,. The group of carnivore/insectivore bird species showed a higher mean total presence in organic fields (M=-7.5; Pr>=|M| 0.0135). The presence of herbivore/granivore birds, however, was not affected by management type (M=1; Pr>=|M| 0.8555).

Tab. 3: Levels of significance of the sign-tests conducted for the differences "conventional fields – organic fields" in the breeding seasons 2005 to 2007

Parameter[1]	2005		2006		2007		Mean 2005-07	
	M	Pr	M	Pr	M	Pr	M	Pr
Abundance Skylark *Alauda arvenis*	***-8.0***	***0.007***	***-6.5***	***0.029***	***-12.0***	***<0.001***	***-11.5***	***<0.001***
Abundance Pheasant *Phasianus colchicus*	-3.5	0.092	-3.0	0.070	-1.5	0.453	***-5.5***	***0.019***
Abundance Yellow Wagtail *Motacilla flava*	3.0	0.070	***4.0***	***0.022***	4.0	0.077	4.5	0.064
Abundance Lapwing *Vanellus vanellus*	1.0	0.727	0.5	1.000	1.5	0.250	2.5	0.267
Number of species	-3.5	0.248	-1.5	0.690	-3.0	0.362	-1.5	0.690

[1] abundance: territories/10 ha

Discussion

As in this study, none of the small number of comparable studies available in this area indicates positive effect of organic farming on the diversity of breeding bird species (Chamberlain et al. 1999; Belfrage et al. 2005; Piha et al. 2007). Farmland birds require relatively large breeding habitats. Therefore, they possibly benefit less from organic agriculture than taxa which are more directly affected by the way of cultivation (e.g., wild plants, see Bengtsson et al. 2005). For the same reason, differences in the colonisation of conventional and organic farmland by birds could possibly be better analyzed at larger spatial scales than single fields or small farms (Belfrage et al. 2005; Bengtsson et al. 2005).

However, as found in several other studies, the presence of skylarks was found also in this study to be strongly affected by different types of management. Organic agriculture might have been advantageous for skylarks due to more diverse crop rotations (Table 1) and potentially sparser canopy structures (Neumann et al. 2007).

Our results from the non-breeding seasons indicate higher amounts of feed for birds on organic fields. The widespread use of direct drilling techniques on conventional fields (Table 2) might have been responsible for the absence of differences in the availability of vegetable food between farming systems.

Conclusions

With regard to species conservation, organic farming as practised in the investigation area might contribute in particular to the assurance of winter feed for resting carnivore birds. Breeding populations of skylarks might also be promoted by organic farming practices. However, the latter aspect needs to be verified in comparative studies on the breeding success. Organic cropping usually requires mechanical weed control (harrowing, hoeing), which might negatively affect ground-breeding birds (Neumann et al. 2007; Kragten & Snoo 2007).

Acknowledgments

The research was carried out within the Interreg III a-Programme of the European Union (German-Danish project "AVI-LAND").

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The use of mulch to increase Spider *(Arachnidae)* numbers; a habitat approach to biological insect control

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Key words: mulch, population viability analysis, habitat diversity, spiders

Abstract

The potential for insect predators to contribute to a biological balance of insect species was explored with mulch. Insects were collected in pitfall traps in outdoor microplots over 3 seasons in southern Ontario, Canada. Treatments varied each season with crops of oats or soybeans, with residue of straw, corn stalks or paperfibre, and with residue tilled in or surface applied. In 2006 at the peak of spider population density there was a significant effect of the plant and the paperfibre residue on increasing spider density. Existing data sets on spiders by Spiller and Schoener (1988 & 1994) were analyzed to assess the potential to increase spider survival from improved carrying capacity of their habitat. Spider census data was tested with curve fitting models in Aikaike Information Criteria (AIC). Spider populations of Metepeira, with sizeable numbers, were density dependent. Demographic data was assembled from Spiller & Schoener, 1988 and population size was projected with RAMAS Ecolab. Increasing the carrying capacity increased spider populations in the model projections. Mulch improves spatial diversity and could increase spider density from reduced intraspecific competition in the plot experiments. Increasing spider numbers with habitat complexity in agricultural systems could allow spiders to reduce specific pest problems through maintaining the balance of insect species.

Introduction

There is debate whether natural biological control by insect predators can be maintained in sustainable agricultural systems. Spiders (Arachnidae) are the most abundant generalist predator in agriculture and there have been many studies on spiders associated with reduction of pest damage (Wise, 1993). Spider populations in agriculture are decreased directly by pesticides and indirectly by tillage and monocrops that disturb habitat leading to increased intraspecific competition within the spider community. Spiders control their density in response to available “web space” (Schaefer, 1978), and in turn, establish an equilibrium of other insect populations (Strong, 1984). Increasing spider populations in organic agriculture could maintain the balance of insect species and reduce outbreaks of any individual pest.

The use of surface mulch may increase the volume of spiders from increased habitat diversity. Insect collection was added to existing microplots over 3 seasons, to test if the populations of ground insects, including spiders, was increased with surface mulch (straw, corn stalks, paperfibre biosolids) compared to bare soil, tilled in or surface applied and with crop plants of oats or soybeans. Existing data sets by Spiller and Schoener (1988 and 1994) were analyzed with population viability analysis to a) test for the type of density dependence/independence of spider populations, and b) project populations growth rates and carrying capacities that could be achieved through modelling deomographic data. It was hypothesized that surface mulch would increase spider populations by increasing the carrying capacity from habitat diversification. Spider populations were expected to be density dependent.

Materials and methods

Insect pitfall traps were added to outdoor plots 60 cm square x 15 cm deep located in southern Ontario, Canada, that were designed to compare the effects of fungal hyphae on soil carbon (Manns et al., 2007). Treatments formed a 2x3 factorial arrangement with 4 replications. Factors were no plant/ plants x 3 levels of surface residue; in 2004, no plant/oat plants x no residue, dried chopped oat straw/ chopped corn stalks, in 2005, no plant/oat plants x no residue/ corn stalks mixed into the soil/corn stalks set on the soil surface and in 2006, no plant/soybeans x no residue/paperfibre mixed in the soil/paperfibre surface applied. Oats were broadcast over the depth of mulch of straw/corn (5 cm) or paperfibre (1 cm) or raked into the bare surface in mid May of each year. Ground insects were collected daily over a 1 week period in 2004, 1 week each month in 2005 and weekly in 2006 in the May-August season. A plastic vial, 3 cm diameter x 10 cm high, containing 2 cm water, was inserted into the soil in the centre of each plot. Insects were collected and stored in 70% ethanol. Species were identified to order. Published data sets were analyzed for census information on spider populations with and without lizard predations, and for life stage matrix data to project population growth rates and carrying capacities; 1) Spiller & Schoener (1994), Bahamas, census data at 18 time intervals over 3 years of Metepeira and Eustala populations. 2) Spiller & Schoener (1988), Bahamas, census data for 16 months of Metepeira species along with life stage data.

Statistics: Data was analyzed with 2-way ANOVA using MINITAB to separate the effect of surface residue and oat plants on pitfall trap catches. Census data were log transformed using ln(t+1)/ln(t). The census data and log growth rates was entered into SYSTAT (Statsoft) to find the closest fit model of linear regression, Ricker curve, theta-logistic and inverse density dependent relationships. The residual sum of squares from each equation was entered into the Aikaike Information Criteria (AIC) model formula in EXCEL (Microsoft) to calculate the weights of each equation. Demographic data was analyzed with POPTOOLS matrix analysis to derive population abundances. RAMAS Ecolab assessed the demographic data using the density dependence feature with life stage abundance. Differences between means of variables in the data set were compared with 1 way ANOVA with post-hoc Tukey test.

Results

There was no significant treatment effect of mulch or oat plants on spider numbers in 2004 (Fig. 1a) or 2005 (Fig. 1b). At the peak of spider populations in June, 2006 (Fig. 1c) the number of spiders were significantly increased by the plant ($p<0.001$) and by the paperfibre residue, both mixed into the soil ($p=0.004$) and surface applied ($p<0.001$). Treatments with both plants and surface residue had the highest spider numbers captured each year.

All spider census data, both with and without lizard predation, were density dependent, indicated by the close fit to the Ricker model. There was a greater number of spiders in each stage class with no lizards, but stable age abundances projected adult numbers around 45% and egg (30%) and juvenile (25%) of the total population with and without lizard predation. A stable distribution of the population was achieved at 254 spiders with no lizards and at 160 spiders with lizard predation using the density dependent feature in Ecolab with carrying capacity of 80 and growth rate of 1.0. Increasing only the carrying capacity decreased the projected abundance in the model.

Manipulating the model parameters in Ecolab, the spider population would be maintained at 400 with a growth rate of 1.1 in the life table matrix without lizard predation. The population could also increase linearly to a higher carrying capacity by increasing the growth rate over 1.25 with no lizard predation, and 1.1 with lizard predation. The population was projected to 5000, using 30 monthly intervals with a growth rate of 1.25.

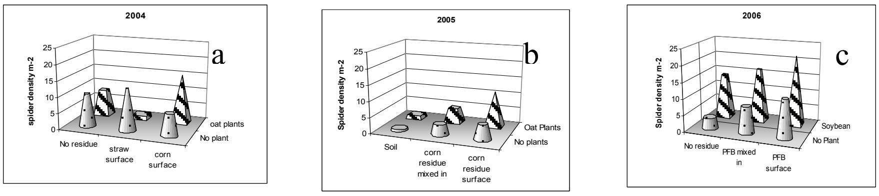

Figure 1: **Spider numbers caught in pitfall traps in 2004 (a) 2005 (b) and 2006 (c) in the factorial design with/without plants x residue treatments.**

Discussion

The numbers of spiders observed in this study ranged from 1 to 21 m^{-2}. Lycosidae or hunting spiders are commonly caught in pitfall traps at representative density of 1 m^{-2} in cereal fields (Honek, 1988). Movement between the small plots, separated only by a 5 cm height of the wooden frame, could occur, but as Lycosidae are highly sedentary (Edgar, 1969) treatment differences would be possible. This was most evident with the peak of spider populations in 2006 when many juveniles were counted in the pitfall traps. Straw bales were used years ago to preserve spiders in the fields where densities from 2 to 300 m^{-2} were observed to reduce plant damage (Nyffeler & Sunderland, 2003). Spiders densities of 2-600 m^{-2} were recorded with Linyphiidae, the most common species in Europe while in North American agriculture, Lycosidae were the dominant species with densities from 0.02 to 14 m^{-2} (Nyffeler & Sunderland, 2003).

The census data for Metepeira was correlated with the Ricker curve in this study, which is consistent with the 1st order negative feedback process of intraspecific competition (Hunter, 2001). The Ricker model is identified by a uniform decrease in growth rate over the time period (Varley et al., 1973) which limits population growth. Density dependence is best fit to data with high rates of population increase, and thus was found only with the Metepeira species in the data set.

The carrying capacity was increased in the Ecolab model projection to simulate the addition of web sites. Manipulating the model parameters of the life stage matrix showed that increased carrying capacity greater than 1.0 was necessary for linear population increases. Adult survival had the strongest effect on the population abundance when there was no control by predation in the sensitivity analysis. If the habitat increases adult survival by reducing intraspecific competition, (the same effect as reducing predation), then population numbers should increase with the survival rate and number of web sites.

The object of ecology is to maintain stable populations. A modeling study on the strength of predatory interactions within the food web confirmed that weak to intermediate strength links are important for stability in the food web by reducing the size of oscillation cycles (McCann et al., 1998). In food webs dominated by generalist species such as spiders, less variability in population dynamics would be expected. Lizard predation did not affect the population growth rate or variance of the spider populations analyzed. In the model projections, the reduction in variance with lizard predation, increased the potential for growth in the population. The similarity in carrying capacity with and without lizards, indicates that intraspecific competition, or parasitoids were a greater force than predation on population size. With the large population of Metepeira studied, intraspecific competition was the dominant issue, while with spider species with small populations, predation has a much larger effect.

Conclusions

Spider populations were increased from surface mulch in association with crop plants in our small plots, and computer modelling affirmed that decreased predation from intraspecific competition could be increasing the population numbers. The specific species of spiders may be also be important in their potential for pest control, as lyniphiidae have been found to increase to much greater numbers than lycosidae dominant in this study. It is possible that a small number of spiders may control populations of other species by reducing the size of pest population oscillations.

Acknowledgments

Symons Trust Fund for Canadian Studies, Trent University, Peterborough.

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Working with biodiversity in OA

Enhancing Biodiversity and Multifunctionality of an Organic Farmscape in California's Central Valley

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Key words: Multifunctionality, Biodiversity, Organic Farming, Ecosystem Function

Abstract

Organic farmers in the USA increasingly manage the margins of previously monocultured farmed landscapes to increase biodiversity, e.g. they restore and protect riparian corridors, plant hedgerows and construct vegetated tailwater ponds. This study attempts to link habitat enhancements, biodiversity and changes in ecosystem functions by: 1. inventorying the existing biodiversity and the associated belowground community structure and composition in the various habitats of an organic farm in California's Central Valley; and 2. monitoring key ecosystem functions of these habitats. Two years of inventories show greater native plant diversity in non-cropped areas. While nematode diversity did not differ between habitats, functional groups were clearly associated with particular habitats as were soil microbial communities (phospholipid fatty acid analysis). Earthworm diversity did not differ between habitats, but biomass was higher in non-cropped areas. Habitats with woody vegetation stored 20% of the farmscape's total carbon (C), despite their relatively small size (only 5% of the total farm). Two years of monitoring data of farmscape C and nitrogen (N) through emissions, run-off and leaching showed distinct tradeoffs in function associated with each habitat. Clearly habitat restoration in field margins will increase both landscape biodiversity and the multifunctionality of the farmscape as a whole.

Introduction

Deviations from the standard practice of monoculture food production through planned diversity could have a significant impact on associated biodiversity and ecosystem function (Vandermeer et al. 1998). Farmers manage habitat heterogeneity temporally with crop rotations or spatially through intercropping, or through "farmscaping". By farmscaping farmers retain or restore natural riparian tree corridors to protect waterways, plant hedgerows (shrubs and grasses along edges of farm fields) to attract beneficial organisms, establish tailwater ponds to reduce the nutrient content of

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irrigation water released into waterways and let previously denuded soil re-vegetate. Although these practices are increasingly being employed around the country there has been little scientific quantification of the effects of farmscaping on biodiversity or associated multifunctionality (Tscharntke et al. 2005).

Although field margins may represent a relatively small area of the overall farmed landscape, alterations of their ecosystem function may be significant enough to impact the multifunctionality of the landscape as a whole. Not only does the vegetation in these margins provide habitat for pollinators and birds, and store nutrients such as C and N, but it provides habitat for organisms belowground. These belowground organisms in turn mediate ecosystem functions such as atmospheric gas exchange, soil C storage, and water quality dynamics.

This study provides an opportunity to establish linkages between nutrient cycling, greenhouse gas (GHG) emissions, aboveground biodiversity and belowground communities and quantify the relative contributions of farmscaping management options to the overall multifunctionality of the farm. Yolo County, California is an ideal region for a landscape study that examines the complex relationship between land use and ecological function. Located in the Sacramento Valley, which typifies intensive, diversity poor, industrial agriculture, Yolo County is the home of numerous growers involved in farmscaping as a means of land stewardship. The Rominger organic farm was selected for this study as it embodies several farmscaping management options on a single soil type within the context of a typical mid-sized organic processing tomato farm (Figure 1). This study attempts to link habitat enhancements, biodiversity and changes in ecosystem functions by: 1. inventorying the existing biodiversity and the associated belowground community structure and composition in the various habitats of an organic farm in California's Central Valley; and 2. monitoring key ecosystem functions of these habitats.

Materials and methods

In the spring of 2005 and again in 2006, GIS (Arcview, ESRI 2005) was used to create a stratified random sample in each of the 6 habitat polygons (riparian corridor, hedgerow, north field, south field, drainage ditches, and tailwater pond) of the Rominger farm. Using each randomized point as the center, 16 m^2 plots were established which included four 50 x 50 cm^2 subplots (Figure 1).

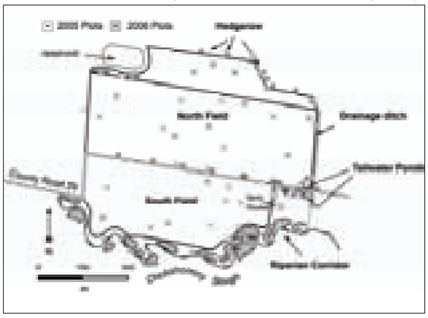

Figure 1: Map showing sampling points from 2005-06 in six farmscape habitats

Biodiversity: Vegetation cover (%) for each plot was recorded by species at each canopy layer. Soil microbial community structure was analyzed using phospholipid fatty acid (PLFA) analysis. Nematodes were extracted from 500g of sub-sampled soil, identified to family, and classified into functional groups. Adjacent to each of these 24 sampling points, a 30 cm^3 pit was excavated and sorted for earthworms which were identified to species and weighed in the laboratory.

Ecosystem Functions: We inventoried soil C and N pools, soil aggregation, and infiltration rates of each of the 24 points. Each habitat was monitored for both gaseous and aqueous C and N losses throughout the two year experiment. The GHG, CO_2 and

N_2O, were sampled monthly using closed chambers and a continuous monitoring device (LiCOR 8100). Ceramic cup suction lysimeters where deployed at 30 and 60 cm depth to monitor dissolved organic C (DOC) and nitrate (NO_3^--N), while cumulative

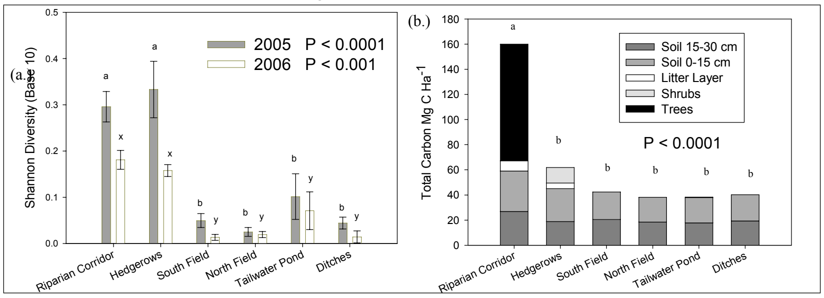

Figure 2: Inventories indicate greater (a.) native vegetation biodiversity and (b.) carbon storage in non-cropped areas of the farm

NO_3^--N was assessed using anion exchange resin bags buried at 75 cm depth. Surface runoff from the north and south crop fields was monitored using automated collection samplers (ISCO units) during stormwater and irrigation events.

Soil cores were taken from each sub-plot at 0-15 and 15-30 cm depths, and analyzed for gravimetric moisture, KCl-extractable NO_3^--N and NH_4^+-N, potentially mineralizable N, microbial biomass carbon (MBC), electrical conductivity (EC), and pH.

In the spring of 2005 and 2006, understory aboveground biomass was harvested from each subplot and shrubs were clipped. Crops were similarly harvested at the end of each summer. Ground, dry plant, fruit and soil sub-samples were sent to the UC DANR laboratory (http://danranlab.ucdavis.edu) and analyzed for total C, N, P and K (http://danranlab.ucdavis.edu). Shrub and tree C was estimated using measured heights and diameters and allometric biomass regression equations.

Statistical Analysis: Differences between habitats were analyzed using analysis of variance (ANOVA) followed by pair-wise comparisons using Tukey Honestly Significant Differences. Relationships between soil organisms and habitats were analyzed using Canonical Correspondence Analysis (CCA).

Results

There were clear differences between the six habitats in terms of above- and belowground biodiversity and ecosystem functions. Plant inventories showed similar patterns of native diversity following the extremely wet winter of 2005 and the extremely dry winter of 2006 (Figure 2a). Non-native plant diversity, however, was much higher in the ditches and tailwater ponds particularly after the drier winter.

The PLFA analysis showed only small differences between microbial communities across habitats with the exception of the

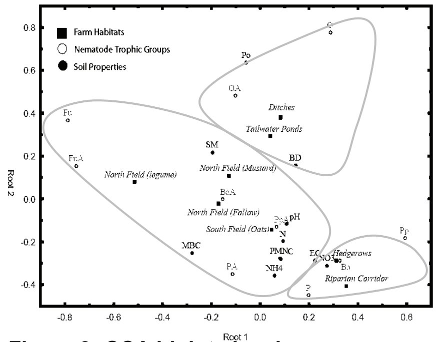

Figure 3: CCA biplot showing associations between nematode trophic groups, soil properties and farm habitats

drainage ditches which harboured several distinct PLFA markers. Although there were no differences in the diversity of earthworms (over all only four species were found) more earthworms were found in the non-cropped habitats. Nematode inventories showed clear separation of species among habitats (Figure 3). The drainage ditches were an extremely "leaky" habitat in that both GHG emissions and NO_3^--N leaching were high. Leaching losses in the ditches averaged 17.9 g N m^{-2}, higher than all other habitats except the tailwater pond, with the lowest mean loss of 2.0 g N m^{-2} in the riparian corridor. There were only small differences in total soil C among habitats, but when the contributions from woody vegetation were considered, large differences were observed (Figure 2b). Total C storage in the riparian corridor was estimated to be 160 Mg C ha^{-1} while the crop fields only stored 40.1 to 42.4 Mg C ha^{-1}. Together the riparian corridor and hedgerows account for 20% of the total estimated C stored on the farm despite being only 5% of the total area.

Discussion

While the non-cropped habitats account for only a small fraction of the farmed landscape, they play a crucial role both in terms of habitat for above- and belowground organisms as well as locations of dynamic nutrient cycling (e.g. higher CO_2 emissions in the riparian corridor as well as carbon production). There are numerous studies that have compared both the biodiversity and ecosystem function of organic vs. conventional production fields, but few have studied this in relation to managed edges of fields, and fewer still consider associations between the two. We have found that in some habitats, there may be functional tradeoffs (e.g. increased NO_3^--N leaching associated with food production). While each habitat may provide many subtle functions and are best evaluated by the overall contribution to multifunctionality, some functions are quite pronounced. For example, the important role of C storage in the habitats with woody species overshadows soil C storage at the landscape level. While organic management typically stores more soil C than conventional, e.g. at a nearby research station, the highest soil C levels were in an organic tomato maize rotation (22.8 Mg C ha^{-1} at 0-15 cm) compared to 9 other cropping systems (Kong et al. 2005), our study shows this can be further increased in at an organic farm by farmscaping. The soil C at the 0-15 cm depth at the Rominger farm's organic crop fields ranged between 19.7 and 21.8 Mg C ha^{-1}, increased to a mean of 23.4 Mg C ha^{-1}, when the total C storage for all the farm habitats was considered.

Conclusions

Managing agricultural field margins can not only increase the biodiversity of organic farming systems but also significantly contribute to increased multifunctionality of the agricultural landscape, providing a variety of ecosystem services of human value.

Acknowledgments

This research was supported by USDA OERI grant 2004-51106-02242 to L. Jackson.

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Diversity as a key concept for organic agriculture

Langer, V.[1] & Frederiksen, P.[2]

Key words: crop diversity, farm diversity, indicator, biodiversity, mixed farming

Abstract

Diversity is a key concept of organic agriculture and is intuitively perceived as having positive, but not always explicit, consequences for the internal functioning of the farm as well as for the impact on environment and farmland nature. In two groups of specialised organic farms (arable and dairy) and a group of mixed farms, links between production diversity and diversity at the scales above and below, as well as relations to potential farmland biodiversity, are examined. Results show that diversity in different scales are not consistently correlated, i.e. neither high diversity in farm household on-farm activities, nor diversity in agricultural production are linked to high crop and land use diversity. Furthermore, there are no simple relations between diversity measures and potential benefits for farmland biodiversity

Introduction

Diversity is a key concept of organic agriculture in a range of scales: within-field diversity (intercropping or mixed cropping is perceived as better than monoculture), diversity in crops and livestock (many crop and livestock types are perceived as better than few), production diversity (mixed farming is perceived as more harmonious than specialized farming) (Köbke, 2000) and organic farms with a diversity of activities (both agricultural and non-agricultural) are seen as desirable in connection with short market chains and rural development (Ploeg et al, 2002b). Diversity per se is in this way intuitively perceived as having positive, however not always explicit, consequences, not only for the internal functioning of the farm, but also for the impact on environment and farmland nature. The notion of improved internal function of the farm with higher diversity has been documented by e.g. more efficient nutrient cycling on farms with both crop and livestock production, improved resource efficiency by grazing with more types of animals (Sehested et al., 2004) and in the well known fact that rotations with many crop types decrease the risk of pests and diseases. The notion that a diversity of income generating activities beyond the agricultural production increases the stability of the farm by risk dispersion and contributes to rural development, is also well documented (Ploeg et al., 2002a). These activities include processing and marketing agricultural products (e.g. farm shops, box schemes), farm tourism, alternative energy production, hunting and fishing activities, and there are indications that organic farms more frequently than conventional engage in these activities. As the ongoing structural development within the organic farming sector in many regions takes the route of farm specialization and enlargement similar to the conventional sector (Langer et al., 2005; Levin, 2007), developing the concept of

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diversity and possibly adding facets to the picture of specialized organic farms and their counterparts, mixed farms, seems appropriate. Therefore, we ask the two questions illustrated in figure 1:

How is diversity in production linked to diversity at the scales above and below? In other words, do farms with specialized agricultural production exhibit less diversity on the scale above – the farm household – and below: crop and livestock diversity?

How is diversity on these different scales linked to potential farmland biodiversity, measured by land use and structure?

Tab. 1: Diversity measures on different scales relevant for organic farming

Scale	Diversity measure	Measures for potential biodiversity
Landscape	Crop diversity (number of crop types)	Degree of disturbance: • %permanent grassland • % annual crops • % of annual crops mechanically weeded
Agricultural production	Specialized versus mixed farms Diversity of production sectors Diversity in livestock types	Field size
Farm household	Diversity of economic activities on the farm in addition to agricultural production	Area of unfarmed habitats/ha Diversity of unfarmed habitats

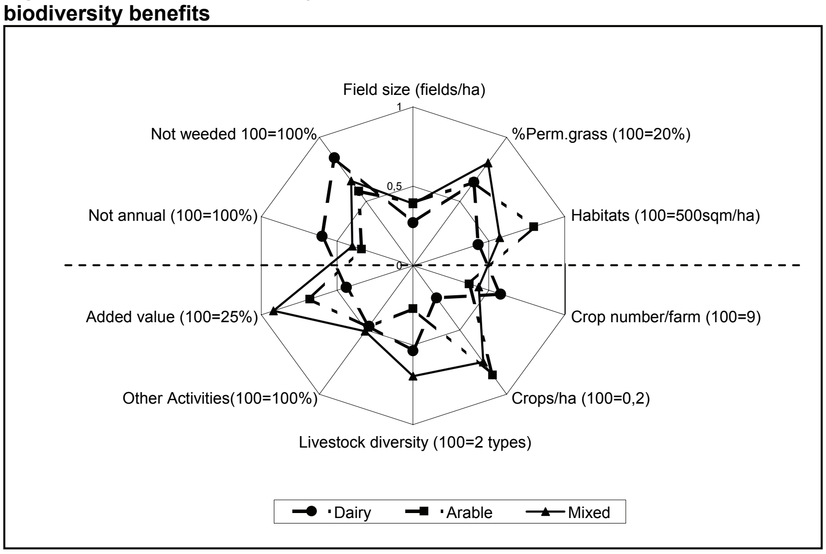
Materials and methods

The links between diversity in three different scales as well as links between production diversity and characteristics relevant for farmland biodiversity were examined on three groups of organic farms, distinguished by being either specialized or mixed: Specialized dairy farms (N=80, mean 1,28 LU/ha, 109 ha), specialized arable farms (N=137, mean 0,14 LU/ha, 31 ha) and mixed farms (N=75, 1,03 LU/ha, 41 ha) were surveyed for land use and management, livestock production and household activities in 2001 (Frederiksen and Langer 2004) and classified into farm types based on their production structure. For crop diversity, the number of crop types out of nine possible (cereals, oilseed, legumes, crop for silage, row crops, seed crops, clover-grass ley, fallow, and permanent grassland) were calculated per farm and per ha farmed area. As a measure of on-farm economic activities beyond production two measures were used: whether the farm household was engaged in any other activities, and whether these included activities with the aim of adding value to agricultural products through processing or direct marketing. Measures of potential biodiversity were degree of disturbance (distribution on permanent, annual, weeded annual), which is known to affect weeds and below/above ground fauna in fields, and quantity/quality of unfarmed habitats, known to affect biodiversity on landscape level.

Results

Diversity on different scales (lower half of diagram) and characteristics potentially favourable for farmland biodiversity (upper half of diagram) are shown for the three farm types in figure 1. Mixed farms are seen to have a larger number of commercially produced livestock (Livestock diversity) as well as a higher frequency of engagement in activities with the aim of adding value to agricultural products (Added value) than the two specialized farm types. Crop diversity measured by number of crops per ha is similar on mixed farms and specialized arable farms, whereas it is considerable lower on specialized dairy farms (Crops/ha). Mixed farms have a larger proportion of permanent grassland than the two specialized farm types, whereas mean field size is similar to specialized arable farms but smaller than specialized dairy farms and a density of unfarmed habitats intermediate between the two specialized farm types. Specialized dairy farms exhibit considerably more undisturbed land area, measured by less annual crops and a smaller proportion of this under mechanical weeding.

Figure 1: Measures of diversity in different scales in relation to potential biodiversity benefits



Discussion

The concept of mixed farming is often used when discussing diversity in production, but is an ill defined concept, often merely defined by its contrast, specialized farming. Quantitative definitions in the literature are few and not necessarily suited for organic farms. In EU statistics mixed farms are simply farms where no single production sector, e.g. dairy cows, contributes with more than 2/3 of the economic size. Crop diversity has been used as indicator of both management intensity (Herzog et al., 2006) and as a landscape heterogeneity measure. The results here show, that due to the correlations between farm size, field size and crop number, which are highly contextual, using number of crops per ha supplements the measure of crops per farm unit. The results confirm that mixed farms contribute to potential farmland biodiversity benefits by providing not only larger areas with permanent grassland than both arable and dairy farms, but also a high number of crops per ha, altogether securing a high heterogeneity for the benefit of biodiversity (Benton et al., 2003). On the other hand the large specialized dairy farms, in spite of having larger fields and less crops per ha, contribute positively to biodiversity benefits by providing a higher proportion of perennial grassland as well as more annual crops, not mechanically weeded, and thus altogether a less disturbed environment than on the two other farm types.

Conclusions

Diversity in different scales are not consistently correlated, i.e. neither high diversity in farm household on-farm activities, nor diversity in agricultural production are linked to high crop and land use diversity. Furthermore, there are no simple relations between diversity measures and potential benefits for farmland biodiversity. Crop diversity may be assessed on farm scale when discussing it as a measure of improving internal functions on the farm and spreading risk. However when used as a measure of potential benefit for farmland the close links between farm size and number of crops means that crop diversity should be discussed on an area scale. Whether crop diversity is beneficial for biodiversity, depends on the specific crop types. In the discussion of structural development within organic farming, concepts of specialisation and mixed farming should be expanded, and the links with other farm characteristics considered crucial for satisfying the organic principles should be explored.

Acknowledgments

Funding for this project “Nature Quality in Organic farming” was provided by DARCOF, the Danish Research Centre for Organic Food and Farming.

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Testing and scaling-up agroecologically based organic conservation tillage systems for family farmers in southern Brazil

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Key words: agroecology, cover crops, weed suppression

Abstract

In southern Brazil several small farmers developed an innovative organic conservation tillage system (OCT) that does not depend on herbicides for weed control but relies instead on the use of cover crop mixtures (including various combinations of rye, vetch and raphanus) that leave a thick residue mulch layer on which traditional grain crops are directly planted, suffering very little weed interference during the growing season and reaching agronomically acceptable yield levels. Our research showed that the rye, fodder radish and vetch mixture effectively suppressed emergence of summer annual weeds in OCT systems. Because of the allelopathic effect of phytotoxins associated with the cover crops residues, farmers avoid toxic effects by placing crop seeds below the toxic layer (allelopathic zone) formed by the phytotoxins leached a short distance (5-10cm) from the mulch into the soil. In addition to weed suppression, residues also have positive effects on subsequent crops from increased soil quality parameters, improved crop nutrition, and in some cases suppression of soil-borne pathogens. Yields in most cases are 5-10% lower in OCT systems when compared to CT systems, but such differences are easily offset by the lower costs of production and the environmental benefits of OCT systems. In our trials the combination of grass and legumes enhanced biomass production and therefore mulch thickness, weed suppression, and organic matter inputs.

Introduction

In southern Brazil several small farmers developed an innovative organic conservation tillage system (OCT). Unlike conventional no-till systems, these novel OCT systems do not depend on herbicides for weed control but rely instead on the use of cover crop mixtures (including various combinations of oats, rye, pigeon pea, vetch, raphanus, etc) which leave a thick residue mulch layer on which traditional grain crops (corn, beans, wheat, etc) are directly planted, suffering very little weed interference during the growing season and reaching agronomically acceptable yield levels (Petersen et al 1999). Since very little research has been conducted to understand the ecological underpinnings of these systems, we initiated a research project aimed at assessing the processes involved in weed suppression that enhance soil fertility and crop productivity. Our hypothesis was that elucidating the mechanisms at play would provide principles and guidelines to hundreds of other farmers who, because of cost and/or herbicide dependence, want to transition towards OCT systems.

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From agroecological experience with similar systems, we knew that simply copying the cover crop mixtures used by successful farmers does not work for widely diffusing the technology. Agroecological performance is linked to processes optimized by OCT systems and not to specific techniques. Weed suppression and optimal soil fertility are emergent properties of the whole system.

The main objectives of this research were:

- to assess the agroecological performance (how do OCT systems function?) of a range of OCT systems currently used by small farmers in Santa Catarina.
- To elucidate the agroecological mechanisms explaining optimal levels of weed suppression (allelopathy) and crop productivity (soil fertility and moisture effects) in OCT farms
- To agronomically fine tune the best-bet OCT systems based on rye, fodder radish, and vetch mixtures
- To organize a participatory farmer-farmer research/extension initiative (field visits, cross visits, training sessions, on-farm experiments and demonstrations) aimed at explaining the agroecological principles underlying OCT performance, and translating such principles into practical OCT strategies to be used by hundreds of farmers in other areas

Materials and methods

Cover crops are planted in early fall and produce sufficient biomass by early spring. The cover crops provide a layer of plant residue on the soil surface that can suppress weeds by exhibiting allelopathic effects, and/or enhance conditions unfavourable for weed germination and establishment (Monegat 1991). The cover crop biomass also enhances soil fertility. In order to understand such effects in the field, weed abundance and biomass as well as soil, crop growth and yield parameters were evaluated in five OCT systems in farmers' fields and in 5 neighbouring farms using conventional tillage (CT). We also established experimental plots to test several OCT designs to fine-tune the rye-fodder radish-vetch cover crop mixtures. In each plot we measured weed abundance and diversity, soil quality parameters (physical, chemical, and biological features), rates of mulch decomposition, and crop yields. Eighteen plots (6x6 m each) were assigned to the 6 treatments, replicated three times. After the cover crops were rolled over with a mechanical roller, soybeans were planted in September. Weed biomass samples were collected each 45 days from 0.5 m2 in each plot, separating cover crops and weeds for later drying

Results and Discussion

Comparing farmer-managed OCT systems with neighbouring CT systems allowed us to clarify the effects of cover crop mixtures on the emergence of summer annual weeds in an organic versus a conventional no-tillage onion system. Summer annual weeds in the OCT fields exhibited lower densities than in the CT fields. Broad-leaved weeds emerged more in tilled fields than in the no-tillage fields. The rye, fodder radish and vetch mixture effectively suppressed emergence of summer annual weeds in OCT systems. Crop yields were similar in both OCT and CT fields.

Our research suggests that a key effect of cover crops mixtures is the substantial suppression of weeds, thus reducing weed competition and eliminating the need for herbicides. Weed suppression in OCT systems is due to allelopathic effects of cover crops, and rye and fodder radish play a key role in this regard (Boydston and Hang 1995). Rye releases toxins including Β-phenyllactic acid and Β-hydroxybutiric acid and various benzoxazolinone compounds (Barnes and Putnam 1987). Residues of fodder radish partially incorporated into the soil reduce weed density via release of glucosinolate compounds (Boydston and Hang 1995).

Cover crops residues also enhance soil cover and thus have positive effects on subsequent crops because of increased soil quality parameters, improved crop nutrition, and in some cases suppression of soil-borne pathogens. Yields of OCT systems may be equal to but in most cases are 5-10% lower than in CT systems, but such differences are easily offset by the lower costs of production and the environmental benefits of OCT systems.

Figure 1 summarizes the data on cover crop biomass, weed biomass, and number of weed species in each plot. Cover crop biomass was above 4 t/ha in all plots except in the control, which had no cover crops. The lowest production of weed biomass occurred in plots with the combination of rye, fodder radish and vetch (0.26 t/ha) and rye-vetch (0.35t/ha), while all the other plots exhibited biomass values above 0.70 t/ha, and above 3,5 t/ha in the control without cover crops. The soil cover in the rye-vetch and rye-vetch-fodder radish plots was 92% at 60 days, which explains why these two cover crop mixtures exhibited higher weed suppressive potential. The vetch-rye-fodder radish and the rye-vetch mixtures had lower diversity of weed species (1.5 to 1.7 species), compared with 5.2 species in the control plots (fallow) which exhibited the highest number of species of all treatments followed by the rye- fodder radish plot.

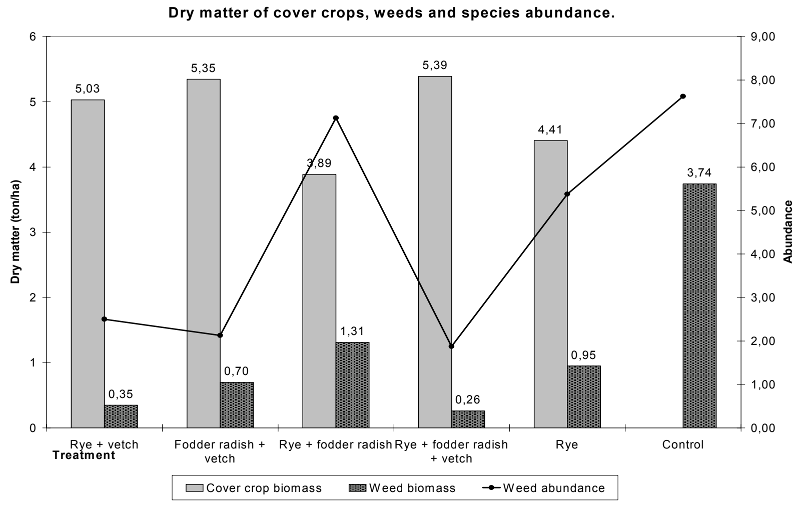

Figure 1: Cover crop and weed biomass and weed species diversity in experimental plots under various cover crop mixture treatments (Campos Novos, 2005)

Conclusions

Although phytotoxins associated with the cover crops residues can be toxic to the food crops grown after the cover crops are rolled, farmers avoid negative effects on crop emergence by waiting a few weeks between rolling the cover crop and seeding the crop, or more commonly by placing crop seeds below the toxic layer (allelopathic zone) formed by the phytotoxins leached a short distance (5-10 cm) from the mulch into the soil. In addition to weed suppression, residues also have positive effects on subsequent crops because of the increased soil quality parameters, improved crop nutrition, and in some cases suppression of soil-borne pathogens. Yields in most cases are 5-10% lower in OCT systems when compared to CT systems, but such differences are easily offset by the lower costs of production and the environmental benefits of OCT systems. In our trials the combination of grass and legumes enhanced biomass production and therefore mulch thickness, weed suppression, and organic matter inputs. The combination also offers a balanced carbon to nitrogen (C:N) ratio, which gives a gradual release of plant-available N, in contrast to the N-immobilization (tie-up) by an all-grass cover, or the rapid N release and potential leaching losses from an all-legume cover. Other nutrient effects seemed apparent: legumes tended to enhance availability of phosphorus (P), while grasses, especially rye, enhanced availability of potassium (K). By increasing cover crop diversity with fodder radish, the process of allelopathy was enhanced.

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Organic farming and biodiversity – how to create a viable farm business including conservation issues

Stein-Bachinger, K.[1] & Fuchs, S.[2]

Key words: nature conservation, target species, arable farming systems, management plan, multidisciplinary approach

Abstract

The extension of organic farming (OF), the increasing recognition of the advantages for improving agro-biodiversity, and the fact that the protection of nature and natural species cannot be taken for granted, has resulted in several interdisciplinary activities. The first of these was the Brodowin Nature Conservation Farm project. Conflicts between nature conservation and modern, large-scale OF, focusing on arable land use systems, were identified, evaluated and solved. Suggestions for adequate financial reward for ecological performance were worked out. The tested optimisation strategies were implemented in a second project: preparing a whole farm management plan based on maps marked with fields having a high potential for specific target species. The aim was to achieve the highest benefit for nature conservation issues with the least expenditure by the farm. A manual is being produced as a third project, with a series of examples for the integration of nature conservation measures, based on the results of our own projects and data sourced in literature, along with different experts. The manual will allow the user to see immediately either how target species/groups can be directly promoted or how measures can be selected, and what effects these have on the business.

Introduction

Agri-environmental programmes as well as nature conservation by contract are expected to improve biodiversity and wildlife quality on farms on a voluntary basis. OF plays a central role in agri-environment policy (e.g. KULAP in the State of Brandenburg) due to the positive environmental effects it has demonstrated in a number of investigations in the past (e.g. Hole et al. 2005). However, it is also well-known and accepted that special requirements for the improvement of the habitat of specific target species cannot be taken for granted. Conserving biodiversity in arable farming systems requires specialist knowledge and money (e.g. Noe et al. 2005, Flade et al. 2006, Stein-Bachinger et al. 2005). In the future, the shortage of funds will lead to a concentration on valuable areas (Flade et al. 2006) and the effectiveness and efficiency of the agri-environmental programmes has to be improved on the road to more result-oriented schemes (e.g. Matzdorf et al. 2007). In organic farming systems three facts can be postulated: (i) the potential to improve biodiversity is often higher on organic farms (Flade et al. 2006), (ii) agri-environmental measures specifically designed for arable systems in OF have been in short supply and are not sufficiently aligned with OF-requirements (e.g. weed pressure versus enhancing segetal flora, internal fodder production versus promotion of ground-breeding birds in forage (Stein-

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Bachinger et al. 2005), (iii) there is a lack of well-structured materials which concentrate on proved and recommended nature conservation measures, taking the agronomic and economic consequences into account as well as offering alternatives and compromises. In order to work out solutions for these issues, three projects focusing on the optimisation of nature conservation in large-scale OF in North-East Germany were initiated and still are being operated.

Materials and methods

Between 2001 and 2006, the Brodowin Nature Conservation Farm project focused on maintaining or creating habitat conditions for the flora and fauna of open and half-open agricultural areas, that garantuee a sufficient reproductive success to keep vital populations in the long-term (Stein-Bachinger et al. in prep.). Investigations were carried out in close cooperation with a large organic farm in North-East Germany (1200 ha). The recommended optimisation measures based on the effects on the target species and on agriculture were used in a second project. In 2007, we (biologists and agronomists) prepared a whole farm management plan for Brodowin, in cooperation with the farmer and the administration, based on maps marked with fields having a high potential for specific target species (arable measures as well as perennial or permanent structural measures). As a third project (2007-2008), a manual is being produced for the integration of nature conservation measures into organic farming systems, based on our own results and data sourced in literature, along with experts recruited among farmers, advisors, the administration, and scientists.

Results and discussion

Within the framework of the Brodowin Nature Conservation Farm project, recommendations for the protection of farmland birds, brown hare, amphibians, insects and segetal flora were made concerning arable and structural measures. The effects of modified farming systems were investigated with regard to their agronomic and economic aspects. The interdisciplinary character allowed for a detailed evaluation and recommendation of more than 20 different production measures which promote biodiversity in legume-grass forage, cereals, pulses and field margins taking the whole farm organisation into account (Stein-Bachinger et al. in prep.). Table 1 shows selected measures in cereals and pulses and their efficiency for target species.

Tab. 1: Modified production measures in cereals and pulses and their efficiency for nature conservation goals

Measure	Description	Efficiency for nature conservation			
		Farm-land birds	Brown hare	Amphi-bians	Sege-tal flora
Reduce intensity of weed control	No harrowing/hoeing	+*	+		+
Reduce sowing density	Half the sowing density, no harrowing/hoeing	+	+		++
Reduce soil tillage operations	Stubble breaking after mid-September		+	+	++

* Efficiency: + = high, ++ = very high

Figure 1 shows that the reduction of weed control and sowing density leads to a decrease in yields of spring and winter cereals. These three years' data, along with results from literature and expert knowledge, were used for economic calculations (e.g. partical analysis, cross margins). The modified measures have to be awarded 50 to 150 €/ha/year to compensate for the reductions in yield and potential problems with undesirable weeds. For farmland birds and brown hare, the measures should be carried out upon the whole field; for amphibians and segetal flora, small-scale implementation, preferably on 'hot spots', is recommended. Further criteria have to be considered for a goal-oriented field selection e.g. for farmland birds: no or only a small area of forest around the fields (< 20 %) and a field size of 5 - 20 ha.

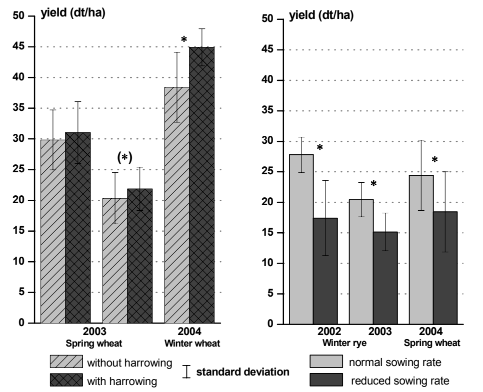

Figure 1: Effects of a reduction in the intensity of weed control and sowing density on the yield of spring wheat, winter wheat and winter rye in Brodowin, significant differences with α=5% are marked ∗, with α=10% (∗), Wilcoxon-Test)

The proved optimisation strategies were used in a subsequent step to prepare a whole farm management plan. The farm consists of 85 arable fields. Fields with a high potential (e.g. high territory densities or reproductive success) for farmland birds, brown hare, segetal flora and amphibians were identified. For example, on 16 of these 85 fields the effects of nature conservation measures for farmland birds will be above average, and thus the implementation will concentrate on these locations. The aim is to achieve the highest benefit for nature conservation with the least expenditure of effort by the farm. In 2008, seven measures will be implemented; in subsequent years, the preparation of a catalogue of measures with selection and expansion possibilities is planned. The farm will promote itself with information boards for visitors as well as on the farms' website and with newsletters for 1700 subscribers of the vegetable box scheme.

According to our experience and that of other authors (Noe et al. 2005), a lot of farmers do not necessarily disagree with conservation criteria, but they often do not know what to look for and how to integrate modified production measures into their farm business. Therefore the compilation of all of the above-mentioned results and experience will lead in a third step to a manual that allows the user (farmers, advisors and the administration) to see immediately either how target species/groups can be promoted directly or how measures can be selected, and what consequences they can have on the business. Experts recruited among the user group and scientists with different expertise are involved to discuss and evaluate the profiles of nature conservation-friendly production measures and target species in order to integrate a broad range of aspects and knowledge.

Conclusions

The success of increasing biodiversity on the farm and landscape level depends essentially on the availability of suitable and proved information, as well as on practical examples which open the view for developing organic farming within the conservation movement and achieve a balance between the objectives of all stakeholders. The foundation of 'Nature Conservation Farms' can be a step towards reflecting one's own values in relation to the wild flora and fauna and to providing examples of multifunctional agriculture.

Acknowledgments

The research activities are primarily supported by the German Federal Agency for Nature Conservation (BfN), with funds granted by the Federal Ministry of Environment, Nature Conservation, and Nuclear Safety (BMU). Additional support was provided by the Federal Ministry of Consumer Protection, Nutrition, and Agriculture (BMVEL), the State Ministry of Agriculture, Environment, and Spatial Planning (MLUR) of Brandenburg, and the Brandenburg State Office of Nature Protection. The projects have been carried out by the Ökodorf Brodowin e.V. (registered association) and the Centre for Agricultural Landscape Research (ZALF).

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Beneficial Invertebrate Activity in Organic and Conventional Vegetable Fields in Eastern England

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Key words: Beneficial invertebrates; organic vegetables; field margins; farm management

Abstract

Beneficial invertebrate activity was assessed in 2005 and 2006 in three organic and one conventional vegetable field using pitfall and pan traps. Data was generated from a total of 208 trapping sites in cauliflower, leek, cabbage, purple sprouting broccoli and calabrese crops and 80 sites in planted field margins. More activity of epigeal invertebrates was found in Brassica fields compared with leek fields and there was more in organic than conventional Brassica fields. Activity of useful invertebrate groups in the field margins decreased with vegetation development and there appears to be a need for management of margins in order to optimise activity of the most appropriate beneficial groups for the crop planted.

Introduction

The increase in area of organically farmed agricultural land, brought about mainly as a result of concerns about food quality (Leifert et al., 2007), has necessitated an increased knowledge of the distribution of beneficial invertebrates because crop protection chemicals cannot be used on organic fields. This is especially needed in intensively cultivated vegetable fields because, for instance, some ground beetles are known to be potentially important predators of cabbage root fly eggs (Finch, 1996), a pest of all Brassica crops. Groups such as ladybirds (Coccinellidae) and lacewings (Neuroptera) predate aphids, which can be a problem on a number of crops. Recent work (Prasad & Snyder, 2006) has shown that small and medium-sized ground beetles are useful in vegetable crops but large ground beetles are more likely to predate smaller beetles than pests. Enhancements such as planted field margins and beetle banks have been used to try to increase beneficial invertebrate activity (Landis et al., 2005) and these are likely to be most important in organic systems.

The influence of crop type, management system and field margin on beneficial invertebrate activity in three organic and one conventional vegetable field in eastern England was assessed in 2005 and 2006. Three Carabidae (ground beetle) groups, based on size, and seven other groups were recorded in five crop types and in field margins differing in structure between fields and from year-to-year.

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Materials and methods

Five pitfall traps (8.5 cm diameter, 10 cm deep), 0.5 m apart, part-filled with saturated salt (NaCl) solution containing a small amount of strong detergent as a preservative were used to sample epigeal invertebrates at each site and a yellow box (22 x 31 cm, 20 cm deep), containing 1 cm of salt preservative, was used to sample aerial invertebrates. Sites were 20m apart and in lines 15, 30 and 45 m from the field margins. There were 40 sites in two cauliflower (var marathon) fields in 2005 and again in the same fields with leeks (var roxton) in 2006. In 2006 another organic field with cabbage (var sunta) and purple sprouting broccoli (var bordeaux) had 24 sites, as did a conventional field with calabrese (var iron). The conventional field was sprayed with herbicides and pesticides, for the control of cabbage root fly, and there was the use of inorganic fertiliser. The 4 m field margins of the organic fields were sown with a wild flower mix in late 2004, whilst the margin of the conventional field was sown in June 2006. Four sites were sampled in the two margins of each organic field, with eight margin sites in the conventional field. Traps were set in the first week in May 2005 for the cauliflower fields, the last week of May 2006 for the leek fields and the first week of May 2006 for the other two fields. Four samples were taken, at between three and four-week intervals, to cover most of the period from planting to harvest.

Carabidae (ground beetles) from the pitfall traps were split into three groups; small (<5 mm in length), medium (5-10 mm) and large (>10 mm) and counted, as were total numbers of Linyphiidae and Lycosidae (money and wolf spiders) from pitfall traps and of Staphylinidae (rove beetles), Coccinellidae (ladybirds), Syrphidae (hoverflies), Neuroptera (lacewings), and Hymenoptera (parasitic wasps; Ichneumonidae, Proctotrupoidae, Braconidae, Pteromalidae) from both traps. The totals, transformed by $\log_{10}n+1$, were used in linear mixed-effects models in the R statistical environment (R Development Core Team, 2007). Models had crop as a fixed factor and field and year as random factors and field margin location (field) as a fixed factor and year as a random factor. Means were compared using the Tukey HSD test ($P<0.05$).

Results

There were significant differences in the activity of all invertebrate groups between crop types (Tab. 1) except Hymenoptera. Activity of small Carabidae was greatest in cabbage and least in calabrese whilst there were few medium-sized Carabidae in all crops other than cauliflower. There were more large Carabidae in cabbage and broccoli than in the other crops whilst Staphylinidae activity was least in leek and calabrese. Most Cantharidae were found in cauliflower whilst the cabbage and broccoli had considerably more Coccinellidae than the other crops. Linyphiidae were least active in calabrese with most of the few Lycosidae in cabbage. Leek fields had the most Syrphidae and by far the most Neuroptera. Most Hymenoptera were found in cauliflower, with the least in broccoli. In general, there was less activity of invertebrates in the conventional calabrese with more epigeal invertebrate activity in organic Brassica crops and more aerial activity in the leeks. There were significant differences in activity in the field margins (Tab. 2). There were considerably more small and medium-sized Carabidae, Linyphiidae and Hymenoptera and fewer Staphylinidae, Cantharidae, Coccinellidae and Syrphidae in the margins of the cauliflower fields compared with the same sites in 2006. There were few Neuroptera recorded and the least activity of small and large Carabidae, Coccinellidae, Linyphiidae and Hymenoptera in the margins of the cabbage and broccoli field, although this field's margins had the most Lycosidae.

Tab. 1: Mean numbers of beneficial invertebrate groups recorded from sites in the five crop types (O = organic, C = conventional, Cauli = cauliflower, Cabb = cabbage, PSB = purple sprouting broccoli, Calab = calabrese).

Group	Ocauli	Oleek	Ocabb	OPSB	Ccalab	
Small Carabidae	94^{c}	91^{c}	304^{a}	197^{b}	49^{d}	***
Medium Carabidae	35^{a}	4^{b}	14^{a}	9^{b}	10^{a}	**
Large Carabidae	36^{c}	120^{b}	325^{a}	297^{a}	88^{b}	***
Staphylinidae	167^{a}	76^{b}	159^{a}	142^{a}	84^{b}	**
Cantharidae	5^{a}	2^{b}	1^{b}	1^{b}	0^{b}	***
Coccinellidae	9^{b}	11^{b}	36^{a}	46^{a}	1^{c}	***
Linyphiidae	88^{b}	116^{a}	106^{ab}	83^{ab}	44^{c}	**
Lycosidae	1^{c}	3^{ab}	4^{a}	3^{ab}	2^{bc}	**
Syrphidae	1^{b}	13^{a}	10^{a}	4^{b}	2^{b}	***
Neuroptera	0^{b}	14^{a}	1^{b}	0^{b}	0^{b}	***
Hymenoptera	100^{a}	90^{a}	79^{a}	57^{a}	76^{a}	n.s.

n.s. not significant
** significant for P<0.01
*** significant for P<0.001

Superscripts indicate significant differences between means (P<0.05)

Tab. 2: Mean number of beneficial invertebrate groups recorded from sites in the field margins of the six fields in the two years (05, 06) of the survey

Group	Org05 Caul1	Org05 Caul2	Org06 Leek1	Org06 Leek2	Org06 Cabb/PSB	Con06 Calab	
Small Carabidae	121^{a}	130^{a}	57^{b}	41^{b}	18^{b}	26^{b}	**
Medium Carabidae	260^{a}	249^{a}	68^{b}	90^{b}	92^{b}	83^{b}	*
Large Carabidae	220^{ab}	175^{b}	301^{a}	222^{ab}	70^{c}	173^{b}	***
Staphylinidae	99^{b}	133^{b}	251^{a}a	154^{ab}	208^{ab}	107^{b}	*
Cantharidae	5^{b}b	3^{b}	52^{a}	51^{a}	11^{b}	6^{b}	***
Coccinellidae	3^{a}	10^{a}	24^{a}	20^{a}	7^{a}	23^{a}	*
Linyphiidae	1004^{a}	646^{a}	217^{b}	108^{b}	32^{b}	79^{b}	***
Lycosidae	16^{b}	37^{a}	44^{ab}	22^{b}	74^{a}	5^{b}	***
Syrphidae	0^{c}	0^{c}	44^{ab}	56^{a}	21^{bc}c	24^{bc}	***
Neuroptera	0^{b}	0^{c}	0^{b}	0^{b}	6^{a}	2^{ab}	***
Hymenoptera	496^{a}	316^{b}	183^{c}	159^{c}	78^{c}	99^{c}	***

* significant for P<0.05
** significant for P<0.01
*** significant for P<0.001

Superscripts indicate significant differences between means (P<0.05)

Discussion

Less beneficial invertebrate activity was recorded from the conventionally managed calabrese field, with use of herbicide and insecticide. However, there was also far less activity of the soil-surface active invertebrate groups in the leek fields compared with the organic Brassica fields, although aerial invertebrate activity was generally higher. Ground beetle species distribution has been linked to the extremes of disturbance (Eyre, 2006) and the open leek fields are more disturbed and provide less cover than Brassicas. The planted field margins should provide a supply of appropriate beneficial invertebrates and the margins of the cauliflower fields in 2005 had high numbers of small and medium-sized Carabidae. These are predators of cabbage root fly eggs (Finch, 1996), but there was less activity in the field, especially of medium-sized Carabidae, indicating poor migration from the margins. This lack of immigration into crop fields has been observed with spiders (Sunderland & Samu, 2000) and most immigration from the margins appears to have by large Carabidae, of little use for egg predation (Prasad & Snyder, 2006). Vegetation density differed in the organic field margins between the two years and there was far more activity of the useful smaller Carabidae, as well as the Linyphiidae, in the more open margins of 2005 compared with the dense, total cover in 2006.

Conclusions

Whilst there were considerable differences in beneficial invertebrate activity between leek and Brassica crops, differences in activity in field margins are likely to more important. In order to optimise activity of specific beneficial invertebrates, properly planned management of field margins is likely to be necessary.

Acknowledgments

This work was supported by the European Union Integrated Project QualityLowInputFood (EU FP6 Contract CT-2003-506358).

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Opportunities and Obstacles in Adoption of Biodiversity-Enhancing Features on California Farms

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Key words: biodiversity, ecosystem services, adoption, multifunctionality

Abstract

The USDA National Organic Program requires the conservation of biodiversity and the maintenance or improvement of natural resources on organic farms. On-farm biodiversity-enhancing features such as border plantings can provide many of these ecosystem services. However, which practices farmers currently use to manage non-cropped edges, why and how they use these practices, and how subsidies and technical assistance affect farmers' ability and willingness to manage farm edges for biodiversity are little studied topics. Our study set out to identify the range of practices currently used to manage non-cropped field edges, roadsides, pond edges, and banks of permanent watercourses (sloughs, canals, ditches) in a case study area in California. Secondary objectives were to gauge local farmers' awareness of planted hedgerows and vegetated waterways and to gather preliminary information about the range of incentives and constraints to installing such features.

Introduction

Border plantings enhance the multifunctionality of farms in that they provide numerous ecosystem services. They can provide habitat and dispersal corridors for wildlife (Ouin and Burel 2002), and alternative food sources and habitat for predator and pollinator insect populations (Kremen et al. 2002). They can lower pest populations, displace noxious weeds, and function as buffers to slow soil erosion and runoff and intercept airborne dust (Marshall and Moonen 2002). A diversity of perennial vegetation along watercourses may increase net accumulation of soil carbon and soil organic matter, improve retention of nutrients, and reduce greenhouse gas emissions due to greater plant uptake (Rowe et al. 2005). The USDA National Organic Program requires the conservation of biodiversity and the maintenance or improvement of natural resources on farms marketing products as organic. Therefore, adoption of practices that enhance biodiversity, such as border plantings, is of particular significance to organic farmers.

Several voluntary USDA conservation programs, including the Conservation Reserve Program and the Environmental Quality Incentives Program, give farmers technical

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and financial assistance in installing border features such as hedgerows, buffer strips, and grassed waterways, among others. However, little is known about why farmers do or do not adopt these multifunctional edge management practices, and inferences must be drawn from literature about related conservation practices. Stonehouse (1996) reviewed the literature on adoption of various in-field and field edge soil conservation practices in the U.S. and Canada and found that more and better technical information is needed about most conservation practices, but that often the available information about costs and benefits of such practices is inadequate. A 2001 USDA study (Lambert et al. 2006) found that percentage of off-farm income was negatively associated with participation in federal programs involving conservation structures, indicating the importance of an orientation to farming as a way of life. This study also found that the production of high-value crops was negatively associated with installation of conservation structures.

The above cited literature focuses on farmers as individual decision makers who manage individual farms, instead of a community of decision makers who manage contiguous pieces of a larger landscape. However, many of the ecosystem services potentially attributable to biodiverse farm edges occur at a larger landscape scale, suggesting that a landscape, with its collective of land managers, may be a more appropriate unit of analysis than an individual farm with individual decision makers. The general literature on adoption and diffusion of innovations demonstrates that the observability of innovations as well farmers' physical and social proximity to each other are important factors in the spread of practices across a community.

Materials and methods

We chose the geographic area for this study to include farm and rangeland in western Yolo County, California, encompassing 7,114 ha, or roughly 72 square km. It includes both lowland, irrigated and intensively farmed cropland, as well as hilly, more extensively farmed, unirrigated rangeland. This area has a prevalence of public and private sector programs focused on increasing on-farm biodiversity and conservation. Yolo County has a very active Resource Conservation District (RCD) that works closely with the local office of the Natural Resources Conservation Service to connect local farmers with federal conservation cost-share programs. In the private sector, Audubon California's Landowner Stewardship Program has conducted farmer and landowner conservation projects in and near the study area.

We sought to interview all individuals who make day-to-day farm management decisions over the land in our study area in telephone interviews that were conducted in August-November, 2006. We succeeded in interviewing 22 out of 28 total farm managers, a response rate of 81%. The land managed by the interviewed farmers represents 71% of the total study area and produces over 20 different crops during different seasons, including field crops (tomatoes, alfalfa, vegetable seeds), orchard crops (almonds, walnuts, plums) and cattle. About 61% of the land area are owned by the farm operators, with the remaining 39% being rented. Twelve of the 22 respondents (55%) pursue farming as their sole occupation, while 10 farmers (45%) have off-farm employment. Four of the farms are either fully or partially in certified organic land, two in field crops and two in orchard crops.

Results

Most farmers reported using a combination of two or more practices from a set of six active management practices (disc, apply herbicide, mow, hand hoe, burn, graze). Almost half use discing and herbicide applications in combination either with or without additional practices. In the sample as a whole, edges along natural watercourses tend to be less intensively-managed than other farm edges. Five farmers reported using no active management practices on watercourse edges while all farmers mentioned using at least one active practice on field and road edges. Half of the farmers reported leaving naturally occurring vegetation, including large trees, along waterways compared to only 18% for field and road edges. Thirteen farmers in the sample have planted hedgerows, windbreaks, individual trees, and/or native grasses and sedges, and one-third of these farmers (4) farm organically. Of the remaining farmers, all but one indicated that they had heard of these practices before. Nine of the farmers have installed tail water or rangeland ponds.

Tab. 1: Numbers of farmers using designated practices on farm edges

Practice	# of farmers in total sample using practice on waterway edges (N=22)	# of farmers in total sample using practice on field/road edges (N=22)	# of organic farmers using this practice on any edge (N=4)
Disc/scrape	6	11	1
Herbicide	9	14	2*
Hand hoe	2	3	1
Burn	2	3	1
Mow	6	12	4
Do nothing/ natural veg.	14	8	3
Grasses/ sedges	1	0	3
Hedgerows	4	4	4
Graze	2	0	0
Install pond	NA	9	3

* These farmers have both certified organic and conventional fields.

Discussion

One of the most frequently mentioned objectives in edge management is to keep undesirable elements out of crop fields, in almost all cases weeds but in some cases also rodents and other pests. While RCD materials suggest that filling edge areas with non-invasive native and introduced plants can suppress the growth of invasive weeds, only a minority of farmers in the study appear to consider this potential of hedgerows in their edge management decisions. Six individuals expressed a desire to attract beneficials and possibly even decrease pesticide use as a strong motivating factor, in keeping with the relatively larger number of research studies that have suggested important roles for hedgerows in pest management. Several of these farmers also indicated, however, that the direct impact of such plantings on pest populations is currently difficult for them to discern on their farms and is a topic that could benefit from further research. This observation is consistent with research on conservation practices that technical and performance information about practices is inadequate. The benefits that were more visible to farmers who had edge plantings included increasing wildlife habitat, especially for birds such as quail and pheasants. Two farmers observed dust control as a benefit of hedgerows. Three fourths of the farmers explicitly mentioned awareness of cost-share and technical assistance programs for hedgerow and pond installation. All sampled farmers who have hedgerows and ponds have taken advantage of one of these programs. Despite the presence of and high familiarity with cost-share programs, however, the high cost of hedgerows and other planted features is still one of the most frequently noted constraints to installing such features. Absentee landlords whose main concerns are getting a rent check were also mentioned as potential blocks to conservation projects, consistent with previous research in other parts of the U.S. associating tenure with adoption of all types of conservation practices. Finally, most of the farmers with hedgerows are full-time farmers with no off-farm income and farm relatively larger acreages. These findings are also consistent with other research on adoption of on-farm conservation practices. Two organic farmers and one conventional farmer were mentioned by a majority of respondents for providing examples of border plantings for other farmers to see. All three farmers have played leadership roles in on-farm research and demonstration projects, and were regarded by others as influencing the unusually high adoption rate of border plantings in this area.

Conclusions

This study demonstrates that organic farmers can provide a leadership role in installing multifunctional farm edge features across a landscape. It also, however, reveals critical gaps in information and understanding about the implementation as well as the benefits of such biodiversity features. Demand for relevant information will likely increase along with the continuing increase in organic farmland and the growing awareness of farmers, landowners, scientists, and government of the potential capacity for farm edge features to provide multifunctional ecosystem services.

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Crop Type and Management Effects on Ground Beetle Species (Coleoptera, Carabidae) Activity in an Extensive Plot Trial

Eyre, M.D.[1], Shotton, P.N.[2] & Leifert, C.[3]

Key words: Ground beetles, Carabidae, Fertiliser, Crop Protection, Organic farming

Abstract

The effects of crop type, and of fertility and crop protection management within crops, on ground beetle species activity were investigated using the Nafferton Factorial Systems Comparison Experiment, using pitfall traps in 2005. Thirteen species gave significant responses to crop type, with seven showing a preference for cereals and none for grass/clover. There were 22 significant responses to fertility and six to crop protection within crop types. Sixteen of the responses to fertility and four to crop protection resulted in more activity in organically managed plots. Fertility effects were found most in wheat, barley and grass/clover whilst crop protection effects were mainly in beans and vegetables. A better knowledge of the effects of fertility management is required following changes from conventional to organic farming.

Introduction

Ground beetles (Carabidae) are considered to be one of the more important beneficial invertebrate groups. Increased ground beetle activity in organic crops, compared with conventional, was reported by Pfiffner & Niggli (1996) but Purtauf et al. (2005) found no difference between organic and conventional wheat. Crop type was shown to have a greater effect on activity than management system. The effects of pesticides on beneficial invertebrates have been regularly reported (e.g. Sherratt & Jepson, 1993) but the effects of fertility management have not been rigorously investigated. The Nafferton Factorial Systems Comparison Experiment provides an opportunity to assess ground beetle species activity at the plot scale in a system with a number of organically and conventionally managed crop types. Eyre et al. (2007) found that fertility management had more effect on invertebrate activity than crop protection management. The effects of crop type and management systems on ground beetle species activity were investigated to provide better baseline information for use in the application of natural pest enemies in organic agriculture.

Materials and methods

The Nafferton Factorial Systems Comparison Experiments consists of 128 plots (24 x 12 m) in an area converted to organic management in 2003. In 2005 the plots contained wheat, barley, beans, vegetables (potatoes, cabbage, onions, lettuce, carrots) and grass/clover. The 64 conventionally managed plots were treated with inorganic fertiliser and sprayed with herbicide, fungicide and pesticide where appropriate. The 64 organic plots were fertilised with compost and no sprays were

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used. Each plot was sampled for epigeic invertebrates using five pitfall traps with saturated salt solution and a small amount of detergent as a preservative, were set in the first week of May 2005 and five monthly samples were generated (see Eyre et al., 2007). Samples were sorted in the laboratory and ground beetles identified to species. The number of individuals of 30 of the 53 species recorded, transformed by $\log_{10}n+1$, was used in linear mixed-effects models in the R statistical environment (R Development Core Team, 2007). Analysis of variance was generated using models with fertility, crop protection and crop as fixed factors and the blocks of the trial as a random factor. Data from all plots were used to assess the effect of crop type whilst the effects of differing fertility and crop protection management were assessed within each crop type.

Results

There were highly significant relationships between crop type and the activity of 13 ground beetle species (Tab. 1). Five species were most active in wheat, four in beans, two each in barley and vegetables and none in grass/clover. Five species had the least activity in the vegetable and grass/clover plots, two in beans and one in barley. Significant responses of ground beetle species activity to organic or conventional fertility or crop management in each of the crops are shown in Tab. 2, with plot means showing the preference for management type. Four species gave significant responses to fertility in grass/clover, three preferring organic and one conventional management. One species preferred conventional fertility in beans with the activity of three significantly related to crop protection, two preferring conventional plots. Eight species were affected significantly by fertility in wheat, with more of six in organic plots. One species was more active in organic crop protection wheat plots whilst all eight species giving significant responses in barley were affected by fertility, six more active in organic plots.

Tab. 1: Ground beetle species giving a significant response to crop type and the mean number recorded from plots in the five crop types.

Species	Grass/ clover	Beans	Wheat	Barley	Vegeta bles	
Amara familiaris	3	7	1	2	1	***
Amara plebeja	6	6	10	13	3	***
Anchomenus dorsalis	5	7	5	3	2	***
Bembidion aeneum	35	23	54	47	25	***
Bembidion guttula	9	31	22	12	10	***
Bembidion lampros	12	36	12	13	55	***
Bembidion tetracolum	12	49	8	6	31	***
Loricera pilicornis	20	20	19	31	3	***
Nebria brevicollis	35	74	132	107	122	***
Notiophilus biguttatus	4	5	6	6	7	***
Pterostichus melanarius	51	37	89	71	41	***
Pterostichus strenuus	13	10	11	24	4	***
Trechus quadristriatus	26	31	146	92	44	***

*** significant for P<0.001

Only one species preferred organically fertilised vegetable plots whilst two were more active in vegetable plots with organic crop protection.

Tab. 2: Ground beetle species giving a significant response to either fertility or crop protection within each crop type, together with mean numbers recorded from plots with organic and conventional management.

Crop and species	Factor	Organic	Conventional	
Grass/clover				
Amara plebeja	Fertility	8	4	*
Nebria brevicollis	Fertility	48	21	***
Pterostichus melanarius	Fertility	65	37	**
Trechus quadristriatus	Fertility	19	34	***
Beans				
Amara familiaris	Fertility	5	9	*
Bembidion lampros	Crop protection	29	44	*
Bembidion quadrimaculatum	Crop protection	1	4	*
Trechus quadristriatus	Crop protection	26	38	*
Wheat				
Bembidion guttula	Fertility	30	14	**
Bembidion lampros	Fertility	17	7	**
Bembidion tetracolum	Fertility	13	4	**
Loricera pilicornis	Fertility	11	26	**
Nebria brevicollis	Fertility	166	97	***
Notiophilus biguttatus	Fertility	4	7	*
Pterostichus melanarius	Fertility	126	53	**
Pterostichus strenuus	Crop protection	13	10	*
Synuchus vivalis	Fertility	7	2	***
Barley				
Agonum muelleri	Fertility	9	1	***
Bembidion lampros	Fertility	17	9	*
Bembidion tetracolum	Fertility	9	2	**
Loricera pilicornis	Fertility	19	43	***
Nebria brevicollis	Fertility	147	67	***
Pterostichus melanarius	Fertility	96	45	***
Pterostichus strenuus	Fertility	17	32	**
Vegetables				
Bembidion aeneum	Crop protection	29	22	*
Bembidion tetracolum	Crop protection	48	15	***
Pterostichus strenuus	Fertility	6	2	*

* significant for P<0.05, ** significant for P<0.01, *** significant for P<0.001

Discussion

Of the 13 ground beetle species providing significant responses to crop type, nine were most active in the tall wheat and beans whilst none were most active in grass/clover. Grass/clover provided the densest ground cover and it appears that all 13 species preferred some bare ground, with the smaller species most active in crops with the least ground cover. Eyre (2006) showed that ground beetle species differ in their reaction to disturbance and the less ground cover, the more disturbed and exposed the plot and Kromp (1999) postulated that inorganic fertiliser may have an effect on ground beetle activity in crops. Within crop types, fertility management had considerably more effect on species activity than crop protection management, especially in cereals. There was a marked preference for organically fertilised plots in wheat, barley and grass/clover. The two species with a preference for conventionally managed bean may have reacted to more bare soil and fewer weeds given the herbicide application.

Conclusions

The results indicate that far more attention needs to be given to the effects of fertility management on invertebrate activity and distribution in crops. This will have an effect on the efficient use of beneficial invertebrates in pest control within organic agriculture.

Acknowledgments

The authors gratefully acknowledge funding from the European Community financial participation under the Sixth Framework Programme for Research, Technological Development and Demonstration Activities for the Integrated Project QUALITYLOWINPUTFOOD, FP6-FOOD-CT-2003- 506358.

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Spider (Araneae) Species Activity, Crop Type and Management Factors in an Extensive Plot Trial

Eyre, M.D.[1], Shotton, P.N.[2] & Leifert, C.[3]

Key words: Spiders, Organic farming, Fertiliser, Crop protection

Abstract

Spider species activity in five crop types, with organic and conventional fertility and crop protection management, was assessed using pitfall traps in 2005. Significant differences in activity between crop types were seen with 16 species, with 14 most active in grass/clover and 12 least active in vegetable plots. Within crops there were 20 significant responses to fertility, with 16 more active in conventional plots. Crop protection management produced four significant models, with three preferences for organic management. Small linyphiid species showed a distinct preference for the densest vegetation on conventionally fertilised plots, whilst the larger lycosid species were more active on the more open organic plots. In general, there was more activity in conventionally managed crops, in contrast to other reports.

Introduction

Agricultural management has a considerable effect on the activity of spiders (Cole et al., 2005) and Fuller et al. (2005) found more spider activity in organic wheat than conventional. However, crop type had more effect on activity than management system. Eyre et al. (2007) found that fertility rather than crop protection management had considerably more influence on the activity of beneficial invertebrates and the Nafferton Factorial Systems Comparison Experiment provides an opportunity to assess spider species activity at the plot scale. A number of organically and conventionally managed crop types were surveyed.

Materials and methods

The Nafferton Factorial Systems Comparison Experiments consists of 128 plots (24 x 12 m) in an area converted to organic management in 2003. In 2005 the plots contained wheat, barley, beans, vegetables (potatoes, cabbage, onions, lettuce, carrots) and grass/clover. The 64 conventionally managed plots were treated with inorganic fertiliser and sprayed with herbicide, fungicide and pesticide where appropriate. The 64 organic plots were fertilised with compost and no sprays were used. Each plot was sampled using five pitfall traps with saturated salt solution containing a small amount of strong detergent as preservative. The traps were set in the first week of May 2005 and five monthly samples were generated. Samples were sorted in the laboratory and spiders identified to species. Data analyses with 29 of the 57 species recorded were used in linear mixed-effects models in the R statistical environment (R Development Core Team, 2007), as in Eyre et al. (2007).

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Results

Sixteen species produced significant responses with the crop models and the mean numbers recorded from each crop is shown in Tab. 1. The mean number of most species was low, with only four species having means of over 10 in a crop. Fourteen species were most active in grass/clover, with 12 having the least activity in the vegetable plots. There was more activity of the abundant species in the cereal crops than in beans.

The significant responses of species to fertility or crop protection within crop types and the means showing preferences for organic or convention plots are shown in Tab. 2. Two species produced significant responses in grass/clover with fertility, one preferred conventional plots, the other organic. *O. retusus* preferred bean plots with conventional fertility whilst two *Pardosa* species were more active in bean plots with organic crop protection. Four linyphiid species produced significant responses to fertility in wheat, all preferring conventional plots. Seven of the 10 species giving a significant response to fertility in barley liked conventional management with more of three species in organic plots. There was more activity of three linyphiid species in conventionally fertilised vegetable plots, with one species preferring conventional crop protection and another organic.

Tab. 1: Spider species giving a significant response to crop type and the mean number recorded from plots in the five crop types.

Species	Grass/ Clover	Bean s	Wheat	Barle y	Vegetable s	
Bathyphantes gracilis	6	2	2	3	0	***
Centromerita bicolour	2	2	1	1	0	**
Erigone atra	152	60	87	84	25	***
Erigone dentipalpis	56	17	17	24	10	***
Leptorhoptrum robustum	2	2	1	1	0	**
Lepthyphantes tenuis	24	14	15	15	14	***
Lepthyphantes zimmermanni	3	1	1	1	2	***
Milleriana inerrans	4	2	3	4	2	**
Oedothorax fuscus	7	3	1	5	2	***
Oedothorax retusus	1	1	1	0	0	**
Pardosa agricola	3	3	2	3	1	**
Pardosa amentata	4	4	2	2	2	**
Pardosa pullata	2	0	0	1	0	***
Pachygnatha clercki	0	1	0	1	0	***
Pachygnatha degeeri	14	4	4	6	2	***
Robertus neglectus	1	2	1	1	0	**

** significant for $P<0.01$

*** significant for $P<0.001$

Tab. 2: Spider species giving a significant response to either fertility or crop protection within each crop type, together with mean numbers recorded from plots with organic and conventional management.

Crop and species	Factor	Organic	Conventional	
Grass/clover				
Erigone atra	Fertility	145	168	*
Pardosa agricola	Fertility	4	3	***
Beans				
Oedothorax retusus	Fertility	0	1	*
Pardosa agricola	Crop protection	4	2	*
Pardosa amentata	Crop protection	5	3	*
Wheat				
Dicymbium nigrum	Fertility	0	1	***
Erigone atra	Fertility	59	117	**
Leptorhoptrum robustum	Fertility	0	2	**
Milleriana inerrans	Fertility	2	4	**
Barley				
Bathyphantes gracilis	Fertility	2	4	**
Erigone atra	Fertility	60	107	***
Erigone dentipalpis	Fertility	20	27	*
Leptorhoptrum robustum	Fertility	0	1	*
Lepthyphantes tenuis	Fertility	12	18	***
Milleriana inerrans	Fertility	1	6	***
Pardosa agricola	Fertility	5	0	***
Pardosa amentata	Fertility	3	1	*
Pachygnatha degeeri	Fertility	7	5	**
Robertus neglectus	Fertility	1	2	*
Vegetables				
Diplostyla concolor	Crop protection	0	1	*
Erigone atra	Fertility	19	31	***
Milleriana inerrans	Fertility	1	3	*
Ostearius melanopyrgius	Fertility	0	2	*
Robertus neglectus	Crop protection	1	0	*

* significant for P<0.05, ** significant for P<0.01, *** significant for P<0.001

Discussion

One obvious observation from the results was that although 57 species were recorded, most were trapped at very low numbers. However, the two most abundant species, *E. atra* and *E. dentipalpis*, were the most abundant species on Scottish agricultural land and also on the plots sampled here. Weibull & Östman (2003) found differences in spider activity between cereal and grassland crops and there were considerably more activity in grass/clover plots for most species, with the least on the vegetable plots. Within crops there were 20 significant models with fertility, with more activity of 16 species in conventional plots. There appears to be a difference between small, linyphiid species, preferring denser vegetation on conventional plots, and larger lycosid species, favouring the more open organic plots. Of the four significant responses to crop protection, three showed preferences for organic management, possibly related to increased weed cover (Sunderland & Samu, 2000) with no herbicide application. However, in general most activity was in the conventionally managed crops, a contrast with other reports (Schmidt et al., 2005).

Conclusions

Vegetation architecture is known to affect spider activity and fertility and crop protection management can change crop structure. In the plots surveyed there was more spider activity in the more densely vegetated conventionally managed crops.

Acknowledgments

The authors gratefully acknowledge funding from the European Community financial participation under the Sixth Framework Programme for Research, Technological Development and Demonstration Activities for the Integrated Project QUALITYLOWINPUTFOOD, FP6-FOOD-CT-2003- 506358.

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Weed species diversity and cover-abundance in organic and conventional winter cereal fields and 15 years ago

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Key words: conventional / organic farming, diversity, weeds, winter cereals

Abstract

In this research, we compared the weed species development in conventional and organic winter cereals in Upper Austria. The investigations were done in 2003 in 15 paired conventional and organic farms. Following Braun-Blanquet procedure, a total of 105 weed species were found. 57 of them were found only in organic, four only in conventional fields and 48 in both. Therefore, there were 105 weed species in organic fields and 52 in conventional fields. More of the endangered species (Red List species) were found in organic fields. Low species diversity observed in 2003 compared to that in 1988 in the same field was attributed to higher temperature and low rainfall in the recent years. The question arises if under increasing temperature and dryness the diversity of species is regressing and endangered the biodiversity of weeds and linked with that also insects and other species as well as offers space for weeds with strong competition to cultivated crops.

Background and objectives

Several investigations have shown, that the diversity of flora and fauna is higher under organic in contrary to conventional farming (e.g. Rasmussen et al. 2006; Frieben 1998, 1988; Plakolm 1989, Callauch 1981). The abandonment of herbicides and pesticides as well as the diversified crop rotations are well known as most important factors influencing this development. Supporting conditions for a high species diversity are not only limited to the arable fields but reach also the environment of the cultivated land e.g. hedges or balks. Plakolm (1989) compared the weed populations in arable fields in organic and conventional fields in the years 1983, 1984, 1985 and 1988 in Upper Austria. In organic farms the weed diversity was higher (steadiness) as well as their dominance. The aim of this research was to study the long term development of weed species on these fields after 15 years.

Material and methods

We analysed the weeds in the field border area (behind the first grain row) as well as in the centre of a field (minimum of 20m away from field border). Measurements were done by identification and estimation of abundance following Braun-Blanquet (1964) procedure. In addition to the field observations, we collected relevant data on arable techniques for the interpretation of weed data (effects not analysed).

In 2003, 15 organic and 15 conventional farms, with mainly two fields (total of 59) of winter cereals (triticale, winter rye or winter wheat) were analysed in four arable

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regions of Austria in the same fields, which were already analysed by Plakolm (1989) 15 years earlier. Whereas the natural conditions of the neighbouring fields were similar, there were differences in the cereals, the varieties, the sowing intensities, as well as pre-crops. The size of analysed area was 50m x 2m along the field border and in the centre of the field following the methodology of Van Elsen (2000). The inventory method combined species abundance (number of individuals of one species) and the dominance (cover of one species in percentage) of the whole test field (cover-abundance) (see Dierschke 1994; Braun-Blanquet 1964). The analysis followed the methodology of Fischer (1994). For statistical analysis, we used SPSS. Furthermore we identified Red List (endangered) species of Austria (see Niklfeld 1999).

Results and discussion

In total, we found 109 weed species, where 57 were only in organic and four only in conventional fields and 48 in both. Therefore, 105 species were found in organic fields and 52 in conventional fields, which translated to 100% more different species in organic than in conventional farms. This high species diversity in organic winter cereals compared to their conventional counterparts was significant at $P < 0.05$. In most cases the median of species frequency in organic fields was 21-25, whereas in conventional we found only 6-10 weed species. In three of four regions, the weed species in organic farms was considerably higher, while in one region the differences between organic and conventional farms were not clear. In the later case two organic farms has unusually low weed diversity, which we could not explain. Twenty-six species in the Austrian Red List were counted (Niklfeld 1999), where 18 were found in the organic, seven in the conventional fields and one only in one of the conventional fields.

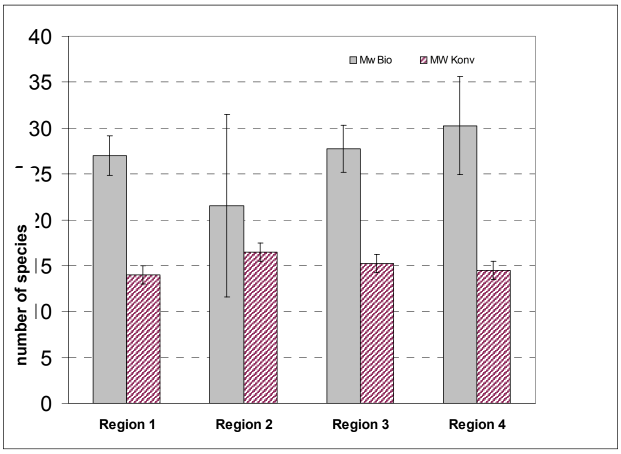

Figure 1: Average number of weed species in organic and conventional fields in four regions in Upper Austria. (Anzahl der Arten means number of weed species; bars represent standard deviations)

Highest species diversity was found in the border section of the field, regardless of whether it was conventional or organic. The ratio between species diversity in the border and in the centre of a field was 4:1, whereas in the organic farms the species diversity was twofold more in comparison to the conventional farms.

The comparison between investigations done 15 years earlier (see Plakolm 1989) and the current one (2003) showed a distinctively lower species diversity in the later. The tremendous dryness in 2003 and considerable higher temperatures can explain this decline. Temperatures in 2003 were 2.4^{0}C higher in the first seven month in contrary to the period of 1960-1990. Further, the current rainfall was 395mm lower compared to the 1960-1990 period, amounting to only 125mm in seven months (ZAMG 2003). Even under these climatic conditions, the median of species diversity was two times higher in organic as in conventional winter cereals. Another reason for the lower species diversity in comparison to Plakolm (1989) was the applied methodology. Whereas Plakolm (ibid) collected weed data from an area ranging from 0.3 to 1.5 ha, we made our observations from an area of 2x100m^{-2} per field. Furthermore, he integrated the species outside the field along the field border.

The analysis of cover-abundance led to the following results: 56 of the 109 species were only found with a cover-abundance of “r” (1-5 individuals /m^2). Most dominant endangered species in conventional plots was *Anthemis arvensis* (“2”; cover 16-25%), all other endangered species were in the rare category (“r”). Most dominant weeds in organic fields were *Anthemis arvensis* (“3”; cover 26-49%), *Centaurea cyanus* (“3”), *Galium aparine* (“+”; cover < 1%), *Myosotis arvensis* and *Sherardia arvensis* were mainly rare (“r”). *Apera spica-venti*, *Convolvulus arvensis* and *Veronica arvensis* were dominant in conventional fields (highest values “4”; cover 50-74%). *Fallopia convolvulus*, *Viola arvensis* were found in both organic and conventional fields with high dominance (-“1; 1-4% cover /2”). *Gnaphalium uliginosum*, *Kickxia spuria, Stachys annua*, *Valerianella dentata* identified by Plakolm (ibid), were not found in the present study. Instead of that, we found *Geranium molle* („r“), *Holosteum umbellatum* (“r”), *Rumex stenophyllus (“r”), Trifolium campestre* (“r”) and *Veronica opaca* (“r”) in several organic fields. *Trifolium campestre* was only found in one conventional field (“r”).

Conclusions

In organic winter cereal fields, weed species diversity is higher than in conventional fields. The high weed diversity in the field borders is expected in any investigation on weed species. Higher survival rates of endangered species under organic farming conditions are not surprisingly, however in some cases we cannot explain, why some of these species were only found under conventional farming conditions. The lower weed species diversity in comparison with previous analysis seems to be an effect of dryness and higher temperature in 2003. Some species get lost, new ones emerged, but we cannot explain this development with this survey. Today it is of interest to know if further climatic differentiation lead to new weed societies with new competition to and interactions with the cultivated crops. Therefore, investigations over several years can only explain these developments.

Acknowledgments

Our gratitude is for all farmers who supported us in our field studies as well as Dr. Gerhard Plakolm, for his methodological advice and the support with reference data.

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Invertebrate communities in soils of organic and conventional farming: conversion trial in the Czech Republic

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Key words: soil, organic farming, conventional farming, epigeic fauna, edaphon

Abstract

This paper focuses on the evaluation of invertebrate communities at an experimental site in Prague – Uhřiněves (CZ) where an organic farming experiment (organic vs. conventional farming) started 13 years ago. The result of the research shows that strong effect to soil fauna during our evaluation had tillage and other disturbances of soil surface and also the amount of organic matter brought into soil. The research proved the complexity and integrity of agro-ecosystems in which individual actions considerably affect the biological activity of the soil and the occurrence of different groups of fauna, often without any relationship to a certain agricultural system. For these reasons, soil-protecting management practices are important to the soil inhabitants and must be established in the agronomy practices of organic farming.

Introduction

Intensification of agriculture within the last 50 years has remarkably affected biodiversity and the quality of soil. At present, there are intense discussions on the impact of agricultural systems on biodiversity (e.g. the effect of organic agriculture – Hole et al. 2005), as well as changes in agro-environmental measures aimed towards a more sustainable management of the landscape.

Arthropods are frequently used as bio indicators for the assessment of landscape and soil quality (Paoletti 1999). Soil organisms are assumed to be directly responsible for processes within the soil ecosystem, especially the decomposition of soil organic matter and the cycle of nutrients (Wardle and Giller 1997). Spiders are acceptable indicators of the biological quality of the habitat because they are dependent on the quality of potential prey. In organic farming some groups of invertebrates have higher diversity than in conventional farming – carabid beetles (Kromp, 1990), spiders (Feber et al. 1998), and earthworms (Brown 1999). There are considerable differences between the management of organic and conventional agriculture. Physical disturbance of soil, such as tillage is a detrimental factor for diversity of soil fauna. (Altieri 1999).

In this trial of the longest duration in the Czech Republic,we focused on soil biology evaluation of conventional and organic agricultural systems.

Materials and methods

Evaluation of invertebrate communities was done at an experimental site in Prague – Uhříněves (CZ) where conversion to organic farming started 13 years ago.

The research was carried out on the large study field, subdivided after the crops were planted and management established. We compared 4 sites, 2 with winter wheat and 2 with winter rape. In the conventional farming system both of these crops were grown following a grain-leguminous mix crop. While in the organic farming system, the preceding crop was two-years of clover which were mulched and ploughed in.

In the spring and summer 2007, we sampled soil invertebrates at those sites. From epigeic fauna we evaluated beetles (Coleoptera), spiders (Araneae), flies (Diptera), harvestmen (Opiliones), centipedes (Chilopoda) and millipedes (Diplopoda). From the soil samples we evaluated beetles (Coleoptera), beetle larvae, mites (Acarina), springtails (Collembola), centipedes (Chilopoda), millipedes (Diplopoda) and earthworms (Lumbricidae). Epigeic fauna was obtained during the season by sets of pitfall traps (20 traps with 4% liquid of formaldehyde). Edaphon was heat-extracted by Tullgren funnels (Tuf, Tvardík 2005) from soil samples (28 samples, area 1/30 m^2, 15 cm depth). Data was evaluated by ANOVA and t-test.

Results

Results of the monitored epigeic fauna show (Figs. 1 and 2) that differences were significant for beetles (F=7.449, p=0.002) and millipedes (F=3.431, p=0.042) only. Beetles were the most plentiful group from the catch in the pitfall traps. In general, the growth of rape was more conducive regarding the occurrence of beetles, especially due to the microclimate provided by the growth. A correlating fact is that in the field of rape, with taller plants and denser coverage, the dominance of beetles was most pronounced. This variation was the only one where, regarding the number of beetles, a conventional field beat the organic one. The difference was significant (t=-4.012, p=0.008). Spiders were captured in all cases in similar numbers. Millipedes clearly preferred the organic variety of both crops which probably relates to the preceding crop rotation. It brought a large amount of organic material into the soil and thus provided a rich supply of feed for these types of invertebrates. Preference for the organic system over the conventional system in rape fields was significant (t=2.248, p=0.044). Diptera were captured in higher numbers in the organic fields of both crops. The study shows that there are differences between communities in fields managed by conventional and organic systems but a stronger effect was noted among invertebrate groups in response to the given tillage.

Figure 1: Average capture rate for more abundant taxons, with standard deviation, in pitfall traps

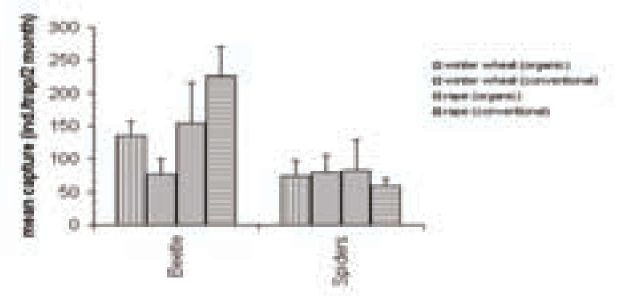
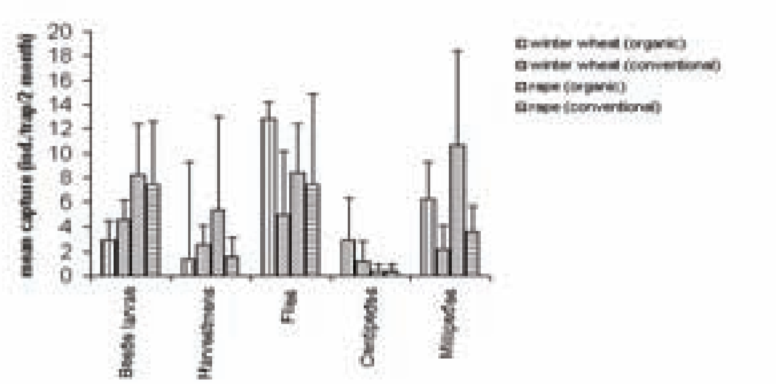
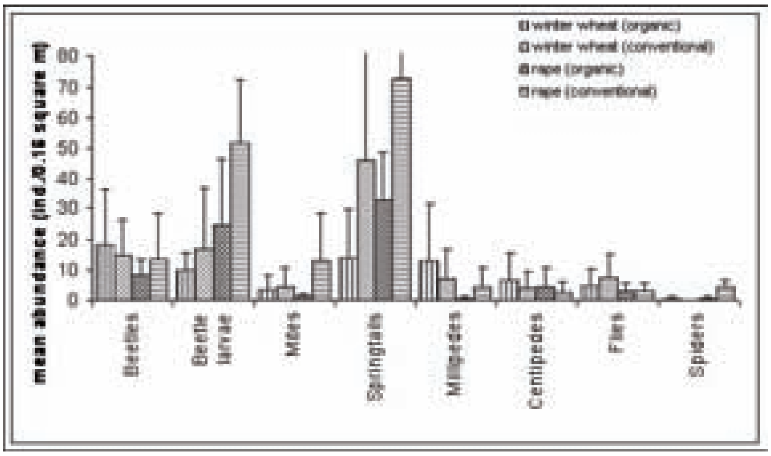


Figure 2: Average capture rate for less abundant taxons, with standard deviation, in pitfall traps.



The abundance of single taxons of edaphic invertebrates show (Fig. 3) that observed differences were evident, but not significant. In soil samples the most numerous group was that of springtails. Together with beetle larvae and mites they represent typical soil fauna which is strongly dependent on the chemical and mechanical properties of soil. Such dependence can explain their much denser occurrence in conventional fields which were not tilled as many times within a year. Centipedes, on the other hand, were more abundant in organic variants. The occurrence of beetles was quite balanced in all types of fields. Earthworms were not statistically evaluated because of their low occurrence in both systems.

Figure 3: Mean abundance with standard deviation in soil samples (0,16 m^2).



Conclusion

The result of the research shows that the amount of organic matter brought into the soil was an important factor in the occurrence of epigeic fauna, which complies with the results published e.g. by Hole et al. 2005, Mäder et al. 2002. This was shown by number of millipedes which process supplied vegetable material. Tillage and other disturbances of the soil surface had a strong effect on the soil fauna during our evaluation. Considerable disturbance of soil (e.g. when hoeing rape) resulted in the occurrence of edaphon in the soil. This brought better results for the conventional variant and was evident by the number of beetle larvae and springtails. The research proved the complexity and integrity of agro-ecosystems in which individual actions considerably affect biological activity in the soil and the occurrence of different groups of fauna, often even without any relationship to a certain agricultural system (organic vs. conventional). For these reasons, soil-protecting management practices are important for soil inhabitants and should be established in the agronomy practices of organic farming. A longer-term study of the whole crop rotation system in the future will provide a more comprehensive view of the entire agro-ecosystem. Its results can then be compared with this published data and the referred publications.

Acknowledgement

The authors wish to thank the Czech Ministry of Education for supporting their research through grant No. 2B06101 and the Czech Ministry of the Environment for the grant they provided (VaV 1c/4/8/04).

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Multi criteria assessment of experiments

A pilot socio-economic analysis of QLIF dairy projects

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Key words: Dairy, milk quality, mastitis, calf rearing, financial cost-benefit

Abstract

A pilot socio-economic impact assessment was carried out on three dairy projects within QLIF to identify the business, consumer and policy issues likely to influence the adoption of the innovations resulting from QLIF. A socio-economic analysis is presented related to the key outcomes from the three projects which include: management systems to reduce mastitis and antibiotic use in organic dairy farms and how milk quality can be enhanced through high forage organic feeding systems. Due to a lack financial data costs had to be assumed based on other studies. The socio-economic analysis identified a significant number of potential economic and social implications of implementing strategies developed in the QLIF project that aim at increasing animal health welfare and milk quality.

Introduction

The integrated project QualityLowInputFood (QLIF) aims to improve quality and ensure safety and reduce cost along the European organic and "low input" food supply chains. Innovations developed within the project will have impacts on businesses operating within organic and "low-input" supply chains as well as on broader social and policy issues. Impact, assessment focused on dairy related WPs 2.1, 4.5.1 and 4.5.2 which had identified methods to improve milk quality and animal health and welfare. While these innovations are of relevance in their own right, they also need to be justified in terms of the financial impacts on businesses as well as the broader socio-economic impacts as these issues are likely to influence their adoption.

Methods

The socio-economic impact assessment of the three selected dairy projects (details in Table 1) is intended to cover primarily economic aspects (value of non-market cost/benefits; financial returns/profitability; risk; producer/consumer welfare; public expenditure), but also social aspects (employment, labour incomes, working conditions, health & safety, culture/recreation, consumer incomes/affordability), policy/ institutional implications and multi-functionality/sustainability issues. Quantitative analyses were only carried out where sufficient data was available and/or where costs could be estimated based on available data from previous dairy studies. Analyses are mainly based on physical data (supplemented with some financial data) supplied by the dairy project teams. The results of the analysis are presented in Table 1.

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Tab. 1: Summary of socio-economic analysis of three dairy related projects within QLIF

Title	1: Effect of dairy management on quality of milk	2: Effect of farm practices on udder health and milk quality	3: Suckling systems for organic calf rearing
Objective	Compare milk quality and cow health in organic, low-input and conventional systems with different feeding regimes in five countries.	Identify factors influencing udder health in CH organic dairy farms; identify therapeutic and preventive measures to avoid antibiotics in mastitis control	Impacts of alternative calf rearing systems: bucket fed (milk replacer or whole milk) and suckling (maternal suckling then nurse cow or nurse cow only)
Main outcomes	▪ Proportion of grass or grass/clover forage higher in UK[377] than in IT, DK, SE ▪ Maize silage and concentrate feeds major diet components in IT, DK, SE ▪ Proportion of forage in organic diets higher in all countries ▪ Organic milk tended to have higher α-linoleic acid, conjugated linoleic acid and vaccenic acid levels and higher levels of fat soluble antioxidants (Vitamin E and carotenoids) ▪ SCC higher on organic ▪ No. of mastitis and other veterinary treatments higher on conventional	▪ Factors significantly affecting SCC are breed, alpine summer pasturing, calf milk feeding strategy, hard bedding and no post-milking procedure. ▪ Advisory intervention did not reduce average herd SCC in the first year. ▪ Herds with moderate udder health pre-drying off can avoid any treatment. ▪ Use homeopathy as therapeutic measure against sub-clinical mastitis in herds with SCC<200k/ml at drying off. ▪ Use teat sealants where increased risk from environmental pathogens and cows have SCC<200k/ml at drying off.	▪ Consumption of maternal or nurse cow milk lead to higher weaning weights at 3 months of age ▪ No immediate health problems linked to suckling systems ▪ Increased natural behaviour (e.g. cow-calf bonding) in suckling systems ▪ Loss of marketable milk in suckling systems compared to bucket fed ▪ Increased stress after weaning in maternal single suckling systems - farmers changed to nurse cow only or maternal single suckling followed by nurse cow systems
Wider impacts	+ Consumer: nutritionally enhanced milk + Animal welfare: forage a natural feed 0 Adoption: reflects current practice - Processor: oxidation and off flavours - Environment: may be higher methane losses from high forage diets	+ Processor: lower SCC milk + Consumer: reduced antibiotics +/- Adoption: reduced inputs but requires system changes + Animal welfare: reduced mastitis + Environment: reduced heavy metals from teat sealants	+ Consumer: integrity of organic product + Animal welfare: mother/calf bonding + Technical: improved growth rates 0 Environmental: no impacts identified 0 Processor: no impacts identified

[377] CH: Switzerland; DK: Denmark; IT: Italy; SE: Sweden; UK: United Kingdom

Financial cost-benefit assessment	**COSTS 3,075 € per year for 100 cows** Value of yield loss due to higher SCC[378] Replacement rate O:20%[379]; C:30% SCC O:251, C:209 kcells/ml Net yield loss (O-C)[380] 0.23 kg/cow/day Annual cost for 100 cows 2400 € Milk price penalty due to higher SCC Organic yield (305d@22.2) 6771 kg/cow Price penalty 0.001 €/kg Annual cost for 100 cows 675 € **BENEFITS 52,760 € per year/100 cows** Veterinary cost decrease[381] Vet. Costs[9] O:35, C65 €/cow Annual saving for 100 cows €3000 Feed cost decrease less yield difference Milk yields O:22.43, C:27.7 kg/cow/day Concentrate use O:5.5, C:10 kg/cow/day Conserved forage O:0.36, C:0.35 kg/c/d Grazed forage O:5.5, C1.5 kg/cow/day Annual saving for 100 cows 2,360 € Value of organic milk Organic milk premium 0.07€/kg Annual benefit for 100 cows 47,400 € **NET BENEFIT of organic production 49,700 € per year for 100 cows**	**COSTS not estimated** Cost of system changes Difficult to quantify costs of short and long term systems changes as very specific to the individual farm – higher costs associated with long terms changes (e.g. changes to breed, alpine pasturing and housing). Costs of inputs Cost of homeopathic and teat sealant treatments are small but also no significant impact on post parturition mastitis. **BENEFITS from mastitis control best practice on organic farms 21,000 € per year/100 cows** Milk yield increase from best practice Top performing farms with best practice in 4 or 5 of key system mastitis factors: 22.3 kg/cow/day; other farms 20.4 kg Annual benefit for 100 cows 20,300 € Milk quality gain due to improved SCC Price penalty reduction 0.001 €/kg Annual benefit for 100 cows 700 €	**COSTS of suckler system if saleable organic milk 105-185 €/calf** Cost of organic milk consumed Milk price O:0.35; replacer: 0.40 €/kg Consumption bucket reared 540 kg/calf Value of tank milk: 189 €/calf Cost of organic milk replacer 216 €/calf Consumption nurse cow 840kg/calf Value of organic milk 294 €/calf Consumption maternal suckling (1m) and nurse cow (2m) 1065 kg/calf Value of organic milk 373 €/calf 'Unmarketable' milk from cull cows (not high SCC/antibiotic) prod. Cost 0.25 €/kg Cost of nurse cow system 210 €/calf Cost of other feeds no data **BENEFITS suckler LW gain 70 €/calf** Live weight gain (kg/calf at 90/365 days) Maternal/nurse cow suckling 136/343 kg Tank milk bucket fed 101/316 kg Milk replacer bucket fed 95/288 kg Value of extra LW (2 €/kg) 70/54 €/calf Other benefits More research required to quantify long term health, longevity and productivity benefits of live weight differences.

[378] Abbreviations: SCC: Somatic cell count; O: organic; C: conventional; LW:
[379] Lampkin et al. (2006)
[380] Based on calculations by Reneau (1986) using the relationship between SCC and yield loss
[381] Costs derived from Jackson and Lampkin (2006), but proportions similar to treatment differences identified in this study.

Discussion

Developing strategies to improve milk quality and reduce antibiotic use are the cross cutting themes in these projects and there appears to be little conflict between the objectives aimed for in the work packages.

In Project 1, systems with high forage diets resulted in milk with enhanced fatty acid and antioxidant profiles. Financial analysis of these systems shows reduced concentrate feed and veterinary costs, but also decreased milk yield per cow and increased somatic cell count (SCC), which largely balance each other out. However, the net benefit of the high forage diet systems was substantially increased by the organic premium reflecting in part the value placed by consumers on enhanced nutritional quality of the milk. In Project 2, management factors were identified as significantly influencing somatic cell counts in Swiss dairy herds. Some factors can be changed in the short term (e.g. post-milking management), but other factors are longer term strategies that are likely to be more costly (e.g. bedding system, breed, summer feeding system). It is difficult to put a cost on such changes as they are specific to individual farms. Dry cow therapies were found to be unnecessary in herds with moderate udder health resulting in saved vet costs (homeopathy, teat seal and/or antibiotics) without major milk losses.

In Project 3, using maternal single suckling and nurse cows to suckle calves, although costing more than bucket rearing, resulted in calves with higher weights at weaning and one year old. However, more milk was fed per kg liveweight gain, and the value of the milk used exceeded the financial benefit of the gain. More work is required to assess the impact of these rearing systems on first lactation performance, longevity and mastitis levels, as well as the impact on intakes of other feeds.

Conclusions

In addition to the project results themselves, the analysis undertaken has identified significant associated economic impacts and highlighted where social impacts may occur. The methodology is limited by some of the assessed work packages being incomplete. Due to a lack of direct financial data, in many instances costs have had to be assumed based on other studies.

Acknowledgments

The authors gratefully acknowledge from the European Community financial participation under the Sixth Framework Programme for Research, Technological Development and Demonstration Activities, for the Integrated Project QUALITYLOWINPUTFOOD, FP6-FOOD-CT-2003-506358.

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Sustainability evaluation of long term organic farm systems

Vazzana C.[1], Raso E.[2] & Migliorini P.[3]

Key words: Sustainability Indicators, LTE, Organic Agriculture

Abstract

The paper deals with the evaluation of sustainability at farm level in a long term experimental farm, organically managed since 1992 in Tuscany. The aim was to develop and implement a multi-objective organic agriculture, to establish new concepts of farming as result of long term research analysis and to provide a practical and easy understanding on what is necessary to change or improve in farming management. Soil fertility and biodiversity indicators are taken into consideration in the period 1992-2006: the weak points and the improvement obtained by the farm management are underlined. The values of indicators changed rapidly towards the desired ones in the first 6 years period. After 13 years, in 2006, the situation appears almost stable, P is still a problem, some little discrepancies for C/N ratio and KAR indicate the need to re-examine some of the production methods.

Introduction

In the context of the promotion of sustainable agricultural models many studies have been conducted to evaluate the degree of sustainability at different levels. Only limited information is available for the precise assessment of a single sustainable farming system able to provide adequate agronomical, economic, environmental and social benefits (Vazzana and Raso, 1997; Verejilken, 1997; Häni et al.,2003.). An European methodology developed since 1993 (Verejiken, 1997) adopted an holistic approach considering the farm as a complex unit in which any action has several or many effects. From this methodology an indicator-based conceptual framework has been derived and applied to many different farms in different social and pedoclimatic situations. A selection of specific indicators is used as a tool to evaluate farm sustainability. The framework is organised in a number of sub-systems: for each sub-system corresponding agro-environmental indicators and processing methods are identified. In this paper we present the results of the framework application to evaluate the sustainability of an organic long term experiment .

Materials and methods

The experimental area is located in the farm of the University of Florence (Montepaldi) situated in the municipality of S. Casciano Val di Pesa, Tuscany. A sustainability evaluation has been applied to the Montepaldi Long Term Organic Experiment (MOLTE) active since 1991. MOLTE includes three micro agro-ecosystems (Migliorini and Vazzana, 2007) and we examine here the performances of the old organic microfarm, from 1992 to 2006. The micro farm covers an area of 5.2 ha, divided into 4

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fields; each field covers 1.3 hectares (260 m x 50 m). The agroecosystem is surrounded by ecological infrastructures such as natural and artificial hedges. Following the local farm management, a four-year crop rotation is adopted in the organic agro-ecosystem: green manure+corn – hard wheat+red clover – red clover – barley.

To measure sustainability different indicators were determined. For each single indicator, an optimal reference value was selected from the literature, considering the territorial and climatic context of the experimental area (Vereijken, 1997) and the threshold (minimal) level that is in compliance with the EU Regulations. The list of indicators is described in Table 1 (Vazzana et al.,1997).

Tab. 1: List of indicators used to evaluate sustainability

Acronym	Name	Description	m.u.	Desirable value
EII	Ecological Infrastructure Index	% of farm area managed as a linear and non linear habitat and corridors for wild flora and fauna	% area	x > 5
PSD	Plant Species Diversity in the farm	Number of species	number	x > 40
SCI_y	Soil Cover Index year	months of the year when the soil is covered with crops /12 months	% month	x > 50
SCI_c	Soil Cover Index critical period	months of the critical period for erosion when the soil is covered with crops /x months	% month	x > 60
$OMAR_s$	Organic Matter Annual Reserve in the soil	OM in the cultivated soil layer	%	x > 2,5
TNAR	Total Nitrogen Available Reserve in the soil	N tot in the cultivated soil layer	‰	x > 1,5
PAR	Phosphate Available Reserve in the soil	P_2O_5 in the cultivated soil layer	ppm	35 < x < 25
KAR	Potassium Available Reserve in the soil	K_2O in the cultivated soil layer	10 ppm	150 < x < 200
C/N	C/N ratio in the soil	Ratio between the quantity of organic C and the quantity of total N of the soil	number	9 < x < 12
PAB	Phosphate Annual Balance	P input/P output	kg/kg	> 1,20

Results

Taking into consideration the subsystems “biodiversity” and “soil fertility “at farm level we can follow the trend of the different indicators in the studied period (1992-2006). When the MOLTE started at Montepaldi farm after a long period of conventional management, soil characteristics were very poor. In fact, in 1992 low organic matter content in the soil, erosion problems, nitrogen and phosphorous imbalance, low C/N ratio were identified as major problems to be solved. Top priority was given to the improvement of these components. The implementation of ecological infrastructure and biodiversity were also taken into consideration. Fig.1a reports the discrepancies of each studied indicators from the reference values considered equal to 1, at the experiment starting time (1992-03). Fig.1b, Fig.1c and Fig.1d show the changing situation after four (1996-97), six (1998-99) and thirteen (2005-06) years.

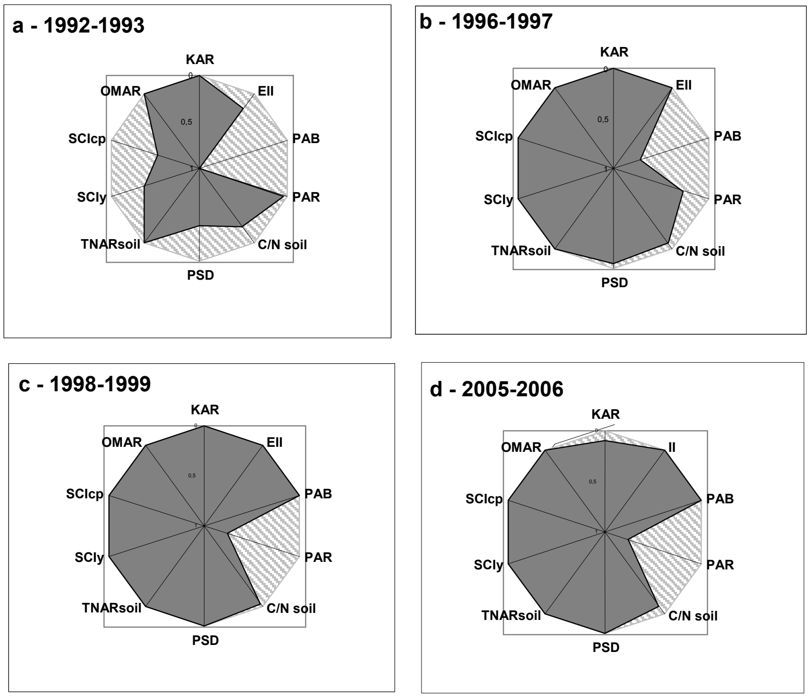

Figure 1: Evaluation of sustainability in an organic long term experimental farm: at starting point (a-1992-03) after four (b-1996-97), six (c-1998-99) and thirteen (d-2005-06) years since conversion.

Before the starting of the experimental activity, the studied area was conventionally cultivated using chemical fertilizers. Soil cover was poor during the critical period of the year with risks of erosion. The farm area covered by natural vegetation was under the reference limits both for ecological infrastructures (5 % of total area) and for species diversity (>40). After the period of conversion to organic management (1996-97), a clear improvement resulted for many parameters (SCI_{cp}, SCI_y, C/N soil) but others (PAB) gave a slow answer and PAR discrepancy increased. The indicator EII reached the optimal value later on, with the plantation of a new linear element (edge). The inclusion of herbaceous strips with natural vegetation between the fields increased the biodiversity as measured by PSD.

The situation was better for all the parameters, except for PAR after a period of 6 year of organic management (1998-99). The use of leguminous crops in the rotation increased the P availability in the soil. The planned agro-biodiversity (EII and PSD) reached stability and good levels. By changing the applied rotation soil was maintained covered by vegetation during most of the year and especially during the critical period. The parameters referring to soil fertility showed a positive trend towards the optimal reference values. At 13 years from the beginning of the experiment (2005-2006) the evaluation of sustainability of the studied microfarm confirmed the picture of

1998-1999, with some minor discrepancies (KAR, C/N soil). The problem of PAR (too high P availability) resulted still unsolved.

Discussion

Soil fertility and agro--biodiversity indicators showed a rapid response time during the first period after conversion of the studied farm from conventional to organic practices. Some of the parameters concerning soil fertility are slow and the effect of changing management was significant only after 6 year. The P problem could be improved with a more critical estimation of farm needs, P input/output ratio, crop exportation and type of organic fertilizers in use. The agro-ecological indicators related to planned biodiversity respond very well to the changes realized in the farm (crop rotation, a new hedge and strips of spontaneous vegetation between the fields). After 13 years, in 2005-2006, the situation appeared almost stable, but some little discrepancies for C/N ratio and KAR indicate the need to re-examine some of the production methods.

Conclusions

From the data available it is clear that agricultural practices connected to organic farming are able to significantly improve soil characteristics and farm biodiversity. A periodic evaluation of sustainability of farm management is an important tool to design and redesign the farming system. In our case the application of a set of indicators allowed to confirm the importance of long-term experiments (LTE) to evaluate and implement the management of organic farms. With the comparison of the indicator values, after 13 years since we began our research experience we can conclude that:

- a minimum period of 6 year after the farm conversion to organic is necessary to reach the equilibrium and the stability of the majority of involved processes.
- valid and applicable results from research can be obtained only if the experimental site is stable and its sustainability is monitored in continuum increasing the understanding of system attributes.

Acknowledgments

We thank G.Casella and R.Vivoli for their technical support during the experimental activities. The research was supported by FIRS Project SIMBIOVEG

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Evaluation of Farm Biodiversity with Indicators in the Context of Sustainability

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Key words: Biodiversity, Assessment, Indicators, Sustainability, Organic Farming

Abstract

Organic farming depends on the promotion of biodiversity and the corresponding functions. No tools are known for the obtention of farm-specific information explaining the influence of farm management on biodiversity. The paper describes an approach that allows estimating such effects. It has been applied in an experimental farm with an organic and a conventional farm section. The results distinguish between both sections. The investigations made so far allow concluding that multiple-structured low-input systems achieve better marks than specialized high-input systems. For further development and validation additional studies are required. It is planned to test the indicator model in numerous farms, in order to disclose bottlenecks and deficiencies.

Introduction

Conservation and promotion of biological diversity belong to the principles of organic farming. The guidelines of IFOAM include the demand to protect organisms, communities and ecosystems with the aim to safeguard the ecological balance. One of the targets defined in EC Regulation 834/2007 is the maintenance of a rich biodiversity by cautious farm management. The reason for this high esteem is the importance of biodiversity for the functioning of agro-ecosystems. Organic farming derives benefits from the natural regulation of harmful organisms and the support of mass cycles.

The influence of organic farming is mostly positive and only in rare cases indifferent or negative (e.g. Bengston et al. 2005, Hole et al. 2005). Divergent statements were sometimes caused by the choice of species or species groups. Such state indicators (e.g. target organism) are not suitable for integration into indicator models oriented on estimating the environmental impact by farm enterprises. What we need are methods rating the consequences for biodiversity on the basis of management data and derived pressure indicators. Such an approach, pursued in an experimental farm for years, is the focus of this paper.

Materials and Methods

The elaborated approach has been integrated into the indicator model REPRO (Hülsbergen 2003) following the existing conception: Potential environmental effects of farm enterprises are analyzed and estimated on the basis of management data and site specifics. In the past, relevant analyses were oriented on the abiotic environment; statements on the biodiversity were missing almost completely. The new approach considers the complex relationships of farm management in form of structural features (acreage and cropping structure), input parameters (fertilizer and pesticide input) as

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well as specifics of process design. For this purpose, partial indicators (PI) have been sampled, evaluated and finally aggregated to get the complex indicator Biodiversity Development Potential (BDP) (Fig. 1). The analysis of the PI is made using evaluation functions which convert the indicator value into a dimensionless figure. Value 1 stands for the best, 0 for the worst effect on the environment (see Fig 2).

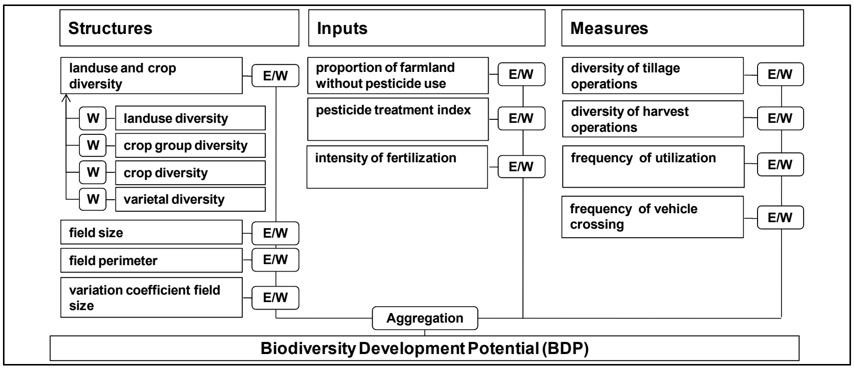

Figure 1: Scheme of partial indicators and aggregation to the BDP; E/W = Evaluation and Weighting

The principle of analysis and evaluation has been described on the example of land use and crop diversity. This PI is a derivative of the crop diversity: Land use and cropping structure are grouped on hierarchic levels. The first level describes types of land use (arable land, fallow areas, ..), which are then broken down to crop groups (cereals, root crops, ..), species and varieties. On each level, calculations of the Shannon Index (SHI) are made. The SHI values of the levels are aggregated with weighting factors and merge in an overall indicator which is then evaluated (Fig. 2).

The described method has been applied in commercial and experimental farms, followed by tests of its practicability. Below, results of its use in the Experimental Farm Scheyern in the south of Germany are given. The farm has concentrated on investigations in agro-ecosystems since 1990. In 1992, it was subdivided into an organically (OF) and a conventionally (CF) run section.

Results and Discussion

The indicator approach allows differentiating between the two farm sections (Fig. 3). Considering the BDP overall index, OF was rated 0.74, CF 0.41. The result reflects the influence of higher land use and crop diversity (more differentiated cropping structure and catch crops) and the omission of mineral fertilizers and plant protection agents. With regard to the PIs, field size and field circumference, which serve the estimation of field structures, OF ranked slightly behind CF. This can be explained by the fact that, compared to CF areas, OF fields are smaller (1.3 ha on average) and of very compact shape (nearly square). The investigations made so far allow concluding that many-sided structured low-input systems, which often are under organic management, achieve better marks than specialized high-input systems. Due to its sensitivity to management measures, the indicator BDP permits a detailed differentiation between farm types. Intensively run or specialized ecofarms, marked by a closer crop rotation and higher intensity of fertilization, are rated lower.

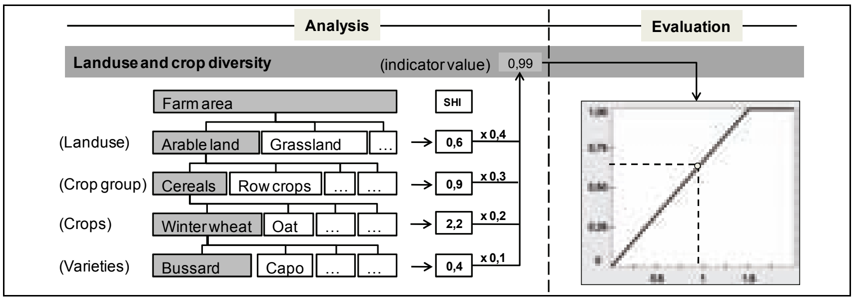

Figure 2: Scheme of the PI land use und crop diversity

The farm-internal sensitivity of the indicator becomes evident when several years are compared (Fig. 4). Variations of the indicator value in CF go back to changes in the cropping structure and the intensity of fertilization and plant protection. OF shows a comparatively constant situation of the cropping structure throughout the reference period; variations are the result of changes in fertilization intensity and use frequency. Especially conspicuous is the pronounced differentiation of the two farm sections after the shift to organic management. The OF areas received clearly higher overall ratings due to the changes in management.

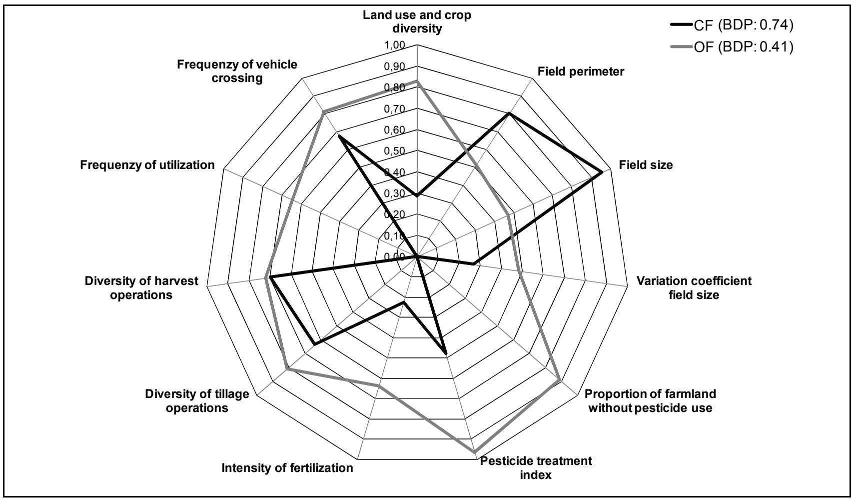

Figure 3: Evaluation of PI compared between OF and CF

Conclusions

The approach produces farm-related analyses of the influence on the biodiversity without extensive surveying or mapping. The method is oriented on high transparency tracing back PIs, algorithms and evaluation functions. The required input data are available in commercial farms. The integration into an indicator model allows wide-spread applications and guarantees a high practicability. However, the indicator cannot provide information on the occurrence of species because the development potential of biodiversity is only estimated. It may be fuzzy due to site conditions, temporal delay, deviating spatial consideration or the structure of the entire farmscape.

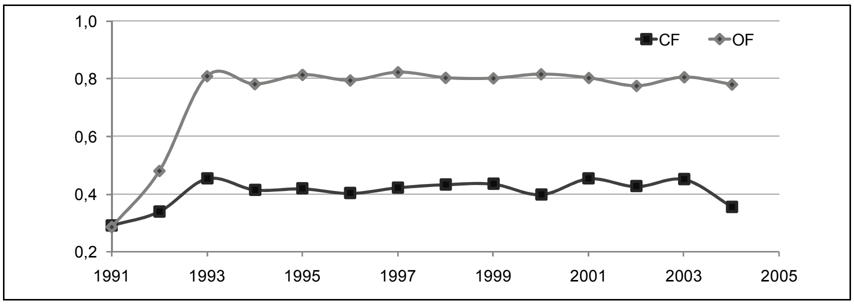

Figure 4: Development of the BDP for CF and OF (1991 – 1994)

The introduced indicator method has been coordinated and discussed in an expert commission. Additional studies are required for further development and validation, because the latter is not yet sufficiently documented. However, preliminary results obtained in the Experimental Farm Scheyern indicate that the development tendencies for groups of species (e.g. weed flora) coincide with those of the BDP (Osinski et al. 2005). It is planned to test the indicator model in numerous farms, in order to disclose any bottlenecks and deficiencies. It should be discussed whether further farm parameters and criteria have to be integrated as PI.

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On the inherent instability of the monoculture

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Key words: Stability, Food webs, Network analysis, Agroecosystem architecture.

Abstract

In the last decades has been recognized that monoculture has harmful consequences: genetic erosion, soil loss, pollution, land concentration, increased poverty and so on. But, there is another aspect that has been underestimated, the instability that results of the oversimplification of monoculture's trophic structure. Here, using network analysis, we show why the trophic structure of monoculture is inherently instable. Considering an agroecosystem as a complex network, we propose that for the design of stable agroecosystems we must generate architectures with redundancy of relations and homogeneous connectivity, because this compensates and modulates perturbations.

Introduction

An ecosystem is a complex network, made of many interacting species (nodes). As result of these interaction emergent phenomena arises, being one of these, the system stability or homeostasis. With the goal of simplify production, conventional agriculture break up redundancy and trophic cycles which are present in natural ecosystems, transforming them in monocultures. Since stability is a phenomenon observed in natural ecosystems and not in monoculture, we need to study it in the first ones.

The network analysis of trophic webs can be used to study the interactions between the components of an ecosystem (Montoya *et al.*, 2006). One advantage of this analysis is its systemic approach, which allows to explore the whole system and find patterns. Recently has been suggested (Montoya & Solé, 2003) that the natural ecosystems trophic architectures can be divided in two classes according to their richness (*S*). Those that present low *S*, are called Poisson, whereas those with high *S* are called Scale Free (SF) or Power Law. Poisson nets have a similar number of trophic relations per species (connections or degrees) and Scale Free have a small number of species with many connections and most of the species with few connections. If the richness is related to ecosystem's architecture, and, if this influences the potential responses to perturbations (*i.e.*, its stability), this may offer clues on how to design agroecosystems.

Materials and methods

We simulated Poisson and Powers Law networks, between S=20 to S=150. These values were obtained from real ecosystem networks information (Montoya & Solé, 2003), and represent the interval on which the architectural change occurs. The simulations were settled to generate low average degree (*i.e.,* 13) networks according to empirical data (Montoya and Sole, 2002).

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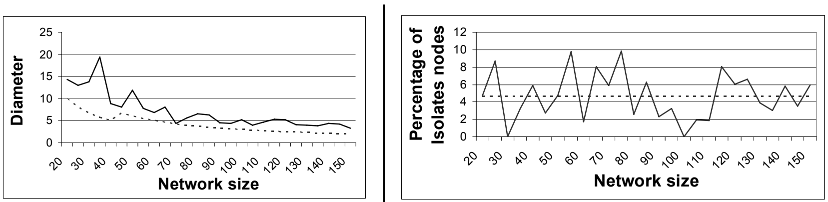
In order to compare the architecture of the networks, we measured the diameter of the simulated networks. The diameter is a measurement of the cohesion of the food webs and represents the shortest distance (links number) between the two more distant species. The diameter was normalized according to the total network size. We also evaluated how the characteristics of the networks were affected with the removal of one of their nodes (*i.e.,* species). We removed the most connected node (directed attack), and the consequences of this perturbation was measured counting the number of isolated nodes (secondary extinctions). This perturbation simulates the effect of completely remove an element of the agroecosystem (*e.g.*, a plague, a weed, etc.).

Results

We found that the diameter diminishes as *S* increases in exponential fashion, independently of networks architecture. But, for values lower than eighty nodes the diameter of Poisson networks is considerably smaller than the SF diameter, therefore the Poisson net is more advantageous because the community is more integrated (Figure 1a). When perturbed, the number of isolated nodes was always zero for Poisson networks, whereas for Scale Free networks this number was variable, with an average of approximately five isolated species (Figure 1b).



a b

Figure 1 a): Changes in Networks Diameter as *S* increases. In small ecosystems the Poisson architecture is more advantageous than SF, because it has lower diameter (higher community cohesion). Continuous line: SF Networks, dashed line: Poisson Networks. b) Secondary extinction vulnerability for SF architecture as *S* increases. Continuous line: changes in the percentage of isolates nodes, dashed line: overall average of isolates nodes.

Discussion

Our results agree with and complement those of Albert *et al*., (2000) and Solé & Montoya (2001). These authors show that Poisson networks are moderately sensible to random or directed removal, whereas SF networks are very robust to random removal, but highly sensitive to directed or specific removal. Which is the probability of randomly remove the most connected node (hub) in both types of nets?. If we consider the probability (Figure 2) of extracting the most connected node as richness increases (i.e., p=1/S), we found the following:

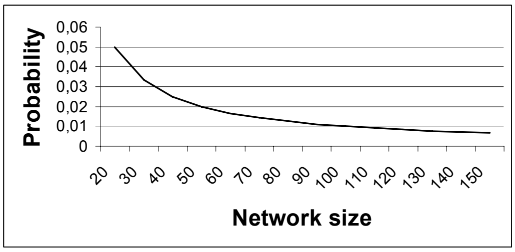


Figure 2: Probability of randomly remove the most connected node

The probability of remove the hub is higher for smaller nets.

The probability of remove the hub is lower for larger nets.

The smaller nets seen on nature have Poisson architecture, whereas in the largest nets, the architecture is SF (Montoya & Solé, 2003). Consequently, if we remove the hub from them we find:

a.- Small Poisson networks: the nets do not disarticulate, and therefore, secondary extinction doesn't take place.

b.- Large Poisson networks: the nets do not disarticulate, and therefore, secondary extinction doesn't take place.

c.- Small SF networks: because (1) happens and the SF network is vulnerable to this perturbation, this architecture results instable.

d.- Large SF networks: Because large SF nets have similar integrity levels as Poisson (Figure 1a), and because (2) happens, this architecture is as stable as Poisson. Nevertheless, extensive evidence (Albert & Barabási, 2002; Newman, 2003) shows that SF networks have in general more advantageous properties than Poisson ones. Therefore, if the larger SF nets are as stable as Poisson and more advantageous in terms of other properties, it is reasonable that natural ecosystem possess this architecture when the nets are large.

Let us extrapolate these results to the agricultural area. If we recognize that a monoculture is an ecosystem in which all the species are related by means of some type of ecological interaction (parasitism, predation, mutualism, competition, *etc*) to one species (*i.e*., the monoculture), we realize its trophic structure is a Star networks (a net in which all nodes are directly connected to a common hub). The Star network is unstable when directed attack occurs, because the whole ecosystem cohesion relies on a single species (in this case, the monoculture). In this architecture, all the weaknesses of the SF networks in low richness ecosystems are taken to the maximum, because its centralization. In this context the Star net is the most inefficient architecture. In it any perturbation will reach the whole system in two ecological interactions in average. In this architecture any type of self-regulation is impossible. We think this is the fundamental reason of all imbalances inherent to the monoculture. If our goal is to design stable agroecosystems, we must copy the topologies found in nature. Our results indicate that the way to do so, in low diversity ecosystems (like agroecosystems) is generating architectures in which all the bets are not in a single species. Redundancy of relations and similar connectivity is the key of the stability, because these compensates and modulates perturbations in the network.

Conclusions

Monocultures are ecosystem with an inherently imbalance architecture, in which all the weaknesses seen on low richness SF networks ecosystems are taken to the extreme. In this architecture any type of self-regulation is impossible and ecosystems functionality is loss.

If our goal is to design stable agroecosystems we must enforce redundancy of relations and similar connectivity for all system species, because this compensates and modulates disturbances in the trophic network.

Acknowledgments

We wish to express our gratitude to Iliana Chollet, Roberto Ruggiero, Dayaleth Alfonzo and Glenda Briceño for their helpful comments and encouragement.

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Methods in organic quality research

Effect of organic and conventional feed on potential biomarkers of health in a chickenmodel

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Key words: Organic food, feeding experiment, chicken model, immunological parameters, biomarkers

Abstract

A feeding experiment was performed in two generations of chicken with feed from organic and conventional produce. The aim was to search for 'biomarkers', indicating different physiological effects from the feeds. Feed and chicken were extensively studied. Various differences in nutrient content were observed in the ingredients. Most consistent finding was a difference in protein content, resulting on average in a 10% higher protein content in the conventionally produced feeds. Although animals on both feeds were healthy, differences between the groups were found. The chicken, fed with conventional feed gained more weight, whereas the animals on the organic feed showed a stronger immune reactivity, a stronger reaction to a challenge to which they were exposed, as well as a slightly stronger recovery from this challenge, being a stronger 'catch-up-growth'. With these findings 'biomarkers' for future research are indicated. Interpretation towards 'health' appeared difficult, as the concept of 'health' is as yet scientifically not well defined.

Introduction

An important reason for many consumers to buy organic is the assumption that organic products are healthier than conventional products. However, until now, very little research has been performed to study the effect of organic food on health. Most studies on organic food are dealing with differences in nutrient contents of organic versus conventional products. Results from such studies can only speculatively be connected to health effects. Very little research has been performed studying actual effects of organic food on physiological processes in consuming organisms.

The present study was the first experimental study in the Netherlands in which the effects of feeds, derived from organic or conventional origin, are studied using animals as a model for humans. The aim was to search biomarkers that can show potential health effects of organic compared to conventional food. Based on results of this first explorative study an indication for 'biomarkers' was expected, which would need further confirmation in follow-up research and which eventually should be useful in research on health effects in humans.

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Based on a scientific discussion within FQH,experts concluded that possible feed effects would most likely show up in the immune system of young organisms, as it is known that through the gut (GALT), food induces the development of the immune system in the developing organism. However, a broader exploration of effects was concluded to be valuable. The present study was both searching for differences in available feed ingredients, as well as an explorative feeding experiment with animals, to identify possible biomarkers for a different effect from these feeds. The study was performed by a Dutch consortium of institutes and coordinated by the Louis Bolk Institute. Results have been presented in a report (Huber 2007).

Materials and methods

The study comprised a blinded animal feeding experiment in two generations of chicken fed either conventional or organic feed. The animals were chicken from the Wageningen Selection Lines, laying hens that during 25 generations were divergently selected for their either high (H-line) or low (L-line) antibody response to SRBC (sheep red blood cells) (Parmentier et al. 1996). Next to these lines a random bred control group (C-line) of chicken was included. The main experimental group was the second generation, consisting out of six groups of 25 animals, 150 in total (3 lines, 2 types of feed). The chicken in the first generation were randomized for each line in 2 groups, received identically composed feeds from either organic or conventional products. The offspring of the resulting 6 line-feed combinations in the second generation received the same feed as their parents.

Three feeds for the different developing stages of the chicken (starter feed, grower feed, layer feed) were composed according to existing norms for organic chicken feed with six ingredients: wheat, barley, triticale, peas, maize and soy, that were produced organically or conventionally. As no products from controlled trials were available, ingredients were obtained from neighbouring 'farm pairs', with the same basic soil and climatic conditions, preferably known as 'best practice farms'. Before the ingredients were used for feed production, they were prescreened for residues of pesticides or mycotoxins. A contaminated ingredient was not used for the feed production, to prevent any adverse health effect due to these compounds. The ingredients used for feed production, as well as the composed feeds, were extensively analysed for macronutrients, micronutrients, trace elements, micro-organisms and bioactive ingredients. As complementary analyses, biophoton and protein ratio measurements and biocrystallizations were performed.

To prevent shortages in the nutritional needs of the chicken the feed was supplemented with potato protein, the amino acid methionine, chalk, grid ,salt, $NaCO_3$ and a small dosage of a commercial mix of vitamins and minerals. The feed was presented as a composite flour. Feeds were coded either A or B.

The 1st generation of chicken was housed in individual cages; the 2nd generation in spacey and enriched indoor runs, in groups of 6 animals. The animals of the 1st generation were fed the experimental feeds from week 11 of their life. The 2nd generation received the experimental feeds from the first day on. Both generations could eat ad libitum. The 2nd generation lived till 13 weeks of age.

Physiological markers were sought in general health features, immunological response parameters, metabolite measurements in plasma and liver through metabolomics, gene activation in the gut through genomics, and in a post mortem evaluation through pathological anatomy. As both groups of animals received balanced and sufficient feed, no large differences were expected. Therefore, a disturbance was provoked to evaluate the animals potential to react to, and recover from, an immunological ‘challenge’. As a challenge the non-pathogenic, immune protein trigger KLH (Keyhole Limpet Hemocyanine) was injected at the age of 9 weeks in the 2^{nd} generation.

General health effects were evaluated and a broad range of immunological measurements was performed, in both generations. Periods of feed changes were monitored, as well as the period before and after the challenge. Blood from before and after the challenge was also analysed by metabolomics. In week 13 the animals were sacrificed and section was performed. Tissue samples were analysed by metabolomics of the liver, by genomics of the gut and by pathological anatomy of the organs. The study was performed blinded. Only after all results were available and the conclusions were drawn, the codes of the feeds were broken.

Results

Comparison of the nutritional content of the organic and conventional feeds showed most consistent differences in the amount of proteins, which was about 10% higher in the conventional feed, due to higher levels of proteins in conventional wheat, soy and barley. The organic feeds mostly contained higher levels of alpha-tocopherol, total folate and iodide, whereas lower levels of LPS endotoxins were found in organic feeds. Based on calculation it showed that the level of phytosterols, vitamin C and vitamin B5 was higher in conventional feeds and organic feeds were higher in vitamin K and isoflavones. In the period of the KLH challenge slight differences in fatty acids in the feeds occurred, with higher levels of unsaturated C18 in the organic feed.

With the complementary analyses the ingredients from the two agricultural systems could be differentiated and where experience with the ingredients was available, could correctly be identified as being the organic or conventional sample.

As the C-line animals represent the natural genetic variation of the population, the results of the 2^{nd} generation of this group, were considered most informative. The results of the H- and L-line animals can be informative for understanding immunological mechanisms, though through the genetic selection this group has lost some potential to react on environmental changes. All animals were diagnosed as being perfectly healthy. However, the groups on the two different feeds showed clear differences in several aspects of their physiology. The animals on conventional feed showed a faster growth and were significantly heavier. After the KLH challenge a 20-30% decline in growth was observed in both groups for about two weeks; after this the animals on the organic diet showed a stronger ‘catch-up-growth’. With respect to the immunological parameters, both the humoral and cellular and both the innate and adaptive components of the immune system showed differences between the animals on the two different feeds. The immunological results were not fully consistent, but were overall interpreted as indicating a higher potential for immunological reactivity of the animals fed the organic feed.

Metabolomics results of the blood showed a clear distinction between the animals on the two feeds, especially after the challenge. It was interpreted as that the animals on the organic feed showed after the challenge a stronger reaction and connected metabolism, indicating a stronger acute phase reaction than the animals on the conventional feed. Metabolomics results of the liver indicated an increased pentose phosphate pathway activity in the animals on the organic feed.

Genomics showed, in the animals on the conventional feed, a lower expression of genes connected with cholesterol biosynthesis. Pathological anatomy showed some differences in the weight of specific organs between the feed groups. More adipose tissue was observed with the conventionally fed animals, but this has not been objectivated.

Discussion

An important outcome is that feed ingredients from different origins can have small but clear immunological and metabolic effects in healthy animals. Concerning the factors in the feed that could explain these differences, the higher protein content in the conventional feed is considered to be the factor that causes the stronger weight gain in the animals on this feed. There are indications in literature that an enhanced status of immune reactivity in animals (such as of those on the organic feed), may be related to a lower body weight. The factor(s) in the feeds that might cause the physiological differences in relation to the challenge are not yet clear. The present findings are in line with Lauridsen (2007) reported results of a feeding study in rats. Here the conventionally fed animals showed an increased body weight and fat tissue deposit, as well as an increased IgG-level of the immune system. However in this study the existing differences in feeds were compensated, resulting in iso-energetic and iso-nutrigeneous feeds with similar crude protein and essential amino acids content. This fact putts under stress our hypothesis of the protein being the cause of the differences in weight of the chicken. The implications of these different physiological reactions in the context of short term and long term ‘health’ of these animals, is still unclear. The concept of ‘health’, and its physiological and immunological parameters, currently lacks scientific identification and solid conventions.

Conclusions

Weight gain and, especially after exposure to a challenge, ’catch-up-growth’, immune responsiveness, metabolic parameters, gene regulation in the gut system and observations by pathological anatomy are suggested as ‘biomarkers’ for future studies of effects from the two different feeding regimes. However, before these ‘biomarkers’ can be used in a study in humans, confirmation of the mentioned results is necessary.

Acknowledgments

The authors thank the Dutch ministries of Agriculture, Nature and Food Quality and of Economic affairs, the Rabobank and the Triodos Bank for making this study possible.

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The effect of medium term feeding with organic, low input and conventional diet on selected immune parameters in rat

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Key words: Organic, conventional, low input food, food quality and safety, immune system, rat

Abstract

There is currently limited evidence for differences in nutritional value and 'healthiness' between organic and conventional foods. While organic standards aim at minimizing antibiotic and/or pesticide residues they have been described as a potential source of high mycotoxin levels, and bacterial diseases or parasites. The aim of this study was to evaluate the effect of rat feeds based on the organic, low input and conventional crops on the rats' immune system function. Preliminary results obtained indicate a potential immunomodulatory effect of 'low input' foods that is not observed in rats fed conventional and organic diets.

Introduction

Conventionally produced crops may contain higher levels of pesticides and their metabolites, and significantly higher levels of nitrates and nitrites (Rembialkowska 2004). Also in vitro experiments have suggested that such contaminants may cause immunosuppression (Finamore et al. 2004) andpesticides were reported to perturb the homeostasis between pro- and anti-oxidant forces in the cell and this oxidative stress may be responsible for immune suppression (Olgun et al. 2004). On the other hand, organic crop production method, were described to result in higher mycotoxin loads, which may reduce growth rates and reproductive efficiency and increase mortality. However, consumption of low levels of fungal toxins may result in improved immunity (Bouhet et al. 2005). Despite the increasing interest in organic food production, there is a limited number of investigations which have studied the effect of organic food consumption on animal or human health or health related physiological factors (MacRae et al., 2005). The aim of this study was, therefore, to assess the effect of diets, based on crops grown in four different agronomical regimes on selected immune parameters of rats after twelve weeks of feeding.

Materials and methods

Barley, potatoes, carrots and onions were produced in the Nafferton factorial systems comparison trials (NFSC) at the University of Newcastle's Nafferton Experimental Farm, Northumberland, UK in 2006. Conventional (pesticide based) crop protection protocols were applied according to the British Farm Assured standards, and organic

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(without pesticides) crop protection protocols were applied according to Soil Association organic farming standards. Under conventional fertility management mineral fertilizers are applied, and composted manure is used under organic fertility management. The combination of the two factors results in four factor combinations showed in experimental protocol (Table 1). Samples from all 4 production systems (four replicates, n=16) were dried at moderate temperature in order to keep their nutritive value. Rat compound feeds were produced based on these materials according to the nutritional recommendations for rat feeding trials. Analysis of the rat feed confirmed that there were significant composition differences in levels of key phytochemicals between treatments (see Wisniewska et al. 2008 in these proceedings). Rats used in this study were grown and reared as described previously (Baranska et al. 2006). Briefly, paternal males and females were fed experimental diets during the bred and pregnancy period (total 10 weeks). Six young males from each dietary group were left after weaning to be fed for subsequent 9 weeks (total 12 weeks) with one of four experimental diets and control standard feed for rodents (Labofeed, Andrzej Morawski Feed Production Plant, Kcynia near Bydgoszcz, Poland). Animals were kept under conditions of controlled light (12-h light/12-h dark cycle) and temperature (22–23 °C) with free access to water and food. After 12 weeks rats (F1) were anesthetized with Thiopental, blood was collected from heart and spleens isolated aseptically and used immediately for *in vitro* studies. All animal procedures were in accordance with the Guiding Principles for the Care and Use of Research Animals and had been approved by the First Warsaw Ethics Committee for Experiments on Animals.

Tab. 1: Experimental protocol

Exp. groups	Type of diet
OF-OP	organic fertility and crop protection management
OF-CP	organic fertility and conventional crop protection management
CF-OP	conventional fertility and organic crop protection management
CF-CP	conventional fertility and crop protection management
LF	control standard rodent's food – Labofeed

Hematological parameters (hematocrit value, RBC (red blood cells) number and hemoglobin content) and WBC (white blood cells) number were assayed using standard laboratory methods. Splenocyte cultures were prepared according to a method used previously in our laboratory for rat lymphocytes (Bik et al. 2006). Splenocyte proliferation *in vitro* was assessed by incorporation of 3H-thymidine in control (cells incubated with culture medium alone, spontaneous proliferation) and mitogen-stimulated cultures (Concanavalin A, ConA, for T-cells and Lipopolysaccharide, LPS, for B-cells) and expressed in counts per minute (cpm) as mean and as stimulation index (SI, ratio of cpm form stimulated to non-stimulated cultures ± SEM). For statistical evaluation of differences between groups the one-way nonparametric ANOVA followed by the Student-Neuman-Keuls test was used. Results were considered statistically significant when $p<0.05$.

Results

In all hematological parameters of rats fed experimental diets were no significant differences (data no shown). The total white blood cell (WBC) number was significantly lower in animals raised on rat compound feeds made from crops produced in the two low-input systems (Fig. 1A). Spontaneous proliferation of splenocytes in rats on the low-input (OF-CP and CF-OP) diets was much higher in comparison with rats in the other groups (Fig. 1B). The significant difference was found also between fully organic (OF-OP) and control (LF) dietary group (Fig. 1B).

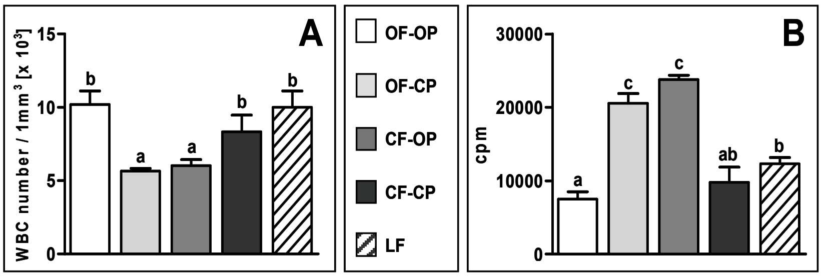

Figure 1: The effect of diet on WBC (A) and spontaneous splenocyte proliferation (B), expressed as mean ±SEM, Different letters indicate a statistically significant difference at *P*< 0.05 for a vs. b and *P*< 0.001 for c vs. a and b in the Student-Neuman-Keuls tests

Mitogen-stimulated proliferation of splenocytes was examined over wide concentration range of both T-cell (ConA) and B-cell (LPS) specific mitogens. The response was dose-dependent and the effect of only one concentration of particular mitogen is shown in Fig. 2. The ability of splenocytes to be stimulated by both T- and B- cell specific mitogens was diet-dependent and was significantly lower in splenocytes obtained from rats fed diets based on crops from 'low input' (OF-CP and CF-OP) systems compared to rats fed fully organic diet. The highest splenocyte proliferation was in OF-OP dietary group, but it did not differ significantly versus mitogen-stimulated proliferation neither from CF-CP nor the LF group (Fig. 2A and 2B). The pattern of mitogenic response in all dietary groups was similar after in vitro cell stimulation with LPS and ConA.

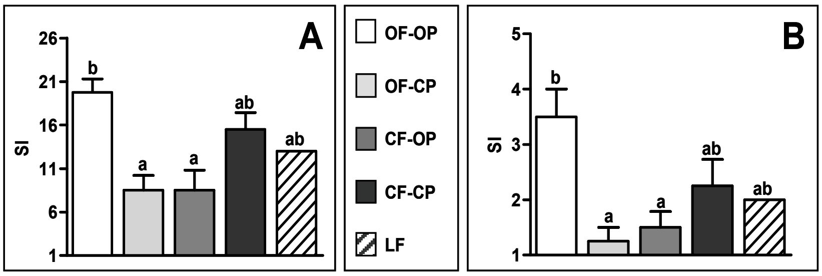

Figure 2: The influence of diet on mitogen-stimulated (ConA 0.125 µg/well – A; LPS 2 µg/well – B) splenocyte proliferation expressed as the mean of Stimulation Index (SI). Different letters indicate a statistically significant difference at *P*< 0.01 in the Student-Neuman-Keuls tests

Conclusions

This study was performed to detect potential effects of diets based on crops produced with or without synthetic pesticides and/or mineral fertilizers on the immune system of rats. No effect of experimental diets on haematological parameters was found, thus confirming a previous study (Baranska et al. 2006). This suggests that there was no influence of feeds produced by different farming systems on the rats' basic health status after 12 weeks of feeding.

Changes in the WBC number, spontaneous and mitogen-stimulated proliferation appear to be induced by diets from products cultivated using one of two factors, i.e. low input cultivation systems. Both OF-CP and CF-OP diets increase spontaneous splenocyte proliferation in comparison to all other diet used, including organic diet. This might be induced by the over-stimulatory influence of these diets on immune cells. The suppression of stimulation by mitogens used might also suggest less efficient rat response to a possible immune challenge. In a previous study (Baranska et al. 2006) we found similar decreased response to mitogens only in OF-CP group, not seen in rats from the conventionally fed (CF-CP) group. We can conclude that different diets have the impact on the rat immunity, however the nature of these effects needs further investigation.

Acknowledgments

This study was supported by the EU Commission under the FP6 Integrated project Quality Low Input Food (FOOD-CT-2003-506358).

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Potential of X-Ray Spectrometry and Chemometrics to Discriminate Organic from Conventional Grown Agricultural Products

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Key words: food authenticity, principal component analysis, X-ray spectrometry.

Abstract

This work describes an innovative analytical method based on X-ray spectrometry combined with chemometrics which presents high potential to discriminate conventional from organic grown tomatoes and coffee beans. This novelty is based on the irradiation of samples in a bench-top EDXRF equipment provided with a Rh tube and further treatment of the spectral data using Principal Component Analysis (PCA). Multivariate analysis results showed a tendency in separating the samples according to the production mode (organic or conventional). Regarding the spectra obtained, the K-alpha peak of potassium showed to be the most responsible for discriminating different categories of samples. The chlorine K-alpha peak presented high capability in discriminating tomato and coffee samples from different origins. The method can be useful for food quality control to rapidly classify samples since the measurements can be done "in situ" with portable instruments. Nevertheless, it will be necessary to build robust classification models with a larger number of samples.

Introduction

The market of organic products increases every year. In 2005 it achieved a value of USD 37 billion, with most part of products consumed in North America and Europe (IFOAM, 2007). The consistent expansion of the organic agriculture results from the increasing concern among consumers about food quality attributes associated with the absence of chemical contaminants, negative environment impacts caused by the production system and use of bad labor practices (Fernandes et al., 2002; Fernandes et al., 2004). Considering that organic food reaches prices substantially higher than conventional food, unscrupulous producers and traders would feel encouraged to offer fake products in the market. On the other hand importers are facing several difficulties for the discrimination of organic and conventional products, mainly to detect and avoid frauds. Thus, it is clear the relevance of developing suitable analytical methods to classify samples (Santos et al., 2006).

In this study, coffee and tomato, two agricultural products highly dependent on synthetic fertilizers and pesticides when cultivated in the conventional system, were analysed by energy dispersive X-ray fluorescence (EDXRF) combined with chemometrics. EDXRF is a technique based on the photoelectric phenomenon that provides absorption/emission effects that generate energy spectra composed by specific energies, corresponding to elements present in the sample. The use of

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chemometrics allows analysing simultaneously all the energies detected as a variable of the model to be built.

The objective of this work was to evaluate the feasibility and potential of this analytical method and use of chemometrics for the discrimination of organic and conventional grown agricultural products.

Materials and methods

Sampling and sample preparation

Test samples were obtained directly in the crop fields. Coffee beans were collected in Santo Antonio do Amparo, Minas Gerais state, a pioneer region in the production of organic coffee in Brazil (Fernandes et al., 2002). Both conventional and organic plantations of the same variety were cultivated in similar soil and climate. The cherries were harvested and naturally dried in patios under sunlight and afterwards the outer skin and pulp were removed in a hulling machine. The coffee beans were then classified by size and sorted by density and color to remove defected ones. The resulting bulk material consisted of 4 batches: one conventional, one in transition from conventional to organic and two organics. For the tests, 5 samples of approximately 0.1 kg were taken from each batch and ground in a rotor mill reducing the particle sizes to < 0.5 mm.

Tomato samples of the hybrid AP 533 were collected in farms that adopt the organic and conventional cultivation systems, respectively located in Borborema and Novo Horizonte cities, São Paulo state, Brazil. The sampling was performed in areas of 2500 m^2 in both farms and twelve plants were randomly selected in each area. Four ripe fruits with average weight of 100 g were taken from each plant. The samples were transported to the Radioisotopes Laboratory (LRi/CENA/USP), Piracicaba, SP. The fruits were thoroughly washed with tap water followed by deionised water and cut in halves for removing seeds. They were frozen at minus 18°C for 24 hours and freeze-dried at minus 52°C and 0.1 atm for 5 days. Particle size was also reduced (< 0.5 mm) in a rotor mill.

Both organic coffee and tomato were produced in accordance with the guidelines from the Instituto Biodinâmico (IBD), an International Federation of Organic Agriculture Movements (IFOAM) accredited member, and the Associação de Agricultura Orgânica (AAO), a Brazilian affiliated of IFOAM.

EDXRF analysis

For the trials, irradiation cells mounted with their bottoms having a 3 μm thick polymeric film (Mylar®) were completely filled with the ground samples. Two replicates for each sample were irradiated for 180 seconds under air atmosphere. *S*amples irradiations were performed using an EDXRF equipment, model EDX 700, Shimadzu (Kyoto, Japan), assembled with a rhodium X-ray tube and a Si(Li) detector, with resolution of 180 eV. The voltage in the tube was 50 kV, with an applied current of 100 mA and beam collimation of 10 mm.

Data Analysis

To proceed with the chemometric analysis, matrices of independent variables were constructed in such a way that the columns refer to the spectrum energies with 2048 values (channels), whereas each line corresponds to one sample. The spectral data were mean centred and submitted to a moving average smoothing with a segment size equal 7. Afterwards the data were treated by Principal Component Analysis

(PCA), using The Unscrambler software, version 9.2, from Camo®. PCA results were validated by using the leave-one-out cross validation method, also named Full Cross validation method.

Results

Figures 1 and 2 show the results obtained by applying PCA to coffee and tomato samples respectively. The score plots were constructed with the first and second principal components.

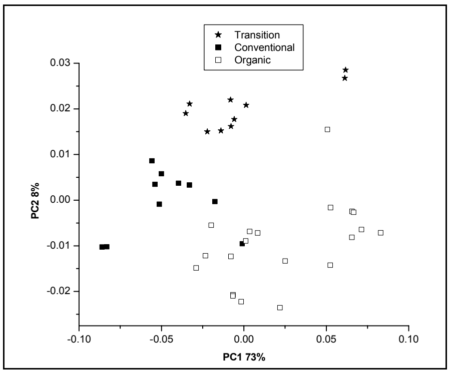

Figure 1: Scores plot obtained by applying PCA for all coffee X-ray spectra

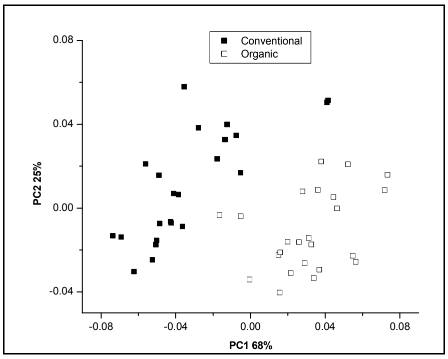

Figure 2: Scores plot obtained by applying PCA for organic and conventional tomato X-ray spectra

Discussion

The PCA results in Figure 1 present a clear separation between the organic, conventional and in transition coffee samples. Regarding to PC1 axis it is possible to observe the separation tendency between organic and conventional coffee with 73% of total explained variance. The PC2 axis shows that the in transition samples are separated from the others with 8% of total explained variance. The results presented in Figure 2 show a clear separation between organic and conventional tomatoes. The PC1xPC2 scores plot accounted for 93% of total explained variance. Even though the tomatoes were produced in different farms and other factors may have contributed to the discrimination process, the method showed to be sensible to the variations resulting from different management systems. In both cases, analysing the loading results, it could be noted that the variables related to potassium K-peaks, element present in high concentrations in coffee and tomato samples, influenced strongly on sample grouping. Considering the tomato samples, the loadings results also indicated the strong influence of chlorine K-peaks on conventional and organic discrimination. This finding may be related to the regular use of KCl in the conventional crops, which adds substantial amounts of Cl in the system. For routine analyses, the proposed method is very promising to distinguish organic from conventional grown food. It is fast, non destructive and does not generate residues. As a further improvement, a larger number of samples must be analysed to provide a more robust classification model to be applied in routine quality control of organic/conventional grown food.

Conclusions

EDXRF and multivariate statistical analysis indicated a good potential for the use of the method in discriminating organic from conventional grown food. The technique generates data in minutes, does not destroy the sample and can be carried out in portable equipments available on the market, allowing to analyse samples *in situ.* These advantages make it promising to be applied in routine quality control of organic products for the determination of authenticity. However, more studies are required in order to develop a robust model including a large number of samples from different locations.

Acknowledgments

FAPESP and CNPq for financial support.

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Authenticity tests of organic products (Golden Delicious and Elstar) applying sensory analysis

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Key words: sensory evaluation, quantitative descriptive analysis, apple quality

Abstract

In the governmental funded project BÖL-02OE170/F, apple samples from different farming systems (organic and conventional) were differentiated and classified by sensory evaluation. Samples from farm pairs derived from geographical neighbouring locations. Each farm pair consisted of one farm producing apples according to organic land use system and one producing conventionally. Factors of influence as growing conditions, climate, soil and harvest time were comparable within each pair.For sensory evaluation, a descriptive analysis panel was trained according ISO-standards of descriptive analysis. The quantitative descriptive analysis method (QDA) enables to show a complete product profile with all sensory characteristics of a product as well as their intensity.Over 2 crop periods (2004/2005), 18 apple samples (9 pairs) were evaluated by QDA method; 5 samples pairs of the variety "Golden Delicious" and 4 sample pairs of the variety "Elstar", each with 3 replicates and 6 apples per replicate. In the first crop year, descriptive analysis was done to develop product profiles of all samples. Based on these data, a classification model was developed to classify sensory characteristics of organic vs. conventional apple cultivation. According to this model, from 9 defined trial sample pairs, 8 sample pairs could be classified according to the farming system in the second year.

Introduction

Beside safety, freshness, general health benefits as well as nutritional value, one reason for consumers demanding organic foods is a tastier product. The results of the questionnaire conducted by Casutt and Guggenbuehl (2006) show that apples are consumed regularly (48% eat more than four apples a week) because consumers like them as a snack between meals and because they are refreshing. A number of studies comparing organic and conventional food have included sensory tests indicating that organic and conventional fruits and vegetables differ on a variety of sensory characteristics, but the findings are inconsistent (Roth et al, 2005, Homutova & Blazek 2006,). This is due to different sensory methods applied. The quantitative descriptive analysis method (QDA) is one of the most sophisticated tools in sensory science and allows - in opposition to preference or acceptance tests - objective descriptions of products in terms of the perceived sensory attributes. Depending on the specific technique used, the description shows a complete product profile with all sensory characteristics and their intensity in appearance, aroma, texture, mouthfeel and flavour attributes. Because without a classification model describing a quality profile with consistent product characteristics of organic versus conventional products, preference/ acceptability measures that reflect relative degrees of liking are difficult to

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interpret. Therefore the aim of the study is to develop a classification model for two different varieties of apples (Golden Delicious and Elstar) of different farming systems. The research project was funded by the German Government (Ministry of Food, Farming and Consumer protection BÖL-02OE170/F).

Materials and Methods

Under the guidance of a panel leader, a panel group (10 – 12 persons) develops a scorecard with a list of attributes fully describing the product and developing definition for each attribute. At the same time a ranking of attributes of the product (apples) is done. At least the panellists learn to practice scoring along the intensity scale (0 to 9 resp. weak to strong). The panellists were trained to be able to communicate precisely without subjective descriptions and to work consistent and reproducible (Stone, Sidel 1993). Sensory evaluation was carried out during two consecutive years (from harvest 2004 and 2005). Two varieties of apple samples were tested, 5 sample pairs of variety "Golden Delicious" from defined field trial (FIBL Switzerland, F. Weibel) and 4 sample pairs of the variety "Elstar" (neighbouring farms, FAL Trenthorst). Each sample pair consisted of one sample derived from an organic producing system (according to Council Regulation [EEC] No. 834/2007 of the European Union) and one from a conventional farm. Harvest and climatic conditions were comparable. Training and evaluation were carried out according QDA-standards of Stone & Sidel (Stone,Sidel 1993).

The panellists were calibrated directly on the test samples. During data collection, panellists got at maximum of 6 product samples per session in a randomized design order (according to sensory evaluation software FIZZ, Biosystemes, France). The samples were served in booths, monadically (each panellists got the samples in different order). All data were quantified by ratings of perceived intensities, using an unstructured line scale with end-anchors and offset goal posts (e. g. from weak to strong). Experimental design was as follows:

1. Factorial: each level of a factor is matched with each level of others,
2. Replicated: samples were evaluated 3 times,
3. Repeated measures: each panellist tasted each sample.

The experimental design yields a four-dimensional data matrix: panelist x attributes x samples x replicates. The data were analysed by "FIZZ" sensory software. Descriptive statistical measures were first calculated for all attributes using scores from panellists. Analysis of variance was performed on each attribute using a randomized block design for balanced data, with panellists as repeated measures. Where F-test indicated a significant difference between test treatments, differences was defined as $P < 0,05$. In addition, data of the quantitative descriptive analysis were also differentiated by classification and regression tree system (CART-system, Breimann et al 1984), which classified the sample pairs by statistic evaluation. This so called tree - system shows the relationship between one or more variables of influence (x variables) on a dependent variable (response variable =Y).The result of this statistical procedure is visualized as a tree (leafs are separated variables, branches are steps of differentiation. This tree can be used as a decision tree to look for key attributes or key parameters influencing the product quality.

Results

Results of the descriptive quantitative analysis show a complete product profile of the evaluated apples (see figure 1 as an example). For multivariate variance analysis, the unstructured line scale is transferred into scores from 0 (no perceived intensity) to 9 (highest perceived intensity). The intensities given are results of all panellists and repetitions. By evaluating differences in the characteristic intensities, for classification into organic vs conventional samples, analogue differences in characteristic intensities were defined. Due to the comparison of both crop years for the variety Golden Delicious (from field trials in Switzerland), results show analogue characteristics of sweet and sour flavour in tendency, in year 2004 for 3 out of 5 sample pairs, in 2005 for 4 out of 5 sample pairs the organic sample was more sweet, the conventional had a more sour flavour. In crop year 2005 the conventional samples had a significantly higher intensity in firmness and juiciness of the pulp, which is seen only in tendency in crop year 2004. Most important for classification was the apple skin, which showed significant more firmness and thickness at all 5 organic samples in year 2005 and of 4 out of 5 samples in year 2004 (for Golden Delicious).

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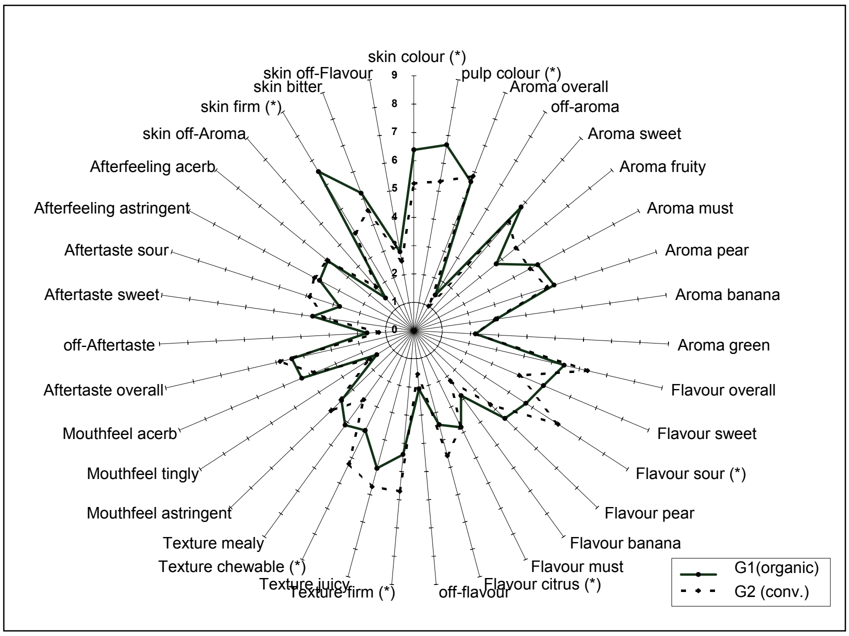

Figure 1: Product profile of one sample pair (coded as organic/conventional), variety "Golden Delicious" (as an example)

Also for the variety "Elstar" significant differences were found in firmness and thickness of the apple skin, the skin of the organic samples were more firm and thick in comparison of the conventional ones. The skin of the organic samples was also more bitter in flavour. In other characteristics, no significant classification could be perceived, in tendency a higher intensity of firmness of the pulp in organic samples could be shown (see table 1). Results of classifying the sample pairs by CART-Systems confirm the differences of characteristics. Sample pairs could be separate clearly within the juice rate and firmness of apple skin.

Tab. 1: Pulp and skin parameters of organic and conventional Elstar (2004, 2005)

Year	**2004**				**2005**			
Samples	conv.	organic	F-value	signif.	conv.	organic	F-value	sign.
Pulp colour	6,81	5,03	57,35	**<0,0001**	5,19	5,69	3,68	0,3841
Skin firmness	2,19	5,17	160,65	**<0,0001**	3,57	4,95	28,57	**0,0081**
Skin thickness	2,71	4,53	59,3	**<0,0001**	3	4,03	15,79	**0,0365**
Skin bitter	3,65	4,36	8,95	0,1665	3,67	4,81	19,6	**0,0442**

Results show that apple samples of organic vs. conventional farming systems and different varieties can be classified by quantitative descriptive analysis. The variety in this study was Macintosh. Our results show that a significantly higher firmness of the skin for organic samples can be observed in this controlled study for other varieties (Golden Delicious and Elstar), too. Beside that, the pulp of organic apples of both varieties was firmer compared to those of conventional ones. Homotuva and Blazek (2006) state, that direct physical measurements and panellists´ evaluation regarding the skin thickness show the same results. The bitterness of the skin, as observed in this investigation can be related to the higher amount of phenolic substances (Weibel et al, 1999). Furthermore, results of the CART-system support the differentiation between apples from organic and conventional farming systems. Measurements of human senses are able to evaluate precisely and reproducible results.

Acknowledgements

The authors thank Dr. Nicolas Busscher (University of Kassel) and Statcom for providing the CART system as well as Prof. Dr. G. Rahmann (FAL-OEL) for coding and distributing the apple samples and the Ministry (BMELV) for financial support of the work (BÖL-02OE170/F).

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Effect of wheat production system components on food preference in rats

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Key words: wheat, food preference, systems comparison

Abstract

In the study presented the effects of two major system components - fertility management and crop protection - were tested in a rat preference test for the first time. Wheat samples produced under 4 combinations of these management factors: - a) organic fertility and crop protection management, b) organic fertility management and conventional crop protection c) conventional fertility management and organic crop protection and d) conventional fertility management and crop protection - generated in the Nafferton factorial systems comparison (NFSC) trial at Newcastle University, were used as experimental diets. Results showed that the organically fertilised wheat was preferred by rats (P = 0.001) while the organic crop protection resulted in reduced wheat consumption (not significant). This might indicate that the rats did not sense or did not select against possible traces of plant protection agents but responded more clearly to differences that were caused by the fertility management.

Introduction

There is extensive evidence that rats are able to sense toxicants and essential nutrients in their food and avoid foods that either contain toxins (Garcia et al., 1974) or are deficient in essential nutrients (e.g. Feurte et al., 2000; Rutkoski and Levenson, 2000). This ability was first employed by (Plochberger and Velimirov, 1992) to investigate nutritional differences between organically and conventionally produced foods. In several studies it was found that rats preferred organically produced foods (Mäder et al., 2007; Mäder et al., 1993; Plochberger and Velimirov, 1992; Velimirov, 2003, 2005). However, so far, it has been difficult to elucidate which components of these production systems (e.g. tillage, seed choice, fertility management, crop protection) or quality parameters in the food might influence this preference. In the present study we intend to elucidate the influence of two major management components, fertility management and crop protection, on the food preference in rats.

Materials and methods

Wheat of the variety Malacca was produced in the Nafferton factorial systems comparison (NFSC) at the University of Newcastle's Nafferton Experimental Farm, Northumberland, UK. Conventional crop protection is applied according to the British Farm Assured standards, and organic crop protection according to Soil Association organic farming standards. Under conventional fertility management mineral fertilisers

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are applied, and composted manure is used under organic fertility management. The combination of the two factors results in four factor combinations: a) organic fertility and crop protection management, b) organic fertility management and conventional crop protection c) conventional fertility management and organic crop protection and d) conventional fertility management and crop protection. Wheat samples from these factor combinations were used in four replicates as experimental diets in the preference test (n=16). A total of 20 rats (male adults; Long Evans) were supplied standard rat food (conventional feed mixture T 779; Tagger Co., Graz, Austria) in order to prevent any deficiency symptoms. The feeding rack is divided by the water bottle into a right and left section, into which the two experimental diets were apportioned. The identity of the samples was unknown to the experimenter. The remaining feed was weighed every 24 hours. Position of the diet was swapped and new feed was supplied over a feeding period of four days. Each four-day-feeding period was carried out using 5 to 6 rats and was repeated four times. Between the different rats 6 possible pairs of the 4 different experimental diets (a-d) were compared four times in a fully randomised design. In addition, random replicates of pairs of the same experimental diet were included. The amount of experimental diet eaten from each of the two sections was analysed with a General Linear Model (GLM) and subsequent Tukey test using Minitab. The residuals were tested for normality and a transformation of the data was not found to be necessary.

Results

When the consumption of individual samples was compared by GLM analysis it was shown that the organic fertility management significantly increased wheat consumption (Table 1) of individual samples (P=0.006) while organic crop protection resulted in reduced wheat consumption (not significant, P= 0.286). The interaction between fertility management and crop protection was significant (P=0.020); consumption for both treatments under organic fertility management was similar but consumption of samples from conventional fertility management combined with organic crop protection was very low compared to the fully conventional treatment.

Tab. 1: Effect of fertility management and crop protection on the amount of individual cereal samples consumed by rats (g rat^{-1} day^{-1})

Fertility Management	Health management		
	conventional	organic	mean
conventional	9.986	4.934	7.311
organic	10.634	12.545	11.590
mean	10.288	8.264	

The total amount of experimental diet consumed per day (sum of both samples in a comparison) increased with increasing proportion of cereal produced under organic fertility management (100%>50%>0%) in the feed offered to rats (Table 2). The intermediate combination with one of the foods organically fertilised is not significantly different from either both conventional or both organic. Total consumption was lower when one or both experimental diets were produced under organic crop protection. The GLM analysis comparing the total amount of cereal consumed (Table 2), showed that there was a nearly significant effect of the fertility management (P=0.051) and the Tukey test confirmed significant differences, but the difference caused by the health management had no effect (P= 0.229).

Tab. 2: Effect of fertility management and crop protection on the total amount of cereal (both samples in a comparison) consumed by rats (g rat^{-1} day^{-1})

Fertility Management	Health management			
	both samples organic	one sample organic	no sample organic	mean
both samples organic	15.41	21.53	22.71	20.71a*
one sample organic	21.50	16.94	20.53	18.98ab
neither sample organic	11.03	18.38	19.30	16.13b
mean	16.81	18.45	20.49	

* Significance in the Tukey test: different letters indicate a statistically significant difference, shared letter indicate no significant difference

A correlation analysis was carried out to relate the mean amount eaten from each of the 16 samples with a set of 14 quality parameters, 21 minerals, 12 indicators of wheat diseases and 16 defence related parameters. Significant correlations are summarized in Table 3. It seems that the rats preferred food with high P and K contents and low N and Cd contents. There was no correlation with different levels of contaminants such as chlormequat and mycotoxins. The experimental food uptake was also significantly correlated to a number of defence related compounds and disease severity indicators that were recorded prior to the harvest of the grain (correlations not shown).

Tab. 3: Significant Pearson's product-moment correlations for the mean amount of rat feed eaten with wheat quality parameters of the grain

Parameter	correlation coefficients	p-value
N (%)	-0.537	0.032
P (%)	0.576	0.020
K (%)	0.695	0.003
Ca (%)	-0.676	0.004
Cd (µg kg-1 dry wt.)	-0.670	0.005

Discussion

In general, previous food preference tests (Mäder et al., 2007; Mäder et al., 1993; Plochberger and Velimirov, 1992; Velimirov, 2003, 2005) comparing organic and conventional foods were confirmed. Consumption of the experimental diet was highest for the organically produced food. By considering the two management components it becomes clear that this was predominantly caused by the preference of the rat for organically fertilised wheat. This might indicate that the rats did not sense or did not select against possible traces of plant protection agents but responded more clearly to differences that were caused by the fertility management.

The high positive correlations with P and K and negative correlation with Cadmium suggest that the mineral composition might have contributed to the food preference in this experiment. This is possible because rats have been reported to select for food that contains needed minerals (e.g. Rutkoski and Levenson, 2000). However, it cannot be concluded that the mineral composition is responsible for the preference since the rat food varied in a multitude of (measured and unmeasured) parameters that might have been co-correlated with the mineral composition and contributed to the preference.

The only indicator for plant health of wheat grain in the data set available, the content of *Fusarium* mycotoxins (all values were below MRL), was not correlated to food preference. However, strong, reproducible differences in the plant health between organic and conventional fertility management in the NFSC have been observed (Cooper et al., 2006). It seems possible that the health status of the plants caused a variation in the quality of the wheat grain that was detectable for the rats.

Conclusions

Samples from the NFSC trial allowed the influence of fertility management and crop protection on preference of rats for organic food to be assessed. Findings emphasize the role of fertility management for producing food of a quality that was preferred by rats and in the organic production system in general. Based on these findings the test design has been improved and further quality parameters have been chosen for a repeat with samples of the 2007 harvest.

Acknowledgments

The authors gratefully acknowledge funding from the European Community financial participation under the Sixth Framework Programme for the Integrated Project QUALITYLOWINPUTFOOD, FP6-FOOD-CT-2003- 506358.

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Quality of organic feedstuffs grown in Trenthorst (Germany) – evaluated by Near Infrared Reflectance Spectroscopy

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Key words: feed quality, NIRS, chemical constituents, energy

Abstract

In the present study we address the development of a rapid technique –NIRS– for the evaluation of organically produced feedstuffs in Trenthorst (Germany). The exclusive use of organically produced animal feedstuffs is fixed in the EU-VO 2092/91 for the year 2011. The differences of the contents of crude nutrients between the data of conventionally and organically analysed feedstuffs, as well as the possible differences of the contents from year to year, point out that a satisfying calculation of feed rations needs an exact knowledge of the chemical constituents of the feed components used. Therefore, well-defined material from field trials of the experimental station of the Institute of Organic Farming in Trenthorst of the years 2002-2005 was used for the determination of the contents of crude nutrients and energy in different grain legumes and cereals. All samples were analysed by classical chemical methods and also scanned by NIRS. Predictions of crude protein, crude ash, ether extract, starch, sugar and energy contents for pigs and dairy cattle showed satisfactory accuracy. The correlation coefficients for crude protein, ether extract and starch were 0.98, respectively. Standard error of prediction was below 0.1 MJ ME (pig) kg^{-1} DM and below 0.08 MJ NEL kg^{-1} DM. The prediction accuracy for crude fiber, fiber fractions and AME_N was poor. The prediction accuracy should be improved during further growing seasons.

Introduction

The exclusive use of organically produced animal feedstuffs is fixed in the EU-VO 2092/91 for the year 2011. But special approvals exist for the use of conventional feed components up to 2011. Nevertheless, all possibilities and resources should be used to evaluate feedstuffs for optimised feed rations to meet the recommendations of the German Society of Nutrition Physiology (GfE, 1999, 2001, 2006). The differences in the contents of crude nutrients from year to year, as well as the local differences of the contents, point out that a satisfying calculation of feed rations needs an exact knowledge of the contents of the feed compounds used.

Feed evaluation requires comprehensive and expensive analytical work. A strong demand for a fast and easy method to determine of the main ingredients exists. Therefore the potential of NIRS should be tested for predicting the chemical composition of organically grown grain legumes and cereals and also for predicting the energy values for dairy cattle, pig and poultry. In order to obtain robust NIRS calibrations, a large and variable set of samples is required with chemical composition determined by standardised methodologies.

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The present study addresses the development of calibration equations to predict the chemical constituents and energy values of organically grown feedstuffs at the experimental station of the Institute of Organic Farming in Trenthorst.

Materials and methods

Over the past years (2002 to 2005), mixed cropping field trials with different grain legumes (blue and white lupines, peas, field beans) and cereals (barley, wheat, oat) were conducted at the experimental station of the Institute of Organic Farming in Trenthorst. In addition plot trials were carried out to test the cultivation ability of blue lupins. Samples from these trials were used for the investigations. At first samples were dried, purified and ground to 1mm. Afterwards the samples were analysed both by chemical analysis and by NIR-spectroscopy.

The chemical constituents of the feedstuffs were determined according to the methods of VDLUFA (1993). The energy values were calculated according to the formulas developed by the German Society of Nutrition Physiology as net-energy for lactation (NEL) for dairy cattle (GfE, 2001), as metabolizable energy for pigs (ME) (GfE, 2006) and as nitrogen-corrected apparent metabolizable energy (AME_N) for poultry (GfE, 1999) using the data from chemical analysis.

NIRS analysis was carried out on the ground samples using the Fourier-Transform NIR spectrometer (NIRLab N-200, Fa. Büchi, Essen) in the spectral range from 1000 to 2500 nm with a step of 1 nm. Each sample was scanned three times and the spectra were averaged. Spectral data were exported to the NIRCal software (Fa. Büchi, Essen) and different mathematical pretreatments (derivation, smoothing) were performed. Calibration equations for crude nutrients and energy contents were calculated by partial least square regression (PLS) on about two-thirds of the samples (n=286). The calibration equations were than validated on the remaining 125 samples. Calibration equations were evaluated in terms of standard error of calibration (SEE) and coefficient of determination (r_{cal}), validation equations were evaluated in terms of standard error of prediction (SEP) and coefficient of determination (r_{val}).

Results and discussion

The statistics of NIRS calibration for chemical characteristics are listed in Table 1. The data set was split to predict the protein contents in a set containing the protein feedstuffs and another containing the cereals. The prediction accuracy for crude protein was satisfactory for both data sets, with SEP of 0.71 and 1.08 %, respectively. The coefficients of prediction were just as good for ether extract and crude ash. The strong absorption of fat in the NIR region is well known (Shenk et al., 1992). Therefore SEE and SEP for ether extract were low (0.32 and 0.34 %, respectively). Although the coefficient of determination for NIRS prediction of crude fiber was satisfactory, the SEE and SEP were high and the prediction accuracy was poor. The NDF and ADF prediction accuracy was fairly low, the SEE and SEP values were too high. To predict the starch content, the data set was split in the range of 30 %. NIRS prediction of starch showed high coefficients of determination in both data sets. The prediction accuracy of starch (SEP = 1.33 and 1.38 %, respectively) was very good and is comparable to results from Xiccato et al. (2003) with SEP of 1.6 %. The sugar calibration was satisfactory with a SEP of 0.74 %.

NIRS prediction of ME concentration showed satisfactory results, the SEE and SEP were low (0.09 and 0.1, respectively). NEL concentration in feedstuffs was very well predicted (SEE = 0.08, SEP = 0.08 MJ kg^{-1} DM). Simply the prediction accuracy for AME_N was poor. The SEE and SEP were high with 0.69 and 0.65 MJ kg^{-1} DM, respectively. Similarly poor results for AME_N prediction were reported by Valdes and Lesson (1992) with SEE of 0.4 MJ kg^{-1} DM. An explanation for the different prediction accuracy among the energy values could not currently be found. Amazingly, the prediction of energy values containing nutritive values (ME and NEL) were successful in contrast to AME_N even though the prediction is more complex because animal response to feeding is involved.

Tab. 1: Standard errors of calibration (SEE) and validation (SEP) and coefficients of determination in calibration (r_{cal}) and validation (r_{val}) obtained by PLS to predict the chemical composition and energy contents in organically grown feedstuffs

Crude nutrients (% DM) and energy contents	Range (%)	Calibration SEE	r_{cal}	Validation SEP	r_{val}
Crude protein (low)	5.6-19.1	0.68	0.98	0.71	0.98
Crude protein (high)	19.4-46.7	1.09	0.98	1.08	0.98
Ether extract	1.4-13.7	0.32	0.99	0.34	0.99
Crude ash	1.7-10.8	0.47	0.94	0.50	0.94
Crude fiber	2.5-39.7	1.93	0.97	1.93	0.96
NDF	12.9-70.5	3.14	0.98	3.33	0.98
ADF	3.5-50.6	2.61	0.96	2.60	0.96
Starch (high)	29.5-70.3	1.18	0.99	1.33	0.98
Starch (low)	3.7-27.6	1.40	0.96	1.38	0.96
Sugar	1.8-15.2	0.68	0.96	0.74	0.95
ME (MJ kg^{-1} DM)	15.26- 16.55	0.09	0.93	0.10	0.90
NEL (MJ kg^{-1} DM)	8.16-9.66	0.08	0.95	0.08	0.95
AME_N (MJ kg^{-1} DM)	8.86-15.27	0.69	0.92	0.65	0.92

ADF = acid detergent fiber, NDF= neutral detergent fiber

Conclusions

NIRS showed good reliability in the prediction of most chemical constituents and energy values of organically grown grain legumes and cereals in Trenthorst. This was particularly true for crude protein and ether extract, whereas the prediction of fiber and fiber fractions was less satisfying, partly due to the low reproducibility of the reference methods. NIRS analyses permitted the prediction of the energy concentrations of organically grown feedstuffs for pigs and dairy cattle. The prediction accuracy, especially for the fiber fractions and $AME_{N,}$ should be improved during further seasons. Further studies are necessary to validate the obtained calibration equations with independent samples from other locations.

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Application of standardised biocrystallization on milk and butter samples

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Key words: organic food, biocrystallization, milk, butter

Abstract

Milk and butter samples from different feeding regimes were tested with standardised biocrystallization method. When computerized texture analysis is applied, milk and butter samples from different feeding regimes can be differentiated as statistical significant.

Introduction

The biocrystallization method has been used on animal products like milk (Merten et al., 1958). The sample is transferred to a watery phase and placed on a glass dish for crystallization with an inorganic salt ($CuCl_2$). Patterns then emerge that can be evaluated with a texture analysis developed for this purpose (Andersen et al., 1999; Meelursarn, 2007). The method was able to differentiate successfully samples from different treatment (Busscher et al., 2007). The present study is intended to show that biocrystallization can also be used for milk and milk products. The samples are derived within EU-QLIF WP5.3.

Materials and methods

Samples: For the pre-trials according the characterization of the biocrystallization, method milk and butter samples were purchased from the local market. Blinded milk and butter samples for the tests were from cow-herds with different feeding regimes and derived from Agroscope Liebefeld-Posieux Research Station ALP (Switzerland) directly via ground mail in spring and fall 2006. The milk samples were fresh, stabilized with Bronopol as well as frozen. The butter samples were produced at the pilot plant of ALP in May and September 2006. UFA/CLA enriched butter was obtained from Holstein cows (n=10) fed with pasture and sunflower seeds during 2 weeks. Control cows (n =10) were fed a conventional diet, composed of pasture and corn silage. The raw milk was collected separately from the two groups. The objectives of this part of the case study was the analysis of shelf life and the differentiation of milk and butter samples deriving from different diets of the cows within EU-QLIF-project.In fall 2006, the samples were stored with 4-6 °C as well as -18 °C for 8 weeks in addition and crystallized in week 1, 2, 4, 6 and 8. Sample preparation milk: After the sample tubes (200 mL) are moved gently in a circular, horizontal manner, 50 mL of the milk sample is transferred into a 100 mL Erlenmeyer-flask. The flask is left to stand for 30 min in a water bath (the frozen sample 90 min). After reaching 20 °C, milli-Q water and 10 % $CuCl_2$ solution are added until the desired mixing ratio milk/$CuCl_2$ is reached (30 min, Heidolph Unimax 2010, 100 rpm). Per dish 200 mg milk and 150 mg $CuCl_2$ is used (volume 6 mL). 2 dishes were

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crystallized per each of the 2-3 sample repetitions in 2 chambers in parallel at 2 different days. For the evaluation all images from each sample were used.

Sample preparation butter: Because no biocrystallization procedure for butter samples existed, a method had to be developed. 100 g of a butter sample is transferred into a 250 mL Erlenmeyer-flask and 100 mL milli-Q water (Millipore) is added at 50 °C. The extraction takes place in a water bath at 50 °C on a Heidolph shaker (Unimax 2010, 175 rpm). The mixture is transferred into a separation funnel for separating the two phases. The watery phase is placed into a laboratory centrifuge (Universal 32R, supplier: Hettich/D) at 4.000 rpm for 10 min and after centrifugation a 10 % $CuCl_2$ solution is added until the desired mixing ratio butter/$CuCl_2$ is reached (30 min, 100 rpm, Heidolph UniMax 2010). Per dish 700 mg butter and 75 mg $CuCl_2$ is used (volume 6 mL). 6 dishes were crystallized per each sample repetition in 2 chambers in parallel at 2 different days. For the evaluation all images from each sample were used. Testing the influence of different mixing ratios on the pattern, commercial butter samples are crystallized with 16 different mixing ratios. For the test to determine the effect of different temperatures during extraction, butter samples from ALP were extracted at different temperatures (water bath). For every sample run a wheat standard is applied (Busscher et al., 2008). Construction and function of the crystallization chambers used here are documented in Busscher et al., (2008). To evaluate the patterns a texture analysis is applied. Here variables are applied by plotting them relative to circular regions of interest (ROIs) 20-100 %. This plotting is also done for the results of the statistical evaluation (F- and p-values). Only those variables are considered which show a monotonous course with ROI. The image analysis results are presented using one region of interest of the picture (ROI = 90 %), but they have also been calculated for interim stages. The variable *diagonal moment* was choosen, because of the best repeatability. The statistical evaluation has been carried out by means of a "linear-mixed-effects" model Programme R (Meelursarn, 2007).

Results

When the described procedures were applied, milk and butter samples could be crystallized (Figure 1). Freezing the milk samples influences the pattern, which can be evaluated by the texture variables as statistical significant (*diagonal moment*, $p < 0.05$) in spring 2006. The effect depends on the ROI. The effect was still measurable but not significant when the samples were sent around in fall 2006. When the 2 milk samples (coded as A, B; B=control) from the different feeding regimes from spring 2006 were crystallized, the pattern show significant differences ($p < 0.05$) for *diagonal moment* and ROI > 40 %, independent from the treatment. Because sample B was influenced stronger from the freezing process than A, the difference between both milk samples from different feeding regimes increases when the samples were frozen (Figure 2). When the 2 samples were send around in fall, the texture analysis variables could not show a significant difference between the feeding regimes, except when the sample were stabilized with Bronopol. Here the difference is significant for ROI > 70% ($p_{diagonal\ moment} < 0.05$). The butter patterns were influenced by different temperatures during extraction. *Diagonal moment* increases with higher temperatures. The increase depends on ROI and on the feeding regime. Furthermore the butter patterns are influenced by different amounts of sample per dish. *Diagonal moment* increases with higher amounts of sample. The increase does not depend on ROI. The differences between the samples is significant when comparing 600, 700 and 800 mg of the sample per plate ($p < 0.05$, ROI 60). The influence of the mixing ratio on the patterns is stronger for the control than for the treatment in the range between 400-1600 mg

Figure 1: Crystal pattern from milk sample (left) A fresh, sent in spring 2006 (5-B2006.05.22.K-J-05-2006.05.26 11.57.cut.tif and from butter sample (right) Nr. 12, sent in spring 2006 (11-B2006.06.27.K-Q-11-2006.07.04 10.12.cut.tif)

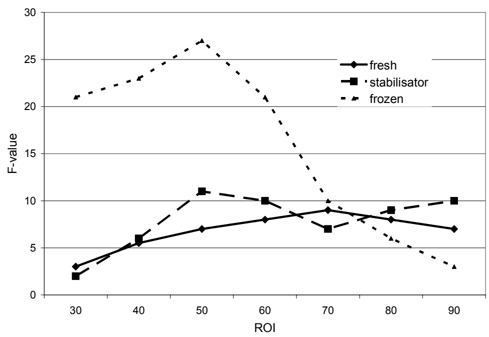

Figure 2: F-Values (lme ANOVA) for the difference between milk samples A and B from spring 2006 according to different sample treatments during transport for variable *diagonal moment* and different ROIs

When the two different butter samples were crystallized with 3 times sample preparation repetition and 3 dishes per sample preparation per chamber in two chambers in parallel on two different days (maximum variation), the difference between the two feeding regimes is significant ($p_{diagonal\ moment} < 0.001$, $30 < ROI < 70$). When the samples of the different feeding regimes were sent around in fall 2006, the difference is also significant ($p_{diagonal\ moment} < 0.05$, $30 < ROI < 70$). When the two butter samples from the different feeding regimes were stored for 8 weeks at 4-6 °C, a significant change in the patterns of both samples can be observed (Figure 3). When the frozen standard is taken as a reference, the storage influences the patterns from sample of milk of cows fed a conventional diet more compared to the other sample. After 8 weeks of storage the patterns from the control sample stored at 4-6°C showed a significant difference to those stored as reference material at -18 °C ($p_{diagonal\ moment}$ <

0,0001, 30 < ROI < 70). The difference between the samples can still be detected as significant ($p_{diagonal\ moment} < 0.05$) independent from ROI.

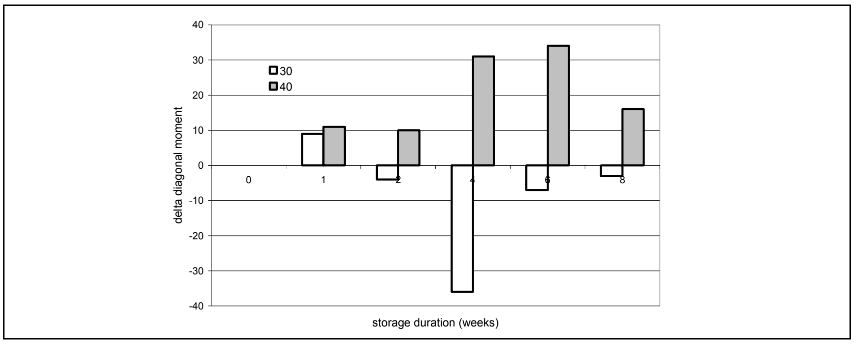

Figure 3: Difference between butter samples stored at 4-6 °C and -18 °C (as standard) for sample 30 (treatment) and 40 (control) (fall 2006, *diagonal moment*, ROI 60).

Conclusions

The standardised biocrystallization method can be applied on milk and butter samples. Samples from different feeding regimes as well as storage duration (shelf-life) can be differentiated as statistical significant.

Acknowledgments

The authors thank B. Rehberger, ALP/CH for organising the samples; M. Huber/P. Doesburg LBI/NL and J.-O. Andersen BRAD/DK for excellent cooperation. The authors gratefully acknowledge funding from the European Community financial participation under the Sixth Framework Programme for Research, Technological Development and Demonstration Activities, for the Integrated Project QUALITYLOWINPUTFOOD, FP6-FOOD-CT-2003- 506358. The views expressed in this publication are the sole responsibility of the author(s) and do not necessarily reflect the views of the European Commission. Neither the European Commission nor any person acting on behalf of the Commission is responsible for the use which might be made of the information contained herein.

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Authentication of organic wheat samples from a long-term trial using biocrystallization

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Key words: authentication, organic food, biocrystallization, wheat

Abstract

Organic and conventional wheat grain samples from a long-term field trial were tested with standardised biocrystallization method. In 1999-2006 the organic samples can be separated from the conventional samples using computerized texture analysis and standardised visual evaluation of the crystallization patterns. Moreover the organic samples can be classified in 2005-2006 after training in 2003.

Introduction

The market for organic food is growing. The further growth of the market depends on whether the consumer still places a higher value on the quality of organic produce than on that of traditional produce. It is thus a question of the exposure given to these foodstuffs and how authentic they are. Studies indicate that holistic methods, such as biocrystallization, are especially suitable for authenticity tests of organic produce, hence a validation of the methods has been demanded (Siderer et al. 2005). Reproducible crystallization patterns emerge when a watery dihydrate cupric chloride ($CuCl_2$) solution with plant extract is crystallized on a glass dish. The emerging patterns are characteristic of sample material. It is a two step process: first, the preparation of the samples in the laboratory with subsequent evaporation and crystallization in close climate chambers (Kahl, 2007); second, the evaluation of the patterns (Andersen et al., 1999). The process of pattern formation has so far not been elucidated. Earlier studies hitherto indicate that, in particular, physical-chemical processes affect the pattern formation during the evaporation. The validation process and scope have been described for biocrystallization (Kahl, 2007) and a suitable statistical model was developed (Meelursarn, 2007). The DOC-trial has been conducted continuously since 1978 (Mäder et al., 2007). The experiment uses a field plot design where different conventional and organic farming systems with identical crop varieties are run together in order to eliminate variation in climatic conditions and soil types. Wheat grain samples from this long-term field trial provide an excellent basis for authentication of organic crop samples.

Materials and methods

Samples: Wheat grains (*Triticum aestivum* L., cv. 'Tamaro' (in 1999 and 2002), 'Titlis' (in 2003 and 2005), 'Runal' (in 2006)) were harvested in 1999, 2002, 2003, 2005, 2006 from the DOC field trial conducted near Basel, Switzerland (Mäder et al., 2007). Material was used from two organic farming systems defined as bio-dynamic (D2) and bio-organic (O2) and two conventional systems, one with mineral fertilizer plus

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farmyard manure (K2) and the other with mineral fertiliser only (M). Additionally, wheat grains from plots without fertilization (N) were included. Samples were taken from an independent source, divided, coded and delivered to the laboratory. The decoding took place after submission of the results.

Biocrystallization procedure: In 1999-2003 bulk samples of the four field replicates were crystallized and 2005-2006 the four field replicates separately. The sample preparation was repeated 2-3 times per sample (sub-samples) and is described in Kahl (2007). For every chamber run a wheat standard is applied (Busscher et al. 2008). The crystallization solution is prepared by mixing the filtered wheat extract with a 10 % $CuCl_2$ solution to a final concentration of 90 mg $CuCl_2$ and 90 (70) mg extract (denoted as 90/90 and 70/90 respectively) per dish (volume is 6.0mL). Construction and function of the crystallization chambers used here are documented in Busscher et al. (2008). 3-6 dishes of each sample preparation (chamber solution) per chamber are crystallized in parallel. Because both chambers are used in parallel for all samples described here, the result is a dish repetition of 6-12 dishes per sample preparation and thus at least 12-24 dishes per sample. For the evaluation of the trials all dishes per sample are grouped together.

To evaluate the patterns the texture analysis developed by Andersen et al. (1999) is used. Only variables of a second order (because of histogram matching) on Scale 1 are considered. The variables are described in Carstensen (1992, ref. in Andersen et al. 1999). Here 15 variables are applied by plotting them relative to circular regions of interest (ROIs) 20-100 %. This plotting is also done for the results of the statistical evaluation (F- and p-values). Only those variables are considered which show a monotonous course with ROI. The image analysis results are presented using one region of interest of the picture (ROI = 90 %), but they have also been calculated for interim stages. For detailled description ref. Meelursarn, 2007. The Linear Discriminant Analysis (LDA) was performed in JMP applying all 15 different variables of the texture analysis. In addition to the texture analysis the patterns were visually evaluated in that all patterns from the samples prepared on one day and in one chamber were placed in parallel with increasing evaporation time (which is recorded with a camera during evaporation) on a light box and evaluated by trained people (for detailled description ref. Kretschmer, 2003, Kahl, 2007).

Results

When the patterns from the harvest 1999 where analysed with texture analysis followed by LDA, all samples can be separated, while the two organic and the one conventional with mineral fertilizer plus farmyard manure (K2) are near together (Figure 1). The misclassification is 32%, when all five samples are taken separately. In 2002 the five samples can be grouped into three classes (results not shown). After decoding the three classes are the two organic and the two conventional, whereas the control represents its own class. The results of the statistical evaluation on the basis of the single variables show that there is a significant effect ($p<0.05$). In 2003 the two organic and the two conventional are grouped, whereas the control belongs to the samples grown conventionally (Figure 2). When the two conventional and the two organic were grouped, the missclassification is 21%. The results of the statistical evaluation on the basis of a single variable reflect the results derived with the LDA and show that there is a significant effect ($p<0.05$). The samples from harvest 2005 and 2006 where evaluated both with computerized texture analysis as well as visual evaluation. Based on single texture variable calculation the organic samples can be differentiated from the conventional samples as statistical significant ($p<0.05$).

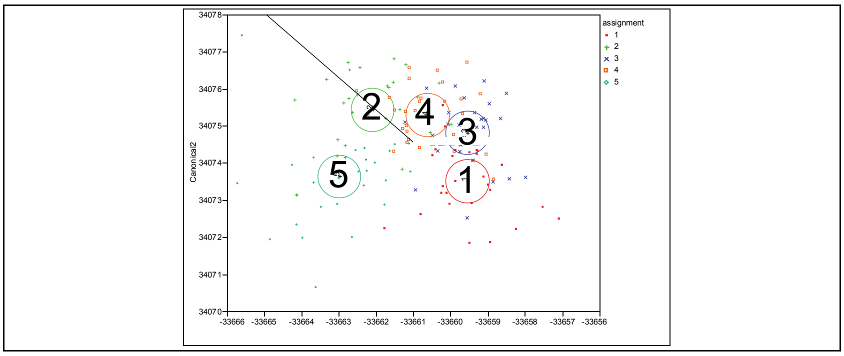

Figure 1: Canonical plot (LDA) using variables of the biocrystallization texture analysis for five blinded samples of the DOC-trial, harvest 1999 (1: O2; 2: M; 3: D2; 4: K2; 5: N). X- and y-axis are the canonicals 1 and 2 of the LDA.

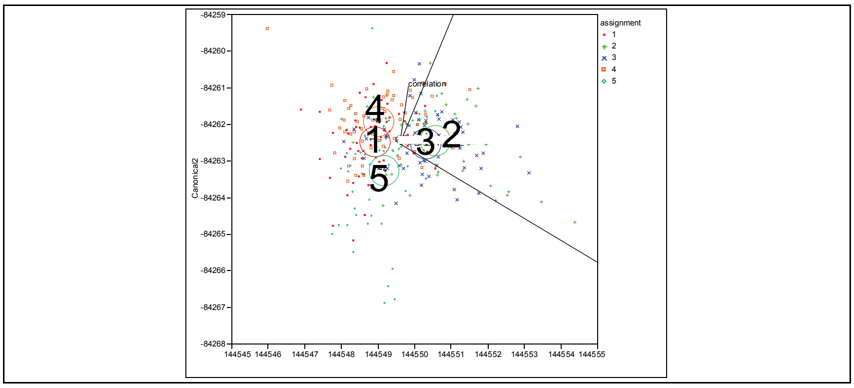

Figure 2: Canonical plot (LDA) using variables of the biocrystallization texture analysis for five blinded samples of the DOC-trial, harvest 2003 (1: K2; 2: O2; 3: D2; 4: M; 5: N). X- and y-axis are the canonicals 1 and 2 of the LDA.

When the visual evaluation was trained on the patterns received from the samples from 2003 and applied on the samples from 2005 and 2006 the classification of the organic samples where 100% correct in both years (Table 1).

Tab. 1: Classification of the five samples from DOC-trial with visual evaluation of the biocrystallization patterns (field replicates tested)

	N	D2	O2	K2	M
2005	N	D2	O2	K2	M
2006	N	D2	O2	M	K2

Discussion

The organic and the conventional wheat samples from the DOC-trial can be differentiated using standardised biocrystallization with computerized texture analysis. Moreover the samples from 2005 and 2006 can be classified by visual evaluation. In 1999-2003 bulk samples where crystallized which allows to improve the method ability for differentiation of samples only. The results from the field replicate measurements in 2005 and 2006 show that the method is able to differentiate and classify samples according to the treatment (farming systems). To what degree each of the evaluation tools can be applied separately or in combination has to be tested in further investigations. The method variation is still too high for being applied in routine analysis, here the crystallization step has to be optimized.

Conclusions

The standardised biocrystallization method can separate and classify defined organic wheat samples from conventional ones (long-term field trial). Texture analysis and visual evaluation of the patterns were applied in parallel. For routine analysis the method has to be optimised and samples from the praxis have to be tested.

Acknowledgments

JK and NB thank B. Kulig, Statcon, Witzenhausen/D for the LDA calculation and Prof. Dr. G. Rahmann, FAL-OEL/D for the organisation of the samples and the Software AG Stiftung/D as well as the BMVEL/D for financial support. Machteld Huber and Paul Doesburg from LBI/NL and Jens-Otto Andersen from BRAD/DK for excellent cooperation within the Triangle-network (specially the development of the visual evaluation tools).

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Organic wheat quality from a defined Italian field-trial

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Key words: organic wheat, quality, lutein, total protein, biocrystallization

Abstract

Organic and conventional wheat grain (Triticum aestivum and Triticum durum) samples coming from a defined field trial in Italy were measured in 2005 and 2006 for their total protein content and the contents of lutein and zeaxanthin. Additionally the samples were analyzed by means of the biocrystallization method. The grain samples could be differentiated by the total protein content, which was higher in the conventional samples. The organic samples contained a higher lutein content in Triticum aestivum but lower in Triticum durum. Biocrystallization differentiated Triticum durum from Triticum aestivum and organic from conventional grown samples when visual evaluation was applied. Differentiation of farming systems was possible for biocrystallization evaluated with computerized texture analysis but not significant for all samples and years.

Introduction

The growth of the organic food market is causing a growing interest in investigations on products deriving from differently managed farming systems. In such comparison studies it is of particular importance to use a possibly wide range of analysis methods, because the quality differences due to the farming system can appear in crops in various forms – in the contents of singular compounds, as well as in the structural features, which can be analyzed on the whole product only. In our research we have united therefore common chemical methods and holistic methods of analysis, so as to receive complementary information about the given samples. The aim of our experiment was to differentiate the organically and conventionally grown grain samples. The samples derived from the Mediterranean Arable System COmparison Trial (MASCOT) in Italian Toscana, a long-term experiment started in 2001 and carried out at the Interdepartmental Centre for Agri-environmental Research "E. Avanzi" (CIRAA) of the University of Pisa. The choice of the applied analysis methods was based on the founds in the available literature. The content of carotenoids, which belong to the secondary plant metabolites, was found to differ in organic and conventional crops because of the different growth conditions, like exposure to pests and diseases (Roose, 2008). Many studies were conducted on the antioxidants contents present in different wheat varieties (Roose, 2008). But to our knowledge there is still limited literature on the contents of antioxidants in wheat samples deriving from differently managed farming systems. Studies indicate that holistic methods, such as biocrystallization, are especially suitable for authenticity tests of organic produce, hence a validation of the methods has been demanded.

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Materials and methods

Samples: Organic and conventional *Triticum aestivum* L. (variety 'Bolero') and *Triticum durum* L. (variety 'Claudio') wheat samples in three field replicates (in total 12 samples per year), harvest 2005 and 2006, coming from the MASCOT-trial (Bàrberi et al., 2006) were analyzed by means of common chemical analysis for the content of total protein, secondary plant metabolites (lutein and zeaxathin), and by means of the biocrystallization method for the picture forming properties. The aim of the experiment was the differentiation of the coded wheat samples. The experiment was performed in the laboratories of the University of Pisa and the University of Kassel. The fertilizer rates for the conventional system were the following ones: for *T. aestivum* 156 N, 92 P_2O_5, and 30 K_2O kg ha^{-1} and for *T. durum* 156 N, 92 P_2O_5, and 0 K_2O kg ha^{-1} on mineral basis and for the organic system: 30 N, 30 P_2O_5, and 30 K_2O kg ha^{-1} for both *T. durum* and *T. aestivum*. The fertilizer applied for the organic system was on organic basis, from dried manure; the amount of nitrogen available after clover was estimated 70 kg ha^{-1}. Total protein: The total protein levels were determined using the procedure of Kjeldahl (EN ISO 3188, 1994). Factor 5.75 was applied to calculate protein content. The statistical analysis was the one way ANOVA for randomized blocks performed by use of the CoStat software (CoHort, 2006). Xanthophylls: Lutein and zeaxanthin were prepared as described in Roose (2008) by extraction with Methanol/THF followed by HPLC-separation and DAD-detection. Biocrystallization procedure: The sample material was crystallized in Italy and Germany in parallel. The experimental conditions at the University of Pisa are described in Mazzoncini (2005). The mixing ratio was 70mg substance based on 10% watery extract in combination with 90mg dihydrate $CuCl_2$ per plate. The resulting pictures were scanned and analyzed by means of the *Image J* computer software for the gray level distribution (Reinking, 2007). The mean values of the gray level distribution were measured within 10 ROI's (regions of interest) of circular shape, with the centers placed in the geometrical center of the picture, and diameters of different length. The diameter of ROI 10 was equal with the picture's diameter, whereas the diameters of ROI 9 to 1 were equal with 90 to 10% of ROI's 10 diameter. The visual evaluation of the patterns from harvest 2005 was carried out at the University of Kassel (Kahl, 2007). The sample preparation at the University of Kassel is described in Kahl (2007). For every sample run a wheat standard is applied (Kahl, 2007). Construction and function of the crystallization chambers used here are documented in Kahl (2007). To evaluate the patterns a texture analysis *acia* is used, where the variables of the second order are used (Kahl, 2007; in contrast to *Image J*). In addition to the texture analysis the patterns were visually evaluated in that all patterns from the samples prepared on one day and in one chamber were placed in parallel with increasing evaporation time (which was recorded by camera) on a light box and evaluated by trained people (Kahl, 2007).

Results and discussion

In both examined years the grains of both species differed significantly in their protein contents depending on the cultivation system (Table 1). The protein content of the organically grown grains was 2-3% lower then in conventionally grown grains. In year 2006 the protein contents of both varieties and cultivation systems were slightly higher, than in year 2005. The differences in lutein content were very small. For *Triticum aestivum* the lutein content of the organic grains was significantly higher in both years. For *Triticum durum* the lutein content was lower in the organic samples, but only for the samples of the year 2005.

In both years there was a significant higher content of zeaxanthin in the conventional varietys of *T. durum*, but no difference for *T. aestivum.*

Tab. 1: Protein content of the wheat samples from MASCOT-trial

Protein content [%]				
	Harvest 2005		Harvest 2006	
	Organic	Conventional	Organic	Conventional
T. aestivum	8,54	11,84	10,10	12,28
significance	***		***	
T. durum	8,15	10,87	8,88	12,47
significance	***		***	

* significance at α=0,05 based on one way ANOVA for randomized blocks.

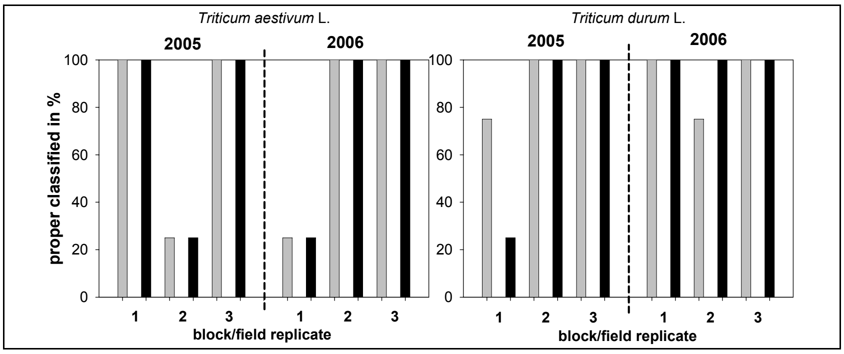

Figure 1: Classification of the MASCOT wheat samples according to the farming system (organic: gray/conventional: black). The bars are showing the percentage of proper classified sample replicates per field replicate/block.

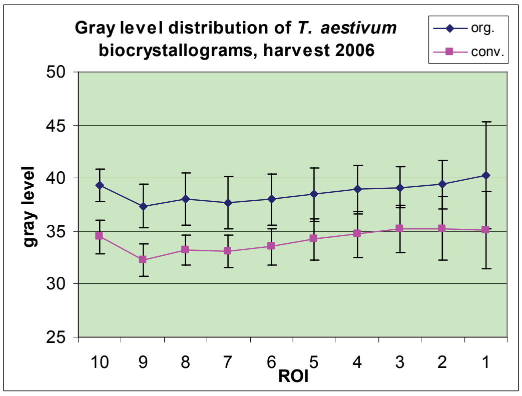

Figure 2: Mean values of the gray levels calculated by Image J for the biocrystallization patterns measured at Pisa/I from MASCOT Triticum aestivum wheat samples (ROI: Region of Interest) in 2006 (3 patterns per field replicate).

The variation of the lutein content in *T. durum* was higher for the conventional samples than for the organic. There was no consistent differentiation between the farming systems for both lutein and zeaxanthin. For *T. aestivum* 70% of the samples can be classified correctly, for *T. durum* 80% (Figure 1). When the biocrystallization patterns from the harvest 2005 were evaluated by applying an adapted triangular-test, the difference between org. and conv. samples was significant for both, *T. aestivum* and *T. durum*. With computerized texture analysis based on the gray level distribution (*Image J*) a significant differentiation was possible for all samples and years for ROI 8, 7 and 6 (Figure 2). With the texture analysis based on second order statistics, there was a significant difference between *T. durum* and *T. aestivum* but the difference between the farming systems was not significant over all samples and years. When the patterns of the biocrystallization at the University of Kassel were visually evaluated by trained people (descriptive test), the farming systems could be differentiated and correctly classified in both years for all samples.

Conclusions

The introduction of holistic methods into our comparison study on organic and conventional wheat samples showed that differences due to different farming systems can be found applying both: common and holistic methods of analyse. The organic and the conventional wheat samples from the MASCOT-trial could be differentiated by total protein measurements and visual evaluation of standardised biocrystallization patterns. The difference could also be described applying different computerized image analysis programs on the biocrystallization patterns, although the difference was not always significant. Evaluation of lutein contents resulted in correct classification of the samples of 70-80%. The variation between the field replicates was higher than between the farming systems and moreover there seemed to be an opposite effect comparing lutein contents of *T. aestivum* and *T. durum*. The biocrystallization needs further development and validation when texture analysis with *Image J* and visual descriptive tests are applied.

Acknowledgements

MK thanks to the Centre “E. Avanzi” CIRAA, Via Vecchia di Marina 6, 56122 San Piero a Grado PISA, Italy for the wheat samples.

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Organic beef production by Maremmana breed: qualitative meat characteristics

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Key words: Maremmana breed, Organic beef, meat quality

Abstract

Meat quality of Maremmana young bulls and steers was evaluated during three consecutive years, according to an extension service experimental program. Cooking loss values of meat samples were lower in meat from steers, whereas shear force values were higher. Meat from steers was darker than meat from young bulls, as a consequence of a low level of Lightness and a high level of Chroma. Meat chemical composition showed a higher content of intramuscular fat in steer meat, which showed also a lower level of saturated fatty acids and a higher level of unsaturated fatty acids. Conjugated linoleic acid content in meat fat either from young bulls or from steers was similar to that found in meat from confined cattle fed preserved forages and concentrates. However steer meat showed higher CLA content than young bull meat.

Introduction

As a consequence of the growing demand from consumers of foods with high quality standards (with particular emphasis to the interactions between human health and food nutritional properties), in the last years, research has been focused on the relationships between organic production system and quality traits of products. In beef production, EU organic rules may easier applied to some autochthonous cattle breeds (like Maremmana breed) that are characterized by extensive production systems. Aim of the work was to evaluate how modification in management and feeding regimen may affect meat quality and fatty acid composition of intramuscular fat from Maremmana young bulls and steers, reared in an organic farm located in the Tuscany Region (Italy).

Materials and methods

The trial lasted three years. During these years, management and feeding regimen of calves were modified in order to optimize the growing rhythm and the slaughtering weight of the calves, according to an extension service experimental program, financed by the Regional Agency for Development and Innovation in Agriculture (ARSIA) of the Tuscany region. Each year, a group of Maremmana calves (eight, six and seven for the first, the second and the third year, respectively), born at the end of the winter, was weaned at the begin of the autumn and confined in feedlot. The weaning weight was 164$\pm$25, 215$\pm$43, and 165$\pm$50 kg, for the first, the second and the third year, respectively. During the first two years, calves were maintained in feedlot from weaning to slaughtering. In the third year, calves were castrated and managed

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on pasture until fattening, when they were confined in feedlot until slaughtering. During the three years, feeding regimen was based on oat hay and oat haylage *ad libitum* administered. Concentrate was daily administered on the basis of 0,8 kg/100 kg of live weight (LW) during the first year, and 1 kg/100 kg LW during the second and third year. Concentrate was composed by 75% of grounded barley and 25% of grounded bean during the first two years and by 80% of grounded barley and 20% of grounded bean during the third year. The slaughtering age and the slaughtering weight were 568±29, 562±71 days, and 494.2±44.3, 567.2±67.5 kg, for young bulls in the first and second year, respectively. In the third year, steers were slaughtered at 642±66 days and the slaughtering weight was 548±9 kg. After 14 days of ageing, the right half-carcass of all animals were dissected. Chemical and physical analysis (ASPA, 1996) were performed on samples of *Longissimus thoracis* muscle, taken from the 5th and 9th rib and stored at -20°C, after vacuum packaging. Fatty acid (FA) methyl esters of intramuscular fat were analysed by a gas-chromatograph apparatus, equipped with a 100 m. capillary silica column (Chrompack CP-Sil 88 Varian, Middelburg, the Netherlands). Atherogenic and thrombogenic indexes were calculated according to Ulbricht and Southgate (1991). All data were reported as means ± SD using the PROC MEANS of the SAS statistical package (1999).

Results

Steer meat showed lower cooking loss and higher shear force values than meat from young bulls (tab. 1). Colorimetric parameters differed between young bull and steer meat: a* values were higher in young bull meat, while L and b* values were lower than those found in steer meat. Consequently, Chroma values resulted higher in the meat of steers. Meat chemical composition resulted similar for young bulls and steers with the exception of the lipid content, higher in steers (tab. 2). FA composition of steer meat resulted in a lower content of saturated and monounsaturated FA and in a higher content of polyunsaturated FA, including omega-6 (n-6), omega-3 (n-3) FA and conjugated linoleic acid (CLA) (tab. 2). As a consequence, the ratio saturated/unsaturated FA was lower in steer meat than in young bull one.

Tab. 1: Meat physical characteristics (Mean±SD)

		Years		
		First	Second	Third
		Young bulls	Young bulls	Steers
Cooking loss	%	30.37±2.61	28.42±3.72	24.10±2.04
Shear force	Kg/cm^2	2.05±0.20	2.20±0.18	2.82±0.31
L*		40.80±0.83	39.75±0.76	38.90±1.02
a*		15.30±0.32	15.88±0.45	20.00±0.74
b*		8.70±1.21	9.20±0.82	6.50±1.23
Chroma		17.60±0.89	18.20±0.75.	21.10±1.02
Hue		29.40±3.01	28.60±2.70	27.70±0.91

Discussion

Meat from steers was darker than meat from young bulls as a consequence of the lower level of Lightness and the higher level of Chroma (tab.1). This results is probably due to the higher slaughtering age. Dry matter, crude protein, total lipids, ash and sugars levels (tab. 2) are similar to those found by Sargentini et al. (2000) in Maremmana heifers and young bulls slaughtered at different ages. The higher level of fat found in the meat from steers could be considered an index of the level of fattening. FA composition of fat from steers is similar to that found by Monteiro et al. (2006). Some differences in FA composition between steers and young bulls could be due to the higher fat level in steers carcasses and to difference in the ratio between triglycerides and phospholipids (French et al., 2000).

Tab. 2: Chemical composition of meat and fatty acid composition of intramuscular fat (Mean±SD)

	Years		
	First	Second	Third
	Young bulls	Young bulls	Steers
Dry matter (%)	26.66±1.03	26.13±1.05	27.10±2.06
Crude protein (%)	21.33±0.54	20.70±0.63	22.21±0.61
Ash (%)	1.10±0.05	1.14±0.07	1.00±0.08
Total Lipids (%)	1.89±0.05 a	1.84±0.58 a	2.97±0.67 b
Sugars (%)	2.34±0.91	2.47±0.75.	2.23±0.63
Fatty acid composition of intramuscular fat (g/100 g FAME)			
Saturated FA (SFA)	52,50±8,20	50,44±7,89	45,26±1,14
Unsaturated FA (UFA)	49,09±0,32	48,12±0,27	54,73±1,14
Monounsaturated FA (MUFA)	41,53±8,23	40,70±4,87	35,30±2,37
Polyunsaturated FA n-3	1,05±0,32	1,03±0,20	2,96±0,25
Polyunsaturated FA n-6	6,28±2,46	6,16±2,04	17,89±2,90
n-6/n-3	6,06±1,45	5,94±1,21	6,08±1,12
SFA/UFA	1,07±0.02	1,05±0.02	0,83±0,04
Atherogenic Index	0.84±0.08	0.78±0.06	0.83±0.06
Thrombogenic Index	1.87±0.28	1.72±0.11	1.81±0.20
Trans - 11 C18:1	1,25±0.01	1,23±0.03	1.47±0.24
Cis-9, *trans* 11 CLA	0,14±0.02	0,14±0.03	0.19±0.04

The intramuscular fat showed a lower levels of saturated FA and monounsaturated FA respect those found by Sargentini et al. (2000), in young bulls and heifers slaughtered at 18 months of age. Nevertheless the levels of monounsaturated FA in steers are lower than that found in young bulls and similar to those found by Monteiro et al. (2006) in Mertolega breed steers, fed a diet composed by wheat straw and concentrates. Total n-3 and n-6 polyunsaturated FA and the n-6/n-3 ratio were lower than those found by Cosentino et al. (2005) in Podolica young bulls fattened at pasture. The saturated/unsaturated FA ratio resulted lower than that reported by Sargentini et al. (2000) in Maremmana heifer meat. The relatively high levels of unsaturated FA determined low values of atherogenic and thrombogenic indexes for both young bull and steer meat. The CLA content of meat fat was similar to that found in meat from cattle reared in non-organic systems (Pezzi et al. 2005) and lower than that found in meat obtained from cattle fattened at pasture (Cosentino et al., 2005). However, CLA content in steer meat was higher than that found in young bulls, in agreement with Sonon et al. (2004).

Conclusions

Variation in management and feeding regimen weakly affected meat quality of Maremmana young bulls and steers, although some parameters as meat fat content and FA composition differed between meat from young bulls and steers.

Acknowledgments

Research supported by Regional Agency of Development and Innovation in Agriculture of Tuscany (ARSIA).

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Organic vs. Conventional Field Trials: the Effect on Cauliflower Quality

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Key words: cauliflower, organic, conventional, rotation, phytochemicals

Abstract

Cauliflowers represent 10% of the vegetable production in EU and are rich sources of phytonutrients. Consumer's requests are for safe products, cultivated without massive chemical inputs. The aim of this work was to evaluate 6 years of organic (OR) and conventional (CO) field trials on 16 genotypes of cauliflower. Yield of production and quality-nutraceuticals characteristic were determined. Yield and florets weights significantly decreased in OR (about 25%) compared to CO. The differences in dry matter, soluble solids and pH between each OR and CO were negligible. The acidity and vitamin C was higher (14 and 18%) in OR respect to CO. Total polyphenol index, thiols and antioxidant indexes were slightly higher in OR compared to CO (not significant). With respect to sulphur-nitrogen volatile amounts, the total average difference between OR and CO was not significant, with however differences for single samplings. Some differences between single typologies were noted with respect to agronomical responses to different crop management. White typologies were positively influenced by CO, while green ones were more productive in OR fields.

Introduction

Cauliflower production in Italy (*Brassica oleracea*, L. var. botrytis) represented about 1% of the world production in year 2004 (Autori Vari, 2005). Spain, Italy and France are the main European countries producing cauliflower with 460, 438 and 336 thousands of tons in 2006 equalling nearly 10% of EU production (Autori Vari, 2007). Cauliflowers are rich sources of phytonutrients such as glucosinolates, vitamin C and polyphenols (John et al., 2002) and the consumer's need safe and healthy products. In a wider sense the "Inner Quality Concept", including crop management → food quality → health effects (Huber, 2006), is the more accredited. So, the main objective of the present work was to assess the suitability (18 genotypes, 3 typologies) of cauliflower for both organic (OR) and conventional (CON) systems over 6 years by analysing yield and quality parameters. Hence, organic (OR) cauliflowers (EU Rule 2092/91) and conventional (CO) fields were included in a crop rotation, in order to overcome the difficulties linked to the soil fertility and the control of biotic adversities (Caporali, 2003). Another aim of this work was to evaluate the effect of OR and CO field trials on the quality-nutraceuticals characteristics of cauliflower, justified by the lack of a specific literature.

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Materials and Methods

Plant material and yield analysis

Field trials were performed in the Research Unit for Horticulture (ORA) of National Council for Agricultural Research (CRA) located in Monsampolo del Tronto (Ascoli Piceno, Italy). The CRA-ORA is carrying on, from 2002, a research on an horticultural rotational system conducted both in OR and in CO. The two lands under crops for the trials (1584 m^2 each) were at a distance of 200m. Analyzed soils were of medium paste, and the chemical analyses were executed in the first 30 cm of depth, showing a good supply of phosphorous and potassium for OR and CON, but a low content of organic matter: 1.11% in OR and 1.21% in CO soils. Four horticultural species subjected to rotation were annually present, each one covering an area of 528 m^2 including tomato (*Lycopersicon esculentum*); cauliflower (*B. oleracea* var. botrytis), common bean (*Phaseolus vulgaris*) and muskmelon (*Cucumis melo*).

Table 1.: N - application in the organic (OR) and conventional (CO) system.

year	OR (U ha^{-1})		CO (U ha^{-1})
	pellet form	hydrosoluble	fertlizer
2002-03	150	10(1)*	190
2003-04	150	15(4)*	190
2004-05	150	1,8(5)**	190
2005-06	200	-	200
2006-07	190	7,5(1)*	200

* number of distribution on soil, ** foliar manure

In OR a green manure of velvet vetch (*Vicia villosa*) and of barley (*Hordeum vulgare*) was cultivated prior to tomato and muskmelon. Cauliflower seedlings were transplanted at the end of Aug (except in 2004 = 5 Sept) at 3rd-4th leave stage and plants were 70×60cm spaced. The N manuring in OR was made by organic pellets and hydrosoluble matter, while for CO only fertilizers were employed, in successive amounts as showed in Tab 1. Four cauliflower genotypes were compared for each year on three times replicated plots (26.8 m^2 each) with the experimental scheme of a split-block design. In total sixteen genotypes were evaluated during the experiment: 8 of white typology (7 HF1 and 1 variety) in 2002-05; 4 of "violetto di Catania" tipology (1 commercial and 3 accessions selected in CRA-ORA) in 2005/06; 4 accessions of CRA-ORA belonging to the "verde di Macerata" green typology in 2006/07. Yield and average florets weight were calculated on 16 genotypes over 6 years of trials (Tab 2). The productivity was calculated by keeping in account the decreases in production due to lost plants for stress and diseases, considering the plants really present at harvest. All data were subjected to ANOVA.

Quality attributes were determined on 3 typologies (Tab 3). Dry matter, soluble solids (SS), pH and TA were measured according the official methods. Vit C was determined by HPLC (Lo Scalzo et al., 2007). The thiols were determined according to Hawrylak & Szymanska (2004). TPI index was measured by the Folin-Ciocalteau method. The antioxidant activity by the lipoxygenase-linoleic acid-crocin method (LIPOX) was carried out according to Lo Scalzo et al., (2007). FRAP assay was carried out according to Benzie & Strain (1996). The determination of S-N aroma compounds was made as described by Di Cesare et al (2003). Each experiment was conducted two times and all analysis were made in quadruplicate and the results were referred to dry weight units. Data were submitted to analysis of variance ANOVA and the averages were compared by Tukey test ($p<0.05$).

Results and Discussion

Cauliflower productivity showed different patterns in the different years: this could be due both to environmental changes and to the genetic influence. The use of N fertilizers coupled with biostimulants enhanced productivity. The rotations had a visible effect on the soil organic matter: the values of 2002 were 1.11 and 1.21% in OR and CO, respectively, while in 2007 were 1.39 and 1.13%, with an increase for OR and a decrease for CO soils. The first three samplings (Tab 2) refer to common white genotypes. Yields were clearly higher in CO compared with CO plots.

Tab. 2: Average productivity parameters of 16 cauliflower genotypes over 6 years of production, using crop rotation in organic (OR) or conventional (CO) field management, Tukey test alpha = 0,05.

samplings		t ha^{-1}		kg florets^{-1}	
		OR	CO	OR	CO
Average 2002/03 (4 HF1)	white	15,64 b	29,24 a	0,706 b	1,255 a
Average 2003/04 (4 HF1)	white	20,55 b	26,59 a	1,106 b	1,254 a
Average 2004/05 (1 var 3 HF1)	white	9,35 b	14,49 a	0,528 b	0,728 a
Average 2005/06 (1 var 3 br. lines)	violet	3,82 a	4,64 a	0,336 a	0,380 a
Average2006/07 (4 var)	green	12,63 a	11,04 b	0,639 b	0,707 a

In the second sampling, “Rafale” and “Triomphant” obtained good yields in OR, with similar OR and CO values for “Triomphant”, assuming a significant adaptation under OR conditions for this variety. The third sampling, in particular cv “Palla di Neve”, resulted in a general reduction of productivity, due to a late in plant set and to a drastic decrease in temperature (4-8°C lower than the seasonal average). Violet genotypes were assayed in 2005/06, showing a very low productivity, suggesting a low adaptability to both field conditions. In 2006/07, the assayed green genotypes resulted in lower productivity than white, but with a good response for OR, not so different from CO.

Tab. 3: Quality parameters of OR and CO cauliflower (7 genotypes, 3 typologies, w=white, v=violet, g=green) over 6 years of trials, Tukey test alpha = 0,05.

Cauliflower tipologies	dm %	SS	pH	TA	Vit C	TPI	Thiols	LIPOX	FRAP
OR white (n=6)	8,0	5,8	6,4	36,8	465,6	411,9	20,4	46,3	129,5
OR violet (n=1)	9,0	7,1	6,5	50,0	1022,2	518,9	70,0	57,4	131,1
OR green (n=3)	9,8	6,7	6,6	41,1	526,9	511,9	19,5	44,1	94,8
OR average	8,6 a	6,2 a	6,5a	39,4 a	539,7 a	452,6 a	25,1 a	46,8 a	119,3 a
CO white (n=6)	7,9	5,6	6,5	33,2	402,2	424,6	18,2	48,5	118,5
CO violet (n=1)	10,0	7,9	6,7	39,0	690,0	591,0	64,0	60,8	163,0
CO green (n=3)	9,9	7,0	7,0	33,5	485,3	414,4	16,0	34,2	85,3
CO average	8,7 a	6,2 a	6,6a	33,8 b	455,9 b	438,2 a	22,1 a	45,4 a	113,0 a

**Early harvested, ** Late harvested*

dm: dry matter; SS: soluble solids (°Bx); TA: total acidity (mEq/100g dm); Vit C (mg/100g dw); TPI: Total Polyphenol Index (mg gallic acid/100 g dm); Thiols: total content of non-protein-SH groups (mg cystein eq./100g dm); LIPOX: antioxidant activity by the lipoxygenase-linoleic acid-crocin method (mg gallic acid/g dm); FRAP: ferric *reducing antioxidant power (mg vitC/100g dm)*

The primary quality characterization of the different cauliflower genotypes (Tab 3, dm, SS, pH and TA) affirmed that there were no differences between OR and CO, not showing a

quality loss in OR-grown cauliflowers. The only significant difference was noted for TA, which was higher in OR than in CO. The nutraceutical profile (Tab 3) shows the highest difference in vitamin C content. OR cauliflowers contained 18% more vit C than CO (significant). The TPI, thiols and antioxidant data resulted slightly higher in OR compared with CO (not significant). These trends were confirmed on other food plant species by other authors: recent studies pointed out that ascorbic acid content in OR-cultivated plants is from 5 to 90% higher than in CO ones (Heaton, 2001); polyphenols and carotenoids resulted higher or unchanged in OR plants, furtherly confirming our results (Lucarini et al., 1999).
The characteristic volatile compounds of *Brassicaceae* were sulphur-nitrogen (S-N-) substances produced from the hydrolysis of glucosinolates that have relevant healthy-implications. The main classes of these compounds were sulphurs, isothiocyanates, nitriles and thionitriles.

Tab. 4: Sulphur-Nitrogen volatiles (mg/100g dm) from organically (OR) and conventionally (CO) grown cauliflowers (5 genotypes over 4 samplings). Tukey test alpha = 0,05. Nd = not found.

Cauliflower genotypes	Sulphurs		Isothiocyanates		Nitriles		Thionitriles	
	OR	CO	OR	CO	OR	CO	OR	CO
Nautilus 2004	392.2	1212.6	37.1 a	85.2 b	Nd	Nd	2,1	3.8
Medusa 2005	951.5	1198.2	369.2	489.6	Nd	Nd	0,9	2.9
Violetto di Sicilia	626.0	539.7	53.5 b	28.5 a	Nd	Nd	1.6	0,6
Noverde 2006	264.3	84.8 a	70.9 a	68.0 a	1.7	0,6 a	6.3	4,4
Velox 2007 E*	139.4	439.7	35.2 a	121.5	0,6	1.6 b	5,9	10.7
Velox 2007 L**	64.6	131.3	124.5	64.2 a	1,1	1,1 a	7,3	9.1
Average	406.3	609.4	115.1	142.8	1,1	1,1 a	4,0	5,2

**Early harvested, ** Late harvested*

Tab 4 shows a different situation in the different samplings. Specific variations have been shown for single genotypes, assuming that the influence of OR and CO could depend on both genetic and environmental factors. CO genotypes of Nautilus, Medusa, Velox 2007 E and L generally produced higher amounts of S-N-volatiles than OR ones. On the other hand, Violetto di Sicilia 2005 and Noverde 2006 resulted higher in OR trials. Other authors affirm that glucosinolates were higher in OR rather than in CO (Adam, 2002). The most important objective of OR is to prevent produce's quality reduction in comparison to CO. The present results confirm this objective, and except for the productivity of common white genotypes, the OR cauliflower did not differ from the CO samples. It's sure that further studies need to fully interprete environmental and genotypic quality characteristcs of cauliflowers in OR and CO management, in order to better answer to consumers and producers demand for high product quality.

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The complete list of references can be found in: Eprints N°: 11758

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Health and Safety of organic products

Feed composition and strategies to improve poly-unsaturated fatty acid levels in organic cow milk

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Key words: omega-3, CLA, grass pellets, roughage quality.

Abstract

Like in various other countries, organic milk in the Netherlands has higher levels of poly-unsaturated fatty acids, particularly CLA and omega-3, than conventional milk. Monitoring results from a total of 25 farms between 2004 till 2007 are presented. Regression analysis indicates a negative effect of maize silage and positive effects of feeding fresh grass, grass pellets, red clover and addition of oil on CLA levels in milk fat. Results with omega-3 are similar, but omega-3 levels in milk fat seem less related to feed characteristics: the model with feed composition, seasonal effects and farm effects as major parameters, explains a smaller part of the variation, while farm influence is much larger with omega-3 compared to CLA.

Farm influence might be caused by genetic differences and constant factors influencing roughage quality. Genetic influences are likely but could not be investigated as milk samples were not taken from individual cows. The influence of grass quality is suggested by the large effect of sampling date found in this study. Moreover, some high residual values and statistical estimates for individual farms seem often related to silage quality, botanically rich pastures and red clover feeding.

Introduction

Poly-unsaturated fatty acids (PUFA), particularly conjugated linoleic acid (CLA) and omega-3 fatty acids are increasingly recognized for their beneficial health impact. Similar to other countries (Butler et al, 2007), there are considerable differences in CLA and Omega-3 levels between organic and conventional milk the Netherlands. On average omega-3 and CLA levels were 60 and 38% respectively, higher in organic milk, with lowest levels during winter (Slaghuis & de Wit, 2007).

Variations in CLA and omega-3 levels, however, are high. Highest levels appear with fresh grass utilization and the addition of rumen protected oil, the latter technology now being used to produce conventional milk with higher levels of omega-3 fatty acids (www.campina.com). This urges for organic dairy producers to improve the levels of beneficial fatty acids in organic milk, particularly during winter. To facilitate this, a participatory research programme concerning the relationship between feeding practices and fatty acid pattern at Dutch organic farms was started in 2004. In this paper, we present the results of this research that started as part of a product development project together with a Dutch cheese factory (Aurora), to produce organic cheese with distinct levels of CLA and omega-3. Later, it became part of the governmental supported research for organic agriculture in the Netherlands (see www.biokennis.nl).

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Materials and methods

From June 2004 until September 2007, bulk milk samples were taken at variable intervals at a variable number of organic dairy farms, on average 15 farms. In total 415 samples were analysed from 25 farms. Samples were taken both at regular intervals as well as shortly before and two weeks after an interesting change in feeding ration, as un-replicated trials at farm level. Farms were selected to include as much variation as possible in feeding pattern, breeds, soil and farm type. Feed practices in the week before milk sampling were recorded by questionnaire. Feed ration composition was assessed based on farmers' estimations, combined with an assumed dry matter intake of 16 and 15 kg per day during summer and winter respectively, and a replacement rate of 0.5 resp. 0.4 kg DMI per kg concentrate in summer resp. winter. The tests were carried out from raw bulk milk by IGER (UK) on frozen samples till June 2005 and by COKZ (Netherlands) using fresh samples using the Kramer bimethylation method. In the analysis only rumen acid (C18:2 c9, t11) is taken as CLA, while omega-3 includes α-linolenic acid (C18:3 c9,12,15), EPA (C20:5, c5,8,11,14,17) and DHA (C22:6 c7,10,13,16,19). Statistical analysis was performed with GenStat 9.1 (2006), using the stepwise multiple linear regression procedure.

Results and discussion

Results are clustered according to season in table 1. CLA and omega-3 levels in this research are 1 resp. 1.5 - 2 mg per g milk fat higher compared with averages of Dutch organic milk (Slaghuis & de Wit, 2007), as a result of the farm selection process, which also resulted in relatively high levels of added oil (in the form of pure oil or included in oil rich residues). However, a comparison between seasons provides little information on the nature and importance of the different feed characteristic as several parameters change simultaneously.

Tab. 1: Means of CLA and omega-3 samples and ration composition per season

	Summer (n=208)	Autumn (n=78)	Winter (n=129)
CLA (mg/g milk fat)	9.51	8.86	5.60
Omega-3 (mg/g milk fat)	11.06	10.83	10.32
	Percentage in ration		
Concentrates	14	16	18
Grass pellets	1	2	3
Fresh grass	63	35	1
Grass silage	13	33	61
Maize silage	3	3	5
Whole grain silage	0	0	1
Red clover	2	7	10
Other roughages	2	3	2
Added oil (g/day)	38	50	78

Statistical data analysis gave a feasible model including only significant factors ($p<0.05$), explaining 74.5 resp. 62.1% of the variance for CLA and omega-3. The model included a constant factor (estimated at 6.6 resp. 11.48 mg CLA and omega-3 per g fat), feed ration components (see table 2; contributing 12 resp. 15.1% to the explained variance of CLA and omega-3), an effect of sampling date expressed as calendar week number in the year (see figure 1, contributing 48.3 resp. 11.7%), a small effect of year, and a farm effect (contributing 38.2 resp. 68.9%).

Tab. 2: Estimated contributions of feed components to CLA and omega-3 in milk fat (as mg per g milk fat per kg DM)

	CLA (mg/g milk fat)	Omega-3 (mg/g milk fat)
Added oil	9.61	5.71
Grass pellets	0.29	0.74
Fresh grass	0.33	Not incl.
Maize silage	- 0.23	- 0.25
Red clover	0.24	0.21
Whole grain silage	Not incl.	- 0.70

Concerning the influence of feed components, the effects of red clover, maize silage, oil and fresh grass intake are consistent with literature (e.g. Chillard & Ferlay, 2004; Elgersma et al, 2006). The positive effect of red clover seems to be related to specific plants components and/or higher levels of PUFA's in clover. Both aspects of red clover seem highly variable (e.g. Vanhatalo et al, 2007), which is coherent with the variable effects of red clover in this research. The positive effect of feeding grass pellets might be related to increased rumen passage and thereby reduced bio hydrogenation (see e.g. Cabrita et al, 2007) as well as to higher levels of PUFA's in the grass as oxidation between harvesting and conservation is limited. The effects of grass pellets in this research are not constantly high, probably due to differences in original grass quality and time span between mowing and pelleting. The highly negative effect of whole grain silage might be an artefact, due to the low number of values (30) on which this estimate is based, but it might also be due to the high level of NDF inducing slow rumen passage and thus increased bio hydrogenation.

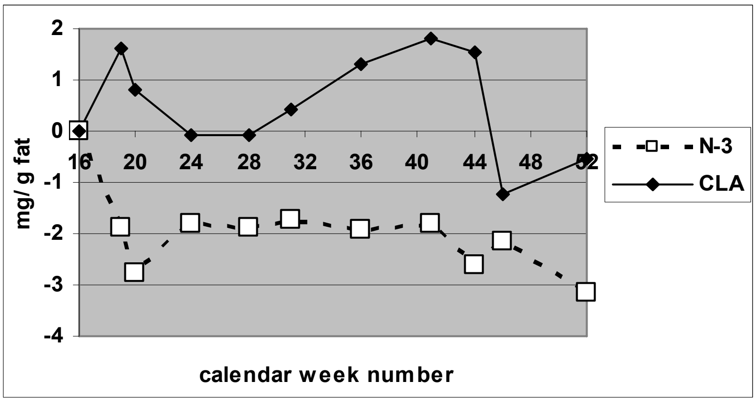

Figure 1: Estimated influence of week on level of omega-3 and CLA

The large effect of sampling date (see figure 1) indicates strong seasonal influences, probably related to grass quality. For omega-3, particularly week 16, when cows are grazing very young grass, is high compared to the other periods, with smaller negative estimates for week 20, when grass is maturing, and winter (week “52” includes all winter values), when silage is fed with lower PUFA levels compared to fresh grass. For CLA, higher levels appear in spring and in autumn, mainly related to young leafy grass in spring and a growth flush of grass in autumn 2006 respectively.

Also, some unexplained high individual values and part of the large farm effect in the model seem related to feed quality factors such as the botanical composition of pastures, red clover feeding and silage conservation strategies (mowing at mature stages or ensiling with high dry matter content). In depth study in 2007, in which additional feed quality information of the grass silage and fresh grass was obtained, did not reveal a clear influence of feed quality on milk fatty acid composition. This disappointing result might be caused by the limited number of samples (n=37), as well as differences between sampling and ingested feed (due to selection or deterioration of the silage during feeding).

The large farm effect might also be caused by genetic influences. Important breed effects appear unlikely in this research, but differences between individual cows of the same breed haven proven to be large (Elgersma et al, 2006) and seem genetically based (van Arendonk, unpublished). This could not be proven in this research as no individual milk samples were analysed.

Conclusions

Feed has a large influence on beneficial fatty acids levels in milk, even though feed components could explain only part of the variance in the bulk milk samples analysed in this research. Part of the large seasonal and farm effect, as well as some high individual residual values seem related to silage quality, red clover feeding and grazing botanically rich pastures. If organic dairy farms want to strengthen their distinguishable position, also vis-à-vis conventional milk with enhanced levels of beneficial fatty acids, they can best opt for using grass pellets as concentrate, red clover, maximum use of fresh grass and/or some oil supplements. The influence of other measures influencing roughage quality could not be convincingly proven.

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Influence of cropping systems on the potential formation of acrylamide in different cultivars of wheat

Stockmann, F.[1], Graeff, S.[2], Weber, A.[3] & Claupein, W.[4]

Key words: acrylamide, asparagine, production systems, cultivars, food products

Abstract

Acrylamide (AA) – probably carcinogen – is thermally created in carbohydrate-rich food (e. g. cereals) within the Maillard-Reaction by the reaction of asparagine and reducing sugars. First steps to decrease AA focused on changes in the technological food production process. However, these possibilities are limited due to occurring taste anomalies and consumer tolerance. Therefore, it might be an alternative to influence the precursors of AA. Up to now, multiple studies considering the influence of fertilisation, species, and cultivars on the content of asparagine (Asn) and reducing sugars have been carried out. But there is still a lack of information about the influence of the production system on the AA level. It can be expected that the amount of AA is different and might be lower in organic production systems, because of the difference in nitrogen management (amount and type). The aim of this study was to check organically and conventionally grown wheat samples of different cultivars for the level of the precursor Asn and the AA-formation-potential. The samples were obtained from locations in Switzerland and Germany. Partial significant differences in the amount of Asn and in the AA-formation-potential suggested an influence of the production system and thus a further chance to intervene.

Introduction

The health and safety of foodstuff nowadays is a very important aim even in industrialised countries (Nau et al. 2003). Normally the avoidance of food toxicants is quite well manageable. But for substances, created through food processing, like acrylamide (AA), it is problematical. Acrylamid, a so called "foodborne toxicant", was first reported in 2002 by the Swedish National Food Administration in connection with food products. It is formed in carbohydrate-rich food stuffs like potatoes and cereals within the Maillard-Reaction (Mottram et al. 2002), where the amino acid asparagine (Asn) and reducing sugars (e. g. glucose) react by thermal processes to AA (Stadler et al. 2002). In this context, Asn is the limiting factor of the formation of AA in cereals (Weisshaar 2004). Furthermore, according to the IARC (International Agency for Research on Cancer 1994) it is a probably carcinogen substance. Consequently many efforts have been undertaken to understand the syntheses, the metabolism, the toxicology, the formation and, in the end, what can be done to minimize the amount of AA in foodstuffs. Up to now, a focal point was to find minimization strategies by changing technological food production steps. It has been successfully shown, that the amount of AA can be minimized by changing temperature, pH, time of heating,

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backing agents and adding additives. However, the possibility to change technological process steps is limited, because of negative impacts on the quality of produced products. Modifications in technical food processing are linked to changes in taste, smell and texture and thus consumers' acceptance can be endangered. Therefore, additional strategies are needed to minimize AA. An alternative to reduce AA might be to limit the contents of precursors (e.g. free Asn) by using crop species and cultivars with lower levels. Furthermore, different amounts of N-fertilization can also increase the Asn level. Weber (2007) investigated different conventionally grown cereal species and cultivars of wheat, spelt and rye and found different levels of Asn. Weber et al. (2008) also found that conventional N-fertilization levels can increase the level of Asn. As organic farming uses different N-fertilization strategies e.g. crop rotation, enhancement of mineralization and organic N-fertilizer that lead to crude protein levels below 13 %, it can be expected that the amount of Asn in organic grain samples is lower. Thus it seems that organic products can contain a lower amount of AA and by this might have an advantage for consumers' health. Up to now only few studies have investigated the impact of organic production systems on levels of AA in foodstuffs, wherefore further research is necessary.

Hence the aim of these study was i) to evaluate differences in Asn content of organically and conventionally grown wheat cultivars, ii) to compare the content of Asn and AA-formation-potential between organically and conventionally grown wheat cultivars and iii) to evaluate the correlation between Asn and AA-formation-potential of organically and conventionally produced wheat cultivars.

Materials and methods

The organically produced 16 wheat samples (Wiwa, MAA 48, TEPP 117, Wenge, Pollux, Ataro, Aszita, AIRA 28) were obtained from field trials of two different locations (Vielbringen, Montezillon) in Switzerland from the seed breeder Peter Kunz in 2004/2005. The selected two locations were in the Regions Chaumont (Montezillon: 770 m above sea level) and Bern (Vielbringen: 560 m above sea level). The annual precipitation ranged about 800 – 1030 mm. Annual average temperature ranged from 6.2 to 9.9 °C. The field trials were arranged in a block design (randomised), with two replications on a sandy loamy soil. Liquid manure was applied as N-source, previous crops at both locations were grass-clover ley.

The conventionally produced 16 wheat samples (Enorm, Altos, Monopol, Batis, Elvis, Tiger, Cubus, Transit, Tommi, Natutastar, Magnus, Terrier, Dekan, Punch, Manhatten, Wasmo) were collected from the experimental station Ihinger Hof of the University of Hohenheim (south-west of Germany, 48° 44' N; 8° 56' E, mean annual precipitation 693 mm, mean temperature 8.1 °C). The samples were arranged in a block design (randomised) with three replications. The soil texture was classified as loamy clay. Sugar beet was cultivated as previous crop. N-fertilization was applied as KAS in accordance to the quality levels of wheat (quality level E, A, B, K) from 170 kg N ha^{-1} to 200 kg N ha^{-1}. The selected cultivars were used because of their relevance in the applied production system.

The lab analyses of Asn and the AA-formation-potential in the grain samples were done according to Weber et al. (2008). Asn- and AA-data were analyzed according to the experimental design with a linear mixed model. Analyses of variance (ANOVA) were performed using PROC GLM of the SAS 9.1 statistical software package (SAS Institute Inc., Cary, NC, USA). Tukey-Tests were carried out for comparison of means using the procedure PROC MIXED. All effects were set as fixed.

Results and discussion

Figure 1 shows the results of Asn levels [mg 100 g^{-1} in DM] in organically produced wheat. The content of Asn differed significantly between the chosen cultivars. Asn levels ranged from 7.8 mg 100 g^{-1} DM as minimum to 13.8 mg 100 g^{-1} as maximum with a mean of 10.7 mg 100 g^{-1} DM. Against this the conventionally produced wheat cultivars (results not shown) had significant differences by a mean content of 15.2 mg 100 g^{-1} DM, with a minimum of 7 mg 100 g^{-1} DM and a maximum of 21.2 mg 100 g^{-1} DM. The higher Asn contents in grain samples of conventional production systems might be the result of higher N-fertilization levels which can significantly enhance the amount of Asn (Weber et al. 2008). Means over two organic locations did not indicate significant differences in Asn level, but comparing the same cultivars a significant difference was given wherefore it is concluded that the location could have an effect.

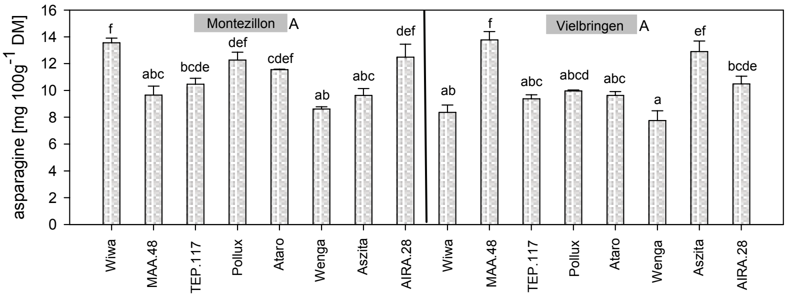

Figure 1: Asparagine levels [mg 100 g^{-1}] of analysed organic wheat cultivars. Cultivars with the same letters did not differ significantly (α<0.05).

In a further step, the content of Asn and AA-formation-potential were analysed and compared between the two production systems (figure 2 I & 2 II). The results showed a statistically significant difference in the amount of Asn (figure 2 I) as well as in AA-formation-potential (figure 2 II) between the systems. Asn potential of organically grown cultivars was significantly lower than in conventionally grown cultivars. Further, the same effect was found for the amount of AA-formation-potential (Fig. 2 II). Wheat cultivars of organic production systems had a significant lower level (almost four times) than conventionally produced samples.

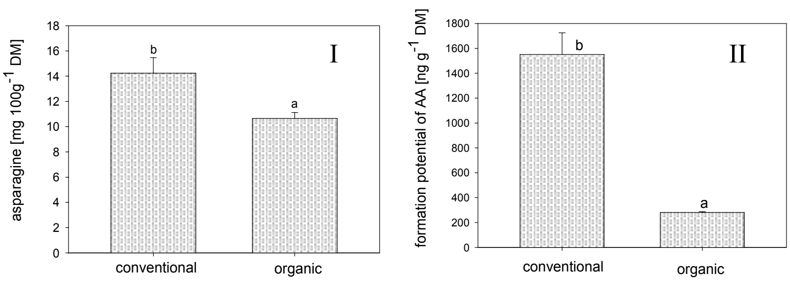

Figure 2: Comparison of means of (I) asparagine [mg 100 g^{-1}] and (II) acryl-amide (AA) formation potential levels [ng 100 g^{-1}] of analysed wheat cultivars. Production system with the same letters did not differ significantly (α<0.05).

The correlation between Asn and AA (figure 3) was only significant for the conventional samples. Due to a narrow range of Asn in organic samples, no correlation was obtained.

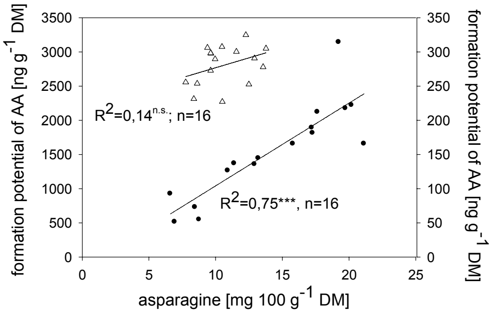

Figure 3: Correlation between asparagine (Asn) and acrylamide (AA) formation potential of conventionally (R^2=0.75*, black dots, left y-axis) and organically (R^2=0.14$^{n.s.}$, white triangles, right y-axis) grown wheat.**

Conclusions

The results of the study indicated significant differences in the content of Asn and the final AA-formation-potential within organically produced wheat cultivars. A possible strategy to minimize AA in foodstuffs seems to be the selection of wheat cultivars low in free Asn. Further, the location might to have an impact on the content of free Asn when comparing single cultivars. The production system seems also to have an influence. However, no clear statement can be given because of different cultivars and locations. Further research on the overall influence of the production system is needed.

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Effects of weed management strategies on quality and enteric pathogen contamination of organic lettuce

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Key words: food quality, weed control, vegetable production, microbiology, farm yard manure

Abstract

Quality requirements for raw edible produce like lettuces include nutritional value and hygienic quality. Organic lettuce is often considered to cause a potential health risk for immunocompromised individuals due to assumed pathogen transfer from organically manured soils into lettuce heads (Lactuca sativa, var. *capitata). The effect of different weed management strategies (rotary tiller, mouldboard plough combined with flame weeding, plastic mulch and straw layer, resp.) on pathogen transfer from fresh and composted farm yard manure were assessed in four field experiments in 2006 and 2007. Results gave no hint on any pathogen transfer given by the assumed pathways (contaminated soil particles transported by mechanical tools and/or splash effect of rain drops). Nitrate contents in lettuce were low ranging from 269 mg/kg to 828 mg/kg in fresh matter respectively. A new method for measuring leaf tissue firmness is being developed by using an artificial denture. Substantial negative effects of manure on lettuce quality were not recorded.*

Introduction

Hygienic harmlessness is an important quality trait especially for raw consumed vegetables that grow close to the soil surface. Due to the potential contamination with human pathogenic microorganisms, use of farmyard manure (FYM), a common practice not exclusive for Organic Farming only, may therefore be considered as a health risk. Pathogens capable of causing human health risks include Salmonellae or human pathogenic strains of *E. coli* that may occur in FYM under certain conditions. These pathogens may cause severe health problems such as gastrointestinal infections for immunocompromised individuals, babies, sick people and the elderly (Buchanan et al. 2000). The survival of these bacteria in the soil after FYM application can amount up to 100 days (Ingham et al. 2004). The transfer of pathogens might happen by splash effects caused by raindrops or overhead irrigation or via transport of soil particles into lettuce heads by mechanical weeding. Apart from hygienic aspects, the amount of beneficial and harmful compounds as well as tissue properties play a dominant role for lettuce quality. High contents of nitrate can decrease, secondary metabolites can increase the nutritional value of lettuce. Crispness of lettuce leaves is a criterion for freshness and constitutes a major factor of the consumer appraisal for product quality. This parameter is indirectly measured by determining the firmness of the leaf tissue. Due to high heterogeneity of the veined leaf tissue, measurements with an Instron penetrometer gave no satisfying results. Thus, we try to determine the firmness of leaves by simulating the consumer perception with an artificial denture.

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This paper highlights key results of field experiments with lettuce focussing on the impact of weed management practices and manuring on selected quality parameters.

Materials and methods

Two field trials were carried out with lettuce (*Lactuca sativa,* var. *capitata*) in each summer season of 2006 and 2007 at the organic research farm Wiesengut in Hennef (Germany, 50°48´ N, 7°17´ E; 62 m a.s.l.; mean annual temperature 10.2°C; mean annual precipitation 846 mm) on a fluvisol. Since data of 2007 are still not fully exploited, only results of 2006 are presented here.

The experimental design was a Latin square with 6 treatments and 6 replications (Table 1). The treatments were selected based on results of Rattler et al. (2006) and included a high risk pathogen transfer treatment with fresh FYM (not incorporated to the soil). Weed management was carried out either by hoeing, flame weeding, plastic mulch or by covering the soil with a layer of straw. All treatments were adjusted to a target level of 170 kg plant available N_{min} ha^{-1}. Thus, the amount of N applied was a function of the amount of mineral nitrogen (NO_3-N and NH_4^+, i.e. N_{min}) in the soil solution in the 0-30 cm soil layer at the time of planting and an estimated mineralization rate of 5 kg N x ha^{-1} and week. The amount of FYM was calculated by assuming 20% of total N applied becoming available during the vegetation time.

Tab. 1: Treatments

<table>
<tr><th>Weed control</th><th>Manure Incorporation</th><th>Manure Type</th></tr>
<tr><td>Mechanical 1</td><td>Rotary Tiller</td><td>fresh FYM</td></tr>
<tr><td>Mechanical 2</td><td>Plough</td><td>fresh FYM</td></tr>
<tr><td>Mechanical 3</td><td rowspan="4">all Rotary Tiller</td><td>composted FYM</td></tr>
<tr><td>Flame weeding</td><td rowspan="3">fresh FYM</td></tr>
<tr><td>Plastic mulch</td></tr>
<tr><td>Straw layer</td></tr>
</table>

In 2006, lettuces were planted on 5 May and 18 July, respectively. Additional overhead irrigation was applied, if needed. In each trial, 16 lettuce heads per plot were harvested at optimal ripeness. Outer leaves either intensely soiled or having lesions were removed. All lettuce heads were weighted separately. Ten heads per plot were used for determining dry matter content, mineral composition, physiological and microbiological parameters (*Enterobacteriaceae*, Coliforms, *E. coli*, Salmonellae, Enterococci). Microbiological parameters were assessed directly after harvest with a pooled sample of 6 washed heads per plot according to German standard cultivation methods (LFGB, 2006). Nitrate content was determined in the dry matter (d.m.) according to Beutler et al. (1986). Results were statistically evaluated by ANOVA followed by Tukey's test using SAS (SAS version 9.1, SAS Institute, Cary, NC, USA).

In order to analyse whether different fertilizer and increased amount of fertilizer have an influence on crispness, an additional field trial was performed in spring 2007 and repeated in summer 2007. These 2007 trials were designed as a Latin rectangle with 12 treatments and 4 replications. Here fertilizers were applied either as FYM or calcium ammonium nitrate. Nitrogen fertilization levels were adjusted to a mineral nitrogen content of the topsoil (0 - 30 cm) of 110, 130, 150, 170 and 190 kg N_{min} ha^{-1}, respectively. The new prototype for measuring leaf firmness uses an artificial denture and is called Degmatasimeter (DTM). The DTM measures the force that is spent for biting through a lettuce leaf and considered to refer to actual forces generated during human chewing. In contrast to this approach, the frequently used Instron penetrometer measures tissue firmness by punctual pressure on a tensed leaf until destruction. Occurring tensile and shear forces cannot be characterised and quantified by this method due to the heterogeneity of the leaf tissue. Consequently, a close correlation to crispness that is experienced by consumers is hardly possible. In the case of the DTM, occurring forces are expected to correspond with the perception of crispness.

Results and discussion

Yields were relatively high (trial 1: 540 g/head, trial 2: 507 g/head) owing the high N - fertilization level. As expected, weed control treatments had no effect on yield. FYM contained *E. coli* in the range of 10^3-10^4 CFU g^{-1} in fresh matter (f.m.) in 2006. In composted FYM in spring 2006, *E. coli* counts were similar to FYM due to low temperatures during the composting process; in summer 2006 (composting temperature reached 60°C), *E. coli* was not detected. In 2006, no effects of the weed control treatments on total aerobic bacterial counts (overall average = $10^{6.25}$ CFU g^{-1}) and Enterobacteriaceae (overall average = $10^{5.44}$ CFU g^{-1}) were observed. A significant increase in the count of coliform bacteria was found following mulching with plastic mulch and with straw (p= 0.001) in spring 2006, but these were not confirmed by corresponding results for *E. coli*, which was detected in only some of the lettuce samples and in very low amounts slightly above the detection limit of 10^2 CFU g^{-1}. These results indicate a minor relevance of soil particle transfer as hygienic contaminant. Coliform counts (10^5 CFU g^{-1}) and counts of *E. coli* are in accordance with Pfleger's results (2006) for natural bacterial counts of heads of lettuce under field conditions without irrigation. *Salmonellae* were not detected in any of the samples. Although the treatments were designed to provoke a high transfer of potential pathogens, the initial results of 2006 do not indicate an enhanced health risk from the use of FYM as fertilizer for lettuces. These findings support the results published by Rattler et al. (2006) who observed similar bacterial counts in field-grown lettuce. Nevertheless, since the standard methods used are often not good enough for proper detection of human pathogenic strains more detailed investigations on the relationship of total *E. coli* counts and, e.g., *E. coli* O157:H7 are needed. Franz et al. (2005) did detect E. coli O157:H7 in lettuce roots but not in edible lettuce parts. While in 2006 few samples of lettuce contained *enterococci*, and only in low amounts, higher counts of *enterococci* were noted in 2007 and still require explanation. Nitrate values (average in spring 2006: 269 mg kg^{-1} f.m., average in summer 2006: 828 mg kg^{-1} f.m.) were considerably lower than the tolerable limits of 2500 mg kg^{-1} f.m. (EC Directive N° 466/2001). These values are in the same range as those found in other surveys, with 495 - 1548 mg kg^{-1} f.m. for organically produced lettuces (Samwel, 2000), but lower than those published by Souci et al. (1994), with 2190 mg kg^{-1} f.m. Given the high nitrogen level of 170 N_{min} ha^{-1}, the nitrate values in the present experiment can be considered comparatively low. However, the nitrate content is generally lower in summer-grown than in winter-grown lettuces because nitrate reductase activity is higher at higher light intensities. In preliminary examinations, measurements of tissue firmness showed a significantly lower coefficient of variance for the DTM prototype (3%) than for the Instron penetrometer (10%). For other technical or chemical measurements, the maximum acceptable coefficient of variance is often 5%, suggesting that the method has been improved by using the DTM. On average, mineral fertilization led to values of 570 g per bite, while organic fertilization resulted in slightly higher values (630 g per bite) in 2007 (trial 1). However, the DTM-values showed did not vary directly with the fertilization levels. Whether or not the DTM can be used to distinguish between different levels of crispness as a function of agronomic strategies is still unclear and requires further investigations.

Conclusions

According to our results, the use of FYM, even when applied in a form that maximizes pathogen transfer risk, does not significantly affect the hygienic quality of lettuce. When good agricultural practice, i.e. no direct manuring of vegetables that are eaten raw, is also taken into account, the hygienic quality of organically grown lettuce cannot be considered a cause for concern. In terms of the nutritional value of lettuce, there are currently no indications that use of manure leads to a lower product quality.

Acknowledgments

This work has been generously supported by the EU commission as part of the QLIF project (Quality Low Input Food, www.qlif.org) within the FP6.

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Pilot scale application of ozonated water wash – effect on microbiological and sensory quality parameters of processed iceberg lettuce during shelf-life

Särkkä-Tirkkonen, M.[1], Leskinen, M.[1] & Ölmez, H.[2]

Key words: ozone, iceberg lettuce, fresh-cut-vegetables, minimal processing

Abstract

The aim of the study was to assess the effect of ozonated water wash on the microbiological and sensory quality parameters of minimally processed iceberg lettuce in pilot scale in comparison to aqueous chlorine wash. Alternative solutions for chlorine are needed, since its use is prohibited in organic food processing. Iceberg lettuce samples were washed with three different ozone solutions and the water wash and the 100 ppm chlorine wash were used as control. Ozone generator based on corona discharge was used to produce ozone at level 7 ppm. The samples (150 g) packed in oriented polypropylene pouches were stored for 10 days at + 5^{o}C and the microbiological and sensory quality was analysed on days 1, 6 and 10. There was no significant difference between chlorine wash samples and the samples washed 1 min in a machine with ozonated water concerning the microbiological quality. Compared with the chlorine with lower concentrations of ozone it is possible to control the microbial load. Concerning the sensory quality all samples endured all of the treatments well except the treatment with 7 ppm ozone for 5 min. As a conclusion the bubbling gaseous ozone in water can be as effective disinfection method as chlorine wash when the following processing parameters are taken into account: concentration of ozone during the whole process, exposure time, water temperature and the amount and type of the organic material.

Introduction

The disinfection of processed vegetables is one of the critical points along the processing line and has a definitive effect on the safety, quality and shelf-life of the product. Chlorine, which is the most widely used sanitizing agent for fresh cut vegetables, is forbidden in organic food production (EU 2092/91) due to the environmental and health risks (Wei et al., 1985). There is also a need for minimizing the water consumption and wastewater discharge rates in the industry. Therefore both the organic and the conventional processing sectors are now seeking alternatives to chlorine which assure the safety of the products, maintain the quality and enable a shelf-life as long as chlorine. Ozone has many characteristics that make it attractive for use as a sanitizer in food processing. High reactivity, penetrability and spontaneous decomposition to a non-toxic product (O_2) make ozone a viable disinfectant (Kim et al. 1999). It does not remain in water or on the surface of the product for a significantly long period of time, thus its use may be considered as a processing method rather than a food additive. There is also no need for storage of toxic chemicals as ozone is produced on demand and it is possible to re-use the

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process water and the ozone treatment is accepted as an environmentally friendly process (Khadre et al., 2001). Many studies show that bubbling gaseous ozone in water is the most effective ozonation method for vegetables and can be effective even in lower concentrations (Kim et al., 1999; Singh et al., 2002; Beltran et al., 2005; Ölmez et. al. 2007). However higher levels of ozone might be needed for a large manufacturing plant because of the amount of organic, dissolved solids and ozone-demanding material in the water (Garcia et al., 2003). Therefore pilot trials should be always conducted before implementing ozone applications in industry.

The aim of the study was to assess the effect of ozonated water wash on the microbiological and sensory quality parameters of minimally processed iceberg lettuce in pilot scale in comparison to aqueous chlorine wash during the shelf-life of the products. Based on the laboratory scale tests and pre-tests (Ölmez et al., 2007) a pilot test was executed in order to find out the optimized ozone treatment (dose, exposure time and temperature) and in order to develop a process applicable in industrial scale.

Materials and methods

Conventional industrial iceberg lettuce heads (*Lactuca sativa L.*) were transported and stored under refrigerated conditions until processing day. The wrapper leaves of the lettuce head were stripped away and the lettuce head was split in four pieces. The pieces were shredded with Hällde RG-200 vegetable cutter in 3 cm pieces (10 mm blade). The shredded iceberg lettuces were washed with five different solutions: 1) 7 ppm of ozone for 1 min. in Meiko GK60 washing machine 2) 7 ppm of ozone for 5 min, washing in a tub (volume 70 l) 3) 7 ppm of ozone for 1 min, washing in a tub (volume 70 l) 4) water wash for 1 min, in Meiko GK60 washing machine 5) chlorine wash for 1 min, 100 ppm active chlorine, prepared from sodium hypochlorite adjusted at pH 6,5 with 1M citric acid**.** The water wash and chlorine wash were used as control. For each wash 4 kg:s of lettuce was shredded. All samples were centrifuged in JMD drying drum (500 r/min). Tap water was used in washing treatments (pH 7.0, temp. +8.5 ^{o}C).

Ozone generator based on corona discharge was used to produce ozone. The ozone productive capacity was ca. 10 g/h when pure oxygen was used as a feed gas. A flow of ozone was dissolved in the tap water by an inverse mixer (+ mixing nozzles) in 70 l tub. The 7 ppm ozone dose for the treatments 1, 2 and 3 means the concentration in the beginning of the process. Gaseous ozone production was measured using on-line measurement system (ATI Dissolved Ozone Monitor, Model A15/64). The samples (150 g) were packed in commercial packaging material (oriented polypropylene pouch, oxygen permeability 900 $cm^3/m^{2}*d$) in ambient atmosphere. The size of the pouch was 12.5 cm x 17.5 cm. All samples were stored for up to 10 days at +5 ^{o}C and evaluated on day 1, 6 and 10.

The microbial analysis included the aerobic plate count (ISO 48333, 3 days at 30 ^{o}C), total coliforms (ISO 4832, 1 day at 37 ^{o}C) and *Enterobacteriaceae* (Nordic Committee of Food analysis, No 144, 1 day at 37 ^{o}C). Each microbial count expressed as log cfu/g of tissue, is the mean of four samples. The sensory quality of the samples was evaluated by five-membered expert panel. Qualitative describing method using semi-structured 100 mm scale was used to evaluate the sensory quality of the samples. The evaluated character was anchored with reference lettuce sample which was prepared the same day just before the evaluation. The organoleptic characteristics included freshness of the smell and off-flavour straight after opening the package, off-flavour on the plate, crispiness, watery taste, freshness of the taste and off-taste. The visual quality evaluation included moisture of the surface, browning of the cut surface and other colour defects. One sample t-test ($p<0.05$) for the significance of the differences of the means compared to the reference was performed using SPSS (Windows 2000, version 12.0). One-way analysis of variance and Tukey's test was used to compare the differences between the samples.

Results and discussion

Concerning the effectiveness of the control of the bacteria there was no significant difference between chlorine wash and the treatment 1 where the samples where washed 1 min. in a Meiko washing machine with ozonated water (Fig. 1). The concentration of ozone was 7 ppm in the beginning of the process and the level of the ozone in the water declined very rapidly during the process being in the end of the process between 0.7-1.0 ppm. As a conclusion, if the level of ozone is high enough in the beginning of the process 1 min as a treatment time is adequate. The chlorine treatment was more effective washing method ($p<0.05$) than treatment no. 2. It can be concluded that 5 minutes ozone treatment is too long and possibly degrades the microbiological quality of the samples by providing excess oxygen to the microbes during the process. This conclusion is supported by the fact that even the water wash (treatment no. 4) gained lower microbe load than the treatment no. 2.

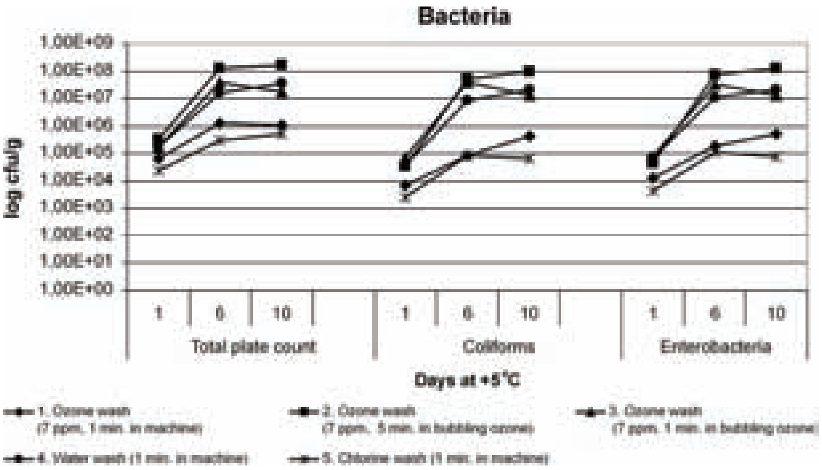

Figure 1: The effect of different washing treatments on the growth of bacteria during 10 days of storage at +5°C.

Concerning the sensory quality all samples endured all of the treatments well except the treatment no. 2 (7 ppm ozone dose for 5 min.). The samples were less fresh concerning the smell and taste ($p<0.05$), had more moisture on the surface ($p<0.05$) and had colour defects like greyish appearance after the treatment. The taste was also described more watery than the other samples. Because any severe discoloration did not occur in case of the other ozonated samples it can be concluded that discoloration is caused rather by the treatment time than the high level of the ozone dissolved in the water.

Conclusion

As a conclusion it can be stated that bubbling gaseous ozone in water can be as effective disinfection method as chlorine wash when the following processing parameters are taken into account: concentration of ozone during the whole process, exposure time, water temperature and the amount and type of the organic material. In order to develop an ozone water wash process applicable in industrial scale, proper testing at the plant must be conducted before applying the method in vegetable disinfection processing. Furthermore a better understanding of the mechanism involved in bacterial attachment on the surface of the fresh vegetable produce is necessary to improve the technology.

Acknowledgments

The authors gratefully acknowledge funding from the European Community financial participation under the Sixth Framework Programme for Research, Technological Development and Demonstration Activities, for the Integrated Project QUALITYLOWINPUTFOOD, FP6-FOOD-CT-2003- 506358.The results presented in this paper are based on the joint effort of the following research teams: University of Helsinki, Ruralia Institute (M. Särkkä-Tirkkonen, M. Leskinen), TÜBITAK Marmara Research Center (H. Ölmez), FiBL (CH: U. Kretzschmar).

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Protein quality and content of nitrite, nitrate and metals in commercial samples of organic and conventional cold meats.

Barbieri, G.[1], Macchiavelli, L.[1] & Rivaldi, P.[1]

Key words: organic cold meat, protein, additives, heavy metals

Abstract

Twenty-six organic and conventional samples of cold meats were analysed and compared with respect to: meat protein quality, nitrite, nitrate and metal content to verify if organic products have any health advantage that may be attractive to consumers.

Proteins quality was assessed by sodium dodecyl sulphate-polyacrilamide gel electrophoresis (SDS-PAGE) and two-dimensional electrophoresis (2D EF). Nitrite and nitrate content were measured by the Griess reaction. Metals were detected by atomic absorption spectroscopy.

Electrophoretic data show differences in the quality of water-soluble proteins in uncooked products, in contrast to thermal treatment results, which revealed no differences between the organic and conventional products, although it is difficult to interpret these data.

Metal analyses show significantly higher levels of Fe, Zn, Ca, Se, and Cu in organic meat.

There was no significant difference detected in nitrite content, while nitrate was lower in organic compared to conventional salami. These results suggest that cooked organic meat products do not have any nutritional advantage over conventional ones, and that only seasoned products preserve the original quality of organic meat.

Introduction

In recent years both consumer demand and the scientific work carried out on organic meat products have increased. However, most studies have been conducted on fat profile (Hansen et al., 2006) of raw meat or on the effect on growth performance (Millet et al., 2005), with little attention paid to the protein quality of cold meats. Yet we know that the content of metals (Jemeljanovs et al., 2004), nitrite and nitrate (*The EFSA Journal*, 2003) are important with respect to food safety. Consumers are thought to be attracted to organic meat by the perception of a superior nutritional profile in comparison with conventional food. This work is the beginning of a project to investigate the composition of cold meats such as salami and cooked and seasoned ham, and to identify differences that could justify the consumers' ideological motivation to choose organic over conventional products.

Materials and methods

Twenty-six samples of organic and conventional meat products were purchased on the local market or obtained from Italian producers. The comparison was made among six salamis, three dry cured hams, and four cooked hams for each class (organic and conventional), choosing products as similar as possible regarding formulation and processing technology. Three replications were made for metals, nitrite, and nitrate analysis, while each electrophoretic sample was performed twice.

Edible parts of the meat samples were ground and proteins were extracted for SDS-PAGE and 2D EF analysis. Water-soluble proteins were extracted in phosphate buffer (pH 7.4) at low ionic strength, while myofibrillar proteins were extracted by a high ionic strength solution (KI 0.75M). The electrophoretic run was performed on ExcelGel 8-18 (GE Healthcare).

Two-dimensional EF protein samples were taken by extraction with urea and nonionic detergent solutions. Immobiline strips (pH 6-11 NL and 4-7) were used to carry out the first dimension.

Gels were stained with Coomassie Blue Brilliant. Electrophoresis patterns were evaluated with Quantity one and PD Quest software (BioRad).

Metal analyses were performed by atomic absorption spectroscopy (Al, As, Ba, Ca, Cd, Cr, Cu, Fe, Hg, Li, Mn, Ni, Pb, Se, Zn).

Nitrite and nitrate were detected by cadmium reduction-Griess reaction.

Statistical analysis: independent t-tests were performed with the SPSS 10.0 software package, comparing two classes (conventional and organic) for each meat product.

Results

The electrophoretic pattern of organic seasoned products shows more peaks, although they are often weaker than in conventional products. In Figure 1, the main peaks of water-soluble proteins detected in SDS-PAGE of salami are shown. No difference was detected in the salt-soluble protein fraction.

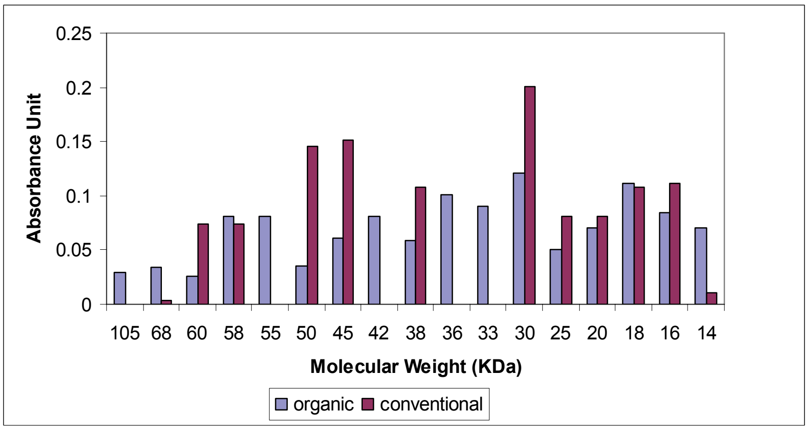

Figure 1: Main peaks of water-soluble protein of salami identified by SDS-PAGE (average value).

The 2D electrophoresis pattern presents more and stronger spots in the region of enzymatic proteins (pI 6-9) in organic meat samples. In contrast, the structural components (actin, light chain of myosin and tropomyosin) do not differ much (data not shown).

The samples obtained from cooked products reveal no significant differences.

Metal analysis data are illustrated in Table 1. Table 2 reports the nitrite and nitrate content per 100 g of edible portion.

Tab. 1: Metal content expressed as mg per 100 g of edible portion.

		Ca	Cu	Fe	Se	Zn
Cooked ham	Conventional	7.3 [a]	0.05 [a]	0.5 [a]	0.03 [a]	1.6[a]
	Organic	6.2 [a]	0.05 [a]	0.6 [a]	0.02 [a]	2.1[b]
dry ham	Conventional	10.8 [a]	0.2 [a]	1.5 [a]	0.03 [a]	3.2[a]
	Organic	12.1 [b]	0.1 [a]	1.8 [b]	0.04 [a]	3.2[a]
salami	Conventional	2.9 [a]	0.03 [a]	0.3 [a]	0.03 [a]	2.9[a]
	Organic	5.0 [b]	0.06 [b]	0.8 [b]	0.04 [b]	4.1[b]

[a,b]Means in a column of the same product without a common superscript differ significantly (P< .05)

Tab. 2: Nitrite and nitrate content expressed as mg per 100 g of edible portion.

		nitrite	nitrate
Cooked ham	Conventional	2.0 [a]	3.0 [a]
	Organic	1.6 [a]	2.3 [a]
dry cured ham	Conventional	0.05 [a]	0.2 [a]
	Organic	0.03 [a]	0.1 [a]
salami	Conventional	0.4 [a]	5.2 [a]
	Organic	0.3 [a]	1.3 [b]

[a,b]Means in a column of the same product without a common superscript differ significantly (P< .05)

Discussion

In organic cold meats, the proteins seem to cover a wider range of molecular weights than in conventional ones. A large number of fragments are observed in SDS-PAGE of water-soluble extracts and especially in the enzymatic region of the 2D EF map. Heat treatment levels out the differences, so that the patterns of cooked meats are very similar between the two types. The presence of new fragments has been highlighted by Hajos et al. (1995), but their meaning is not clear. A strong enzymatic activity could explain the development of a great number of soluble protein fragments. Further research is needed to understand it.

The content of nitrite and nitrate is similar between the two classes. A significant difference was detected in salami for the final value of nitrate. A small difference was found in nitrite content of cooked ham because residual nitrite is very low even in products where it was added.

A more important difference was detected in metal content. Fe, Ca, and Se were significantly higher in the organic meats only in uncooked products, but Zn was higher in cooked organic products also. The Cu content was higher in the organic salami. All other metals analysed did not show any difference between the classes.

The data reported in the literature about the metal content of conventional meat products are roughly similar to those found in our test (6).

Conclusions

For seasoned cold meats, organic products showed a wider range of protein fragments, although these are difficult to translate into a positive marketing message. More interesting is the higher level of some beneficial trace elements in organic meat, probably the result of the pigs' nutrition. Nitrate residue in meats was higher following its addition during processing, as in conventional salami, which is significantly higher than the organic salami. Generally, cooked cold meats showed little difference between conventional and organic products in the variables studied, since processing technology has a stronger impact on the final product than the origins of raw meat.

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Survey of acaricide residues in Italian organic and conventional beeswax

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Key words: beeswax / organic / coumaphos / fluvalinate / acaricide

Abstract

According to EU Regulation 1804/99, beekeepers converting to organic production methods must replace old combs, which contain residues of lipophilic acaricides used to control infestation of Varroa destructor, with residue-free wax. This poses problems due to difficulty in obtaining organic wax, passage of residues from old wax to new residue-free foundations and the risk of contamination of foundations in the wax transforming firms. To monitor the residue levels of Italian beeswax, samples produced between 1990 and 2006 were analysed for residues of most commonly used acaricides. The samples analysed for the two most commonly used active ingredients, coumaphos and fluvalinate, were classified according to the production method (organic, conventional or converting) and according to the kind of wax (melted or foundation). For all the considered a.i. the average levels of residues in all kinds of samples (organic and conventional) grouped by year, decreased during the considered time period. Classification according to production method showed that organic beekeeping practices have definitely reduced levels of residues, although these persist in wax for a long time. Average levels of acaricide residues in organic melted cap beeswax were used by most Italian Control Bodies for fixing thresholds levels for use of wax in organic beekeeping (200ppb for coumaphos and 100ppb for fluvalinate).

Introduction

In the middle of the 90s, after several years of regular use of chemical treatments to save honey bees from the parasitic mite *Varroa destructor* Anderson & Trueman, samples of beeswax started being collected to evaluate the effects of these treatments in the beehive in terms of residues. At the turn of the century organic farming passed from being relegated to a niche market to providing an economically attractive alternative way of farming: in Italy organic hives increased by 40% between 2001 and 2002 (data from Ministry of Agricultural and Forestry Policies). Organic beekeeping is included in Reg.CE 1804/99, which requires, among other things, that hives should be treated against the Varroa mite only with substances of natural origin, such as thymol and organic acids. During conversion of their hives beekeepers must replace the old combs, which contain residues from treatments with lipophilic acaricides, with residue-free wax. This represents the initial obstacle faced by converting beekeepers: problems are due to difficulty in obtaining organic wax, passage of residues from old wax to new residue-free foundations and risk of contamination of foundations in the wax transforming firms.

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Materials and methods

The reported data is derived from specifically collected samples between 1990-1999 and from service analyses (for beekeepers, control bodies, associations, etc.) carried out by the CRA-API (ex Istituto Nazionale di Apicoltura) UNI CEI EN ISO/IEC 17025 certified laboratory from year 2000 to 2006. For each sample, information concerning the kind of production system (conventional, converting, organic) and the kind of wax (melted combs or foundation sheets) was obtained. The latter classification was carried out to monitor the problem of accumulation of residues in foundation sheets during transformation. This phenomenon occurs due to contamination in the melting chambers (where different lots of beeswax with different residue levels) are processed and due to the affinity between the fat-soluble molecules and wax (Bogdanov et al., 2005). 733 samples (356 organic, 275 conventional and 109 converting) were analysed for presence of at least one of the active ingredients (a.i.) of registered and unregistered acaricides most commonly used by Italian beekeepers: coumaphos, fluvalinate, chlorfenvinphos and cymiazole. Analyses were conducted with gascromatography connected to selective revealers (nitrogen-phosphorous for coumaphos and chlorphenvinfos; mass spectrometry for fluvalinate and cymiazole). Data is reported as means ± SE and results are interpreted in relation to time, production system, kind of wax.

Results

The pesticide with the highest levels of mean residues over time is coumaphos (Fig.1), confirming that formulated products containing this a.i. have been the most commonly used acaricides in Italy in the last 10-15 years. Fortunately residue levels have decreased progressively from the 1990-1997 samples (2490ppb±1153SE n=20) to the 2006 samples (125ppb±257SE n=99).

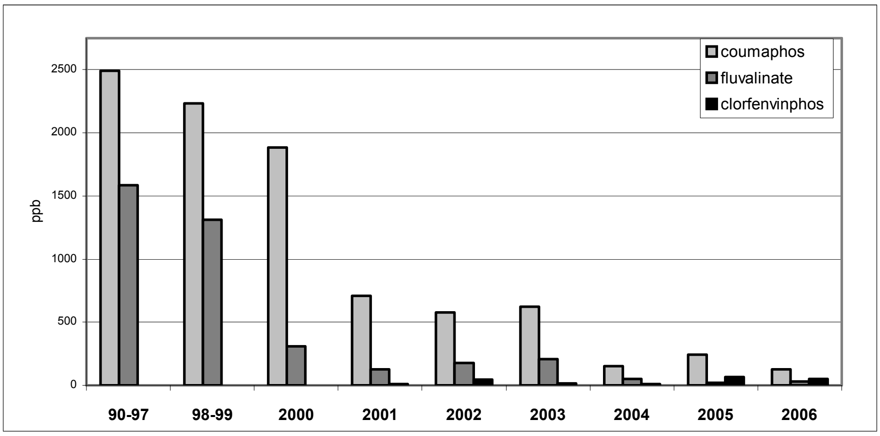
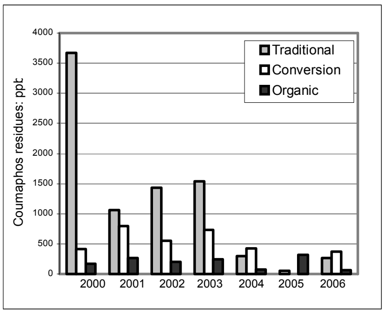


Figure 1: Residues of acaricides in samples of Italian beeswax from the 1990s to 2006 (pooled data from organic, conventional and converting samples).

Residues of clorfenvinphos were also detected in an increasing number of samples (from 0% in year 2000 to 22% in 2005), which, although low (67ppb±54SE in 2005, probably indicating a limited residuality in wax), in 2005 and 2006 were higher than average levels of fluvalinate. In comparisons between conventional and organic wax only coumaphos and fluvalinate were considered. Residues levels for both a.i. decrease passing from conventional to organic wax (–88% and –61% in organic compared to conventional, respectively), while the samples of converting wax have intermediate levels of residues (Fig.2-3). The percentage of positive samples in 2006 is still quite high for both coumaphos (75%) and fluvalinate (40%) but the proportion of positive organic wax samples with residue levels higher than 200ppb for coumaphos and 100 ppb for fluvalinate were relatively low (5% and 6% respectively).



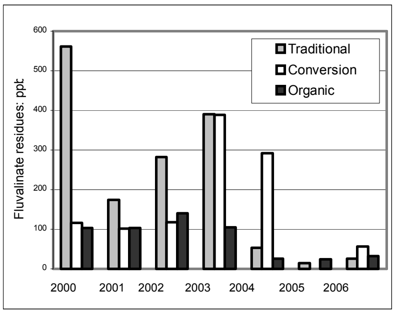
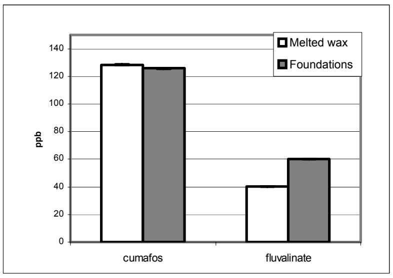


Figure 2 and Figure 3: Residues of coumaphos (left) and fluvalinate (right) in beeswax from different kinds of honey farms (conventional, converting and organic).

Comparisons according to the kind of wax showed that, in the case of fluvalinate, residues levels in foundations were higher in both kinds of production method (Figg.4-5). For coumaphos, however, a different situation was observed: while foundations from conventional farming contained more than double the residues of conventional melted combs (Fig.5), in the samples from organic farming the mean levels of residues of the two kinds of wax were almost equal (Fig.4).



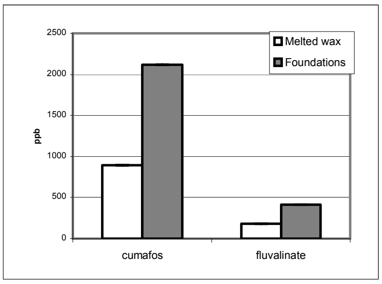


Figure 4 and Figure 5: Residues of coumaphos and fluvalinate in organic (left) and conventional (right) melted wax (from caps) and foundation sheets.

Discussion

The decrease in residues of most acaricides over the years indicates the beekeepers' tendency to shift to alternative products, although it must considered that most of the analyses carried out from the year 2000 concern wax belonging to beekeepers who were personally interested in knowing its residue levels (service analyses), and who therefore probably had a reasonable hope, due to the kind of management, that the wax would be almost residue free. However, the dramatic decrease of mean levels of coumaphos residues between 2000 and 2001 give a clear indication about beekeepers' response to the EU Regulation on organic farming, which was also encouraged by the development of strains of resistant mites (Lodesani et al, 1995; Milani, 1999) and the discovery of the possibility of controlling mite populations in the beehive with more environment friendly products such as organic acids and thymol (Liebig, 1997; Chiesa, 1991), as well as the higher prices obtained by organic honey.

The reason why residue levels in foundations are much higher than in melted wax is probably due to the origin of samples which are sent to the laboratory for analysis: conventional melted wax usually comes from keen individual producers who want to verify the quality of their wax, often with an idea to converting to organic production methods. Conventional foundations represent foundations found on the market, which come from transformation of multiple lots of wax, and are subject to accumulation and enrichment of residues; organic foundations on the other hand are more often a single beekeeper's product, obtained from the transformation of especially selected cap wax, in certified wax processing firms. Most firms have approached the problem of accumulation of residues by spatial and /or temporal separation of the lots of beeswax according to residue levels.

Conclusions

These results show that organic beekeeping practices have definitely reduced levels of residues in beeswax although they persist at low levels for a long time.

On the basis of the data we here present, in the first years following application of Reg.CE 1804/99, some Italian Control Bodies adopted 200 ppb for coumaphos and 100 ppb for fluvalinate as threshold levels for declaring wax compatible for use in organic beekeeping.

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Occurrence and level of patulin contamination in conventional and organic apple juices marketed in Italy

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Key words: apple juice, HPLC, mycotoxin, patulin, Penicillium expansum.

Abstract

A survey on the occurrence of patulin was conducted during 2005 on conventional (98 samples) and organic apple juices (37 samples) marketed in Italy. Patulin could be quantified in 34.8% of the samples ranging from 1.58 to 55.41 μg kg^{-1}. With the exception of one sample, the level of patulin was lower than 50 μg kg^{-1}, the maximum permitted threshold in fruit juices according to the European legislation. A similar incidence of positive samples was found in conventional and organic apple based juices, and the magnitude between the mean contamination levels, although higher in organic (10.92 μg kg^{-1}) than in conventional juices (4.77μg kg^{-1}), was not statistically significant (P=0.771; Mann-Whitney test). The current study was undertaken also to investigate the possible influence of the type of apple juice (mixed, clear or cloudy) on the occurrence and level of patulin contamination. Mean levels of patulin were significantly lower in mixed apple juices (4.54 μg kg^{-1}) than in pure apple juices (9.32 μg kg^{-1}). Levels of patulin contamination were comparable in clear and cloudy juices.

Introduction

Patulin is a secondary metabolite produced by some species of *Aspergillus*, *Byssochlamys* and *Penicillium* (Weidenbörner, 2001). Apples and apple products are excellent substrates for *Penicillium expansum*, the causal agent of blue mould, to produce the mycotoxin. Acute symptoms of patulin consumption can include agitation, convulsions, edema, ulceration, intestinal inflammation and vomiting. Chronic health effects of patulin include genotoxicity, immunotoxicity, and neurotoxicity in rodents, while its effects on humans are not clear yet. The maximum permitted level of patulin in fruit juices and nectars, in particular apple juices and apple juice ingredients in other beverages marketed in Europe is 50 μg kg^{-1}. The permitted threshold is lower for apples juices labelled and sold as intended for infants and young children (10 μg kg^{-1}).

Previous studies have evaluated the patulin content in apple derivatives commercialized in Italy (Beretta et al., 2000; Ritieni, 2003). During November 2003 – February 2004, 169 samples purchased in Italian markets, supermarkets and organic food shops, including 57 apple juices, 15 pear juices and 57 other juices, were analysed (Piemontese et al., 2005). Sixteen of the 33 conventional apple juices were contaminated, as well as 12 of the 24 organic apple juices.

In this study we concentrated on the occurrence and level of patulin in apple based juices not intended for infants marketed in Italy, looking at the influence of the agricultural production process employed (conventional or organic). A second aim of

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the work was the investigation of the possible influence of type of apple juice (mixed, clear or cloudy) on the occurrence and level of patulin contamination. To our knowledge, this was the first investigation performed on a significant number of mixed apple juices.

Materials and methods

Commercial apple (clear and cloudy) and mixed juices not intended for infants (135 samples) were purchased at random from Italian supermarkets or organic food shops during the period April – November 2005. In particular, 98 conventional and 37 organic fruit juices produced in Italy or imported were analysed. The extraction procedure used, modified by Arranz et al. (2004), permitted to quantify 10 µg kg^{-1} or lower levels of patulin. Cloudy juices were left overnight at room temperature or 2h at 40 °C with pectinase enzyme solution and then centrifuged at 4500 rpm for 5 min. Thirty g of clarified juice were extracted with ethyl acetate. The organic phase was dehydrated with 15 g of sodium sulphate anhydrous and then evaporated to dryness. The clean-up was performed modifying the procedure of Stray (1978). The sample was dissolved in 10 ml of toluene and 5 ml of sample were cleaned-up with C_{18} SPE column previously trigged with 5 ml of toluene. The column was washed with toluene and the sample was eluted with 4 ml of toluene: ethyl acetate (1:1). The final eluate was evaporated to dryness, dissolved with 1.5 ml of acetic acid solution, filtered through a 0.22 µm syringe filter and transferred into a HPLC vial.

The mobile phase, eluting at a flow rate of 1 ml/min, consisted of an isocratic mixture of water-acetonitrile-perchloric acid (96:4:0.1) for 16 min, followed by a washing step with an isocratic mixture of water-acetonitrile (35:65). 100 µl of sample were injected onto the HPLC column and the retention time of patulin was 11.82 min. The amount of patulin in the final solution was determined by using a calibration graph of concentration versus peak area and expressed as ng/ml.

The limit of detection (LOD) and the limit of quantification (LOQ), based on the IUPAC definition, were respectively 1.04 and 1.57 µg kg-1. Mean patulin concentrations were calculated by using LOQ/6 for negative samples. The Mann-Whitney test was used to compare the mean patulin levels. The χ2-test was used to compare the patulin contamination frequencies. Statistical analysis was performed by using the SPSS software (SPSS Inc., version 12.0.1, Chicago, IL, USA).

Results

Patulin could be quantified in 47 out of 135 pure apple or mixed apple juices (ranging from 1.58 to 55.41 µg kg^{-1}). An overall incidence of 34.8% was observed in the apple based juices, with 24 samples having between 1.57 µg kg^{-1} (LOQ) and 10 µg kg^{-1} patulin, 22 samples having between 10 µg kg^{-1} and 50 µg kg^{-1} patulin, and one sample exceeding the 50 µg kg^{-1} patulin threshold (Table 1). A mean contamination level of 6.42 µg kg^{-1} was calculated for all contaminated samples. A similar incidence of positive samples was found in conventional (35.7%) and organic (32.4%) apple based juices, although the mean contamination level in organic juices (10.92 µg kg^{-1}) was double the value found in conventional juices (4.77 µg kg^{-1}). The hypothesis that the mean patulin contamination levels in conventional and organic apple juices were not different was accepted (p = 0.771; Mann-Whitney test). Even narrowing the statistical analysis to the pure apple juices, no significant difference can be registered between the mean patulin contaminations in conventional (8.96 µg kg^{-1}) and organic (9.91 µg

kg^{-1}) pure apple juices (p = 0.336). According to the typology of juices, the magnitude between the means of patulin level in pure apple juices (9.32 µg kg^{-1}) and mixed apple ones (4.54 µg kg^{-1}) was statistically significant (p = 0.012, Mann-Whitney test). Also the medians of the two juice typologies were significantly different, respectively 1.39 µg kg^{-1} and 0.27 µg kg^{-1}. A patulin incidence of 47.2% was registered in pure apple juices, while a lower occurrence (26.8%) resulted in mixed apple juices. The χ^2-test showed that the frequencies of patulin occurrence in pure apple and mixed apple juices were not comparable (p = 0.0003). Although higher incidence and level of contamination were found in pure apple juices, also mixed apple juices have a significant mean patulin contamination. The sample with the highest patulin contamination, exceeding the limit of 50 µg kg^{-1} was an organic mixed apple one (55.41 µg kg^{-1}).

Tab. 1: Patulin contamination in juices containing 100% apple juice or a certain percentage of apple juice together with other fruit juices, marketed in Italy

Commodity	Positive / total	%	Number of samples			Mean* ± SD (µg kg^{-1})
			<10 µg kg^{-1}	10-50 µg kg^{-1}	>50 µg kg^{-1}	
Conventional juices	35/98	35.7	20	15	-	4.77±3.32
Organic juices	12/37	32.4	4	7	1	10.92±6.37
Conv. apple juices	19/32	59.4	11	8	-	8.96±4.46
Organic apple juices	6/21	28.6	2	4	-	9.91±5.91
Apple juices	25/53	47.2	13	12	-	9.32±5.07
Clear apple juices	14/28	50.0	8	6	-	10.81±4.27
Cloudy apple juices	11/25	44.0	5	6	-	7.59±5.62
Mixed juices	22/82	26.8	11	10	1	4.54±3.88
Total juices	47/135	34.8	24	22	1	6.42±4.48

*Mean level was calculated using LOQ/6 for negative samples.

The results also show a comparison of the mean patulin contamination level in clear (10.81 µg kg^{-1}) and cloudy (7.59 µg kg^{-1}) apple juices. Such division was possible only for pure apple juices, because all mixed apple juices purchased and analysed in this study were cloudy. The hypothesis that the mean patulin contamination levels in clear and cloudy apple juices were not different was accepted (p = 0.940; Mann-Whitney test). A similar incidence of patulin contamination was registered in clear (50.0%) and cloudy juices (44.0%). Moreover, the χ^2-test showed that the frequencies of patulin occurrence in clear and cloudy apple juices were comparable (p = 0.356).

Discussion

According to a study carried out by Beretta et al. (2000), organically produced apple juices are more contaminated by the mycotoxin than conventionally produced ones. Ritieni (2003) and Tangni et al. (2003) compared organic and conventional produced apple juices without finding any statistically significant difference. Piemontese et al. (2005) showed a statistically higher incidence of positive samples and mean patulin concentration in organic products as compared to conventional ones. On the other hand, a similar incidence of positive samples was found in conventional and organic apple juices, with mean patulin concentrations statistically not different. The fact that no significant differences were registered in this study between organic and conventional fruit juices could be explained with the same care used in both production chains in removing decayed and damaged fruit during juice processing. Few reports are available on the occurrence of patulin in mixed juices containing apple and other fruit juices. Piemontese et al. (2005) analysed 57 samples of "other" juices, including fruit juices other than apple and pear or juices containing apple together with other fruit. Probably, the relative high contamination found in mixed juices could be explained with a lower attention to the quality of the single juice added to the mixture: mixed juices generally contain higher quantities of sugars and other additives. Seasonal differences could be responsible in some way for the differing results by other authors (Sydenham et al., 1997). For this reason, the juices analysed in this study were bought in periods of the year (from April to November) representing the old and the new season. From the study we can also conclude that the clarification of apple juice probably did not significantly change the level of patulin contamination in clear juices compared to cloudy ones. In conclusion, most of the data shown in the present study indicate an acceptable situation about the quality of the fruit juices marketed in Italy, with a low level of contamination in the pure or mixed apple juices. With the exception of one sample, the level of patulin was lower than 50 µg kg^{-1}, the maximum permitted threshold in fruit juices according to the EU - legislation.

Acknowledgments

This research was carried out with a grant from the Italian Ministry for the Environment and Territory within the Framework Agreement "Crop Protection with Respect of the Environment" and with a grant from Piedmont Region "Selection, study of the efficacy and mechanism, characterization and development of antagonistic yeast against postharvest fruit pathogen".

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Sensory evaluation of processed wheat from a defined field-trial (QualityLowInputFood)

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Key words: sensory evaluation, organic wheat quality, variety, QDA

Abstract

The integrated project QualityLowInputFood (QLIF) aims to improve quality, ensure safety and reduce costs along the organic and "low input" food supply chains. Beside safety, freshness, general health benefits as well as nutritional value, one reason for consumers demanding organic foods are more tasty products (Bourn/Prescott 2002). Therefore it is important to evaluate how the sensory attributes such as taste, flavour and texture of fresh and processed products are influenced by the different management systems. For sensory evaluation, in crop year 2005 seven wheat samples were assessed by a trained sensory panel, each with 4 field replicates (in total = 28 samples). The wheat samples were processed to wholemeal bread and biscuits for evaluation.

A descriptive panel (12 persons) was well trained according DIN 10967 as well as for quantitative descriptive analysis (QDA). This method enables to show a complete product profile with all sensory characteristics and their intensity in appearance, aroma, texture, mouthfeel and flavour attributes.

For wholemeal-bread, results in crop year 2005 showed no significant differences between the different farming systems. The influence of varieties were higher than farming management effects. The varieties "Paragon", "Zebra" and "Fasan" were significant different to "Monsun" in texture attributes.

Introduction

Beside safety, freshness, general health benefits as well as nutritional value, one reason for consumers demanding organic foods is a tastier product (Bourn/Prescott 2002). Therefore, it is of particular importance to compare organic, low input and conventional management systems on farm (field trials) and their influence on the sensory product characterisation. Sensory methods can be classified into three categories (Busch-Stockfisch, 2003) with different requirements for the training of assessors (trained or untrained panellists).

1. Discrimination tests allow distinguishing whether there is a difference in general, but without substantiating the differences in detail or quantifying intensities.

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2. Descriptive analysis method allows describing attributes of a product in detail and compares the intensities of these attributes from different products.

3. Preference and acceptability tests allow reflecting relative degrees of liking. The Quantitative Descriptive Analysis (QDA) was used in this evaluation. It is able to show a complete product profile with all sensory characteristics and their intensity in appearance, aroma, texture, mouth feel and flavour attributes. Under the guidance of a panel leader, a panel group consisting 10 – 12 persons developed a scorecard with a list of attributes which fully describes the products and definitions for each attribute. At the same time a ranking of attributes was done. At least the panellists learned to practice scoring along the intensity scale. The panellists were trained to be able to communicate precisely without subjective descriptions and to work consistent and reproducible (Stone & Sidel 2002).

Materials and Methods

The following samples were tested: from field trial at Nafferton Ecological Farming Group, Newcastle, UK, 7 wheat samples of different management systems (fertilizer/innoculum system) and varieties (see www.qlif.org) were send to Kassel University. There wholemeal-bread was processed according standard methods for grain and bread of the German Federal Research Institute for grain (1994) according standard method for wholemeal-bread. Biscuits were also processed on the basis of the standard method for short crust-biscuits, but the recipe had to be adapted to the special conditions of wholemeal (see qlif.org: WP 2.1.1 annual report 2006 effect of crop management practices on quality characteristics of wheat).

Bread and also biscuits were processed 14 hours before sensory training respectively sensory evaluation. Training and evaluation was organised according to following time schedule:

Tab. 1: time schedule sensory evaluation of wholemeal bread- and biscuits

time schedule	wholemeal bread **crop 2005**	Wholemeal cookies **crop 2005**
general training on wholemeal bread	24.01.-03.02.06 6 sessions	25.04.-05.05.06 6 sessions
training with QLIF-samples with focus score training	07.02.-23.03.06 15 sessions	09.05.-01.06.06 15 sessions
evaluation of QLIF-samples (max. 6 samples per session)	28.03.-06.04.06 6 sessions	06.06.-16.06. 6 sessions

1 session = 1,5 h-2 h/ generally 3 session per week

Training and evaluation were carried out according QDA-standards of Stone & Sidel (Stone, Sidel 1993). For the description of wholemeal bread, 29 attributes had been selected, for biscuits the panellists described 24 attributes. The panellists were calibrated directly on the test samples. During data collection, panellists got at maximum of 6 product samples per session in a randomized design order (according to sensory computer software FIZZ, Biosystemes, France). The samples were served in booths, monadically (each panellist got the samples in different order). All data were quantified by ratings of perceived intensities, using an unstructured line scale with end-anchors and offset goal posts (e. g. from weak to strong). Experimental design was as follows:

1. Factorial: each level of a factor is matched with each level of others.

2. Replicated: samples were evaluated 4 times (= field replicates).

3. Repeated Measures: each panellist tasted each sample.

The experimental design yields a four-dimensional data matrix: panelist x attributes x samples x replicates. The data were analysed by “FIZZ” sensory software. Descriptive statistical measures were first calculated for all attributes using scores from panellists. Analysis of variance was performed on each attribute using a randomized block design for balanced data, with panellists as repeated measures. Where F-test indicated a significant difference between test treatments, differences was defined as $P < 0{,}05$.

Results

In crop year 2005, results of the sensory profiling show significant differences in appearance and texture attributes of wheat varieties for wholemeal bread. No significant differences could be found for wholemeal biscuits.

The influence of varieties on sensory attributes was higher than farming management effects.

Tab. 2: Variance analysis of texture attributes wholemeal-bread crop 2005

Analysis (*1)	Paragon compost:yes innocul.:yes	Zebra compost:yes innocul.:yes	Monsun compost:yes innocul.: no	Monsun compost:no innocul.:no	Monsun compost:yes innocul.:yes	Monsun compost:no innocul.:yes	Fasan compost:yes innocul.:yes	Comp. F	Proba.
poresize	**6,51**	**5,29**	**3,05**	**3,07**	**3,07**	**3,05**	**5,59**	**100,33**	<0,0001
group (*2)	A	B	C	C	C	C	B		***
firmness (hand)	**2,19**	**3,7**	**6,76**	**6,79**	**6,31**	**6,53**	**3,12**	**171,82**	<0,0001
group	E	C	AB	A	B	AB	D		***
firmness (mouth)	**2,57**	**3,51**	**5,62**	**5,92**	**5,55**	**6,11**	**3,41**	**92,75**	<0,0001
group	C	B	A	A	A	A	B		***
dry (mouth)	**5,42**	**4,79**	**3,88**	**3,81**	**3,66**	**3,4**	**5,06**	**27,16**	<0,0001
group	A	B	C	C	C	C	AB		***
sticky (mouth)	**6,17**	**5,41**	**4,3**	**4,77**	**4,31**	**4,26**	**5,52**	**24,65**	<0,0001
group	A	B	C	C	C	C	B		***
grainy (mouth)	**4,33**	**3,94**	**4,92**	**4,56**	**4,71**	**4,86**	**4,09**	**6,31**	0,0217
group	ABC	C	A	ABC	AB	A	BC		*

Summary Factor: Product L.S.D. at 5%   * significant at 5 %/** significant at 1 % /*** significant at 0,1 %

*1: analysis of variance FIZZ-sensory software; mean (size 44 - 11 panelists x 4 field replicates)

*2: group: the difference between levels with same letter is not signficant.

Overall, even with compost fertilisation, variety “Monsun” showed no sufficient baking qualities. The rising quality of “Paragon” was too strong, it was also too sticky. “Fasan” and “Zebra” had the best baking qualities.

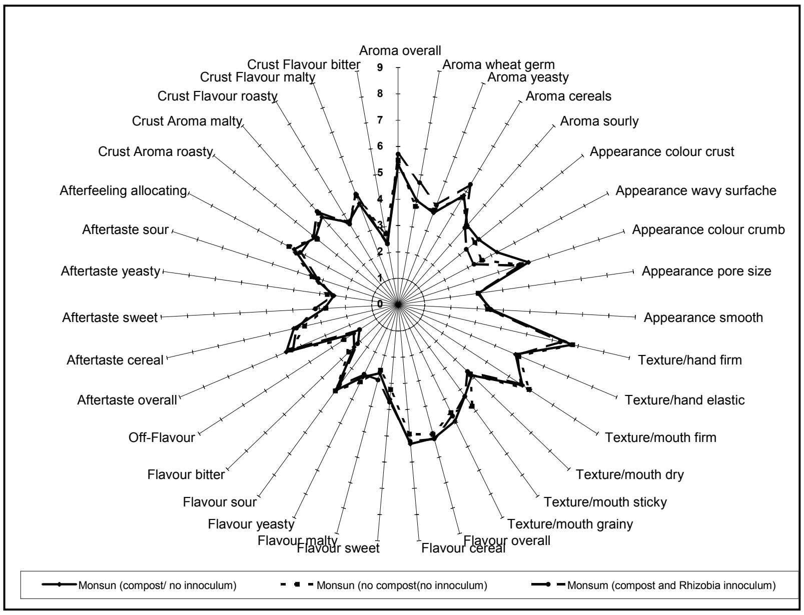

Figure 1: Product profile wholemeal bread of wheat variety "Monsun",compare-son of different farming systems (mean values of panel group) from harvest 2005

In appearance, the varieties Paragon, Zebra and Fasan had a significant higher intensity of crust colour, due to a higher rising quality of the dough. This is also shown by a higher size of pores and a less firm. Most intensive in these attributes was the variety "Paragon", followed by "Fasan" and "Zebra" with nearly same intensities. These varieties had also a more sticky and dry mothfeel in comparision to "Monsun".

Discussion

The reported results are part of a three year comparison of wheat samples within the project QualityLowInputFood (harvest 2005, 2006 and 2007). The results of baking tests as well as the correlation of sensory analyses with data from chemical analyses will be done in autumn 2008.

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Potential Risk of Acrylamide Formation in Different Cultivars of Amaranth and Quinoa

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Key words: asparagine, acrylamide, pseudocereals, cultivar, food products

Abstract

Acrylamide (AA), a potential human carcinogen, is formed in strongly heated carbohydrate-rich food as a part of the Maillard-reaction. The amino acid asparagine (Asn) and reducing sugars are considered to be the main precursors for AA formation. So far, research in AA has mainly focused on potato and cereal products, indicating the relevance of species, cultivars, amount of N fertilizer, and climatic conditions. Potential additional sources of acrylamide in food products might be pseudocereal grains (e.g. amaranth, quinoa). As amaranth and quinoa are often cultivated as cash crops in organic production systems, the aim of this study was to investigate the potential of acrylamide formation in different amaranth and quinoa cultivars. Grain samples were collected from field trials in Germany and Austria consisting of 6 amaranth and 3 quinoa cultivars. The results indicated significant differences in the potential for acrylamide formation of quinoa cultivars and also slight differences between tested amaranth cultivars. It is obvious that the selection of cultivars with a low AA formation potential would offer a suitable strategy for the minimization of AA in foodstuffs.

Introduction

In April 2002, the Swedish National Food Administration announced that certain food products contain high amounts of acrylamide. As affected food products mainly carbohydrate-rich foods, such as potatoes or cereal products, were mentioned (Mottram et al., 2002). These findings attracted world-wide attention, especially as acrylamide is classified as "probably carcinogenic to humans" (IARC, 1994). Since the announcement in 2002, considerable progress has been made in basic understanding, and several aspects of acrylamide research have been addressed, such as methods of analysis, occurrence, formation, chemistry, toxicology, and potential health risk in the human diet. So far, most studies on acrylamide have been carried out on fried potatoes to understand the critical factors that may control or reduce acrylamide formation. Results clearly indicated that the amount of acrylamide increased with frying and baking temperature (Tareke et al., 2002). From the results gained so far, it can be concluded that the contamination of foods with acrylamide originates from a reaction of asparagine with carbohydrates at high temperatures as part of the Maillard-reaction. Based on these findings, many studies have been carried out, and have found ways to minimize the levels of acrylamide in heated products. From the current standard of knowledge, minimization can be accomplished either by

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modifying the processing parameters such as pH, temperature, and time of heating, or by elucidating the mechanistic path-ways of acrylamide formation and eliminating precursors or intermediates.

To date, research in acrylamide has mainly focused on potato products (Weisshaar & Gutsche, 2002) and cereals (Weber et al., 2007) indicating the relevance of cultivar, amount of fertilizer, and climatic conditions. Current studies show that, due to customary consumption habits in Europe, bakery products might contribute to about 25 % of total acrylamide intake. A potential additional source of acrylamide in cereal food products might be popped or toasted cereal or pseudocereal grains, e.g. popped amaranth (*Amaranthus spp.*) or quinoa (*Chenopodium quinoa*) flakes in breakfast cereals, due to the heat application for popping, toasting or roasting. It has been shown that popping or cooking can increase the contents of aspartic acid in amaranth grain (Gamel et al., 2005). However, no studies on acrylamide in amaranth or quinoa products are available so far. Amaranth and quinoa grain are high in fibre, calcium, and iron content and have a relatively high concentration of other minerals as well, including magnesium, phosphorus, copper, and manganese. Moreover, grain amaranth and quinoa have higher amounts of protein (14-18 %) than many other cereal grains and have significantly higher lysine contents. Because they are gluten-free, amaranth and quinoa are also popular with consumers who have wheat and gluten allergies. Recent advancements on the potential of grain amaranth and quinoa as a cash crop and as healthy anti-allergic alternative to cereal foodstuffs have led to consider the expansion of these crops especially in organic production systems. As the largest amaranth and quinoa grain consumer is the health food industry, where organic and transitional productions carry a market premium, it seems to be essential to investigate the potential of AA formation in amaranth and quinoa.

Hence, the goal of this study was i) to evaluate the potential of amaranth and quinoa to form acrylamide, ii) to investigate potential differences of AA formation in multiple cultivars of amaranth and quinoa. Grain samples were collected from field trials in Germany and Austria consisting of 6 amaranth and 3 quinoa cultivars.

Materials and methods

Grain samples of amaranth were collected from field trials in Austria and Germany. Field experiments were conducted on the experimental farm of the BOKU-University at Gross-Enzersdorf in Eastern Austria (48° 12' N; 16° 33' E) during the growing seasons of 2004 and 2005. The amaranth genotypes *Amaranthus cruentus* cv. Amar (Mexican type)*, Amaranthus hypochondriacus I* and *Amaranthus hypochondriacus II (both* crossbred lines) were grown under semi-arid conditions of 9.8°C mean annual temperature and 546 mm mean annual precipitation in a split plot design. The soil type was classified as a chernozem of alluvial origin which is rich in calcareous sediments. Since there was a high amount of soil nitrogen available, no N-fertilizer was applied. In Germany in 2003, the amaranth cultivars K343, Pastewny, and Bärnkraft and the quinoa cultivars Faro, Tango, and 407 were cultivated at the experimental station Ihinger Hof (48° 44' N; 8° 56' E) of the University of Hohenheim, Stuttgart, Germany on a loess derived soil with oat as previous crop. Mean annual temperature was 8.1°C and mean annual precipitation was 693 mm. Target nitrogen amounts were 80 kg N ha^{-1} for amaranth and 120 kg N ha^{-1} for quinoa.

Grain samples were analyzed for free amino acid content by using 2 g of flour mixed with 8 ml of 45 % ethanol for 30 min at room temperature. After sequential centrifugation for 10 min at room temperature and 4000 rpm followed by 10 min at

10 °C and 14000 rpm, the supernatant was filtered through a 0.2 µm syringe filter and filled in vials. Amino acid analysis was performed using HPLC components manufactured by Merck–Hitachi. The fluorescence intensity of the effluent was measured at the excit and emission maxima of 263 and 313 nm were measured. Determination of the sum of reducing sugars was made by using the method of Luff Schoorl (Matissek et al. 1992). AA formation potential was determined according to Weber et al. (2007). SigmaStat version 2.0 was used to compare the amount of precursor factors and of AA formation potential in different cultivars and locations (ANOVA, Tukey). Linear regression analysis was used to determine the correlation between AA contents and precursor factors.

Results and discussion

Figure 1 indicates the AA formation potential of tested amaranth cultivars and genotypes, respectively. AA formation potential ranged by between 320 and 492 ng g^{-1}. No significant difference in AA formation potential was found between the tested cultivars and genotypes. Analysis of the supposed precursors reducing sugars and Asn content indicated a similar capacity of sugar as well as Asn assimilation of all tested cultivars and genotypes. No significant differences were observed between the tested years, or between the locations.

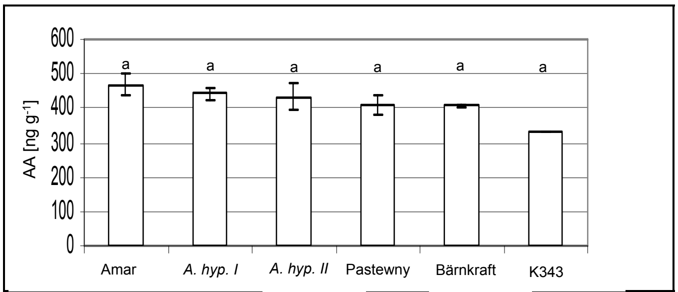

Figure 1: Acrylamide (AA) potential [ng g^{-1}] of investigated amaranth cultivars and genotypes.

In contrast to amaranth, tested quinoa cultivars (Figure 2) showed a statistically significant difference ($P = 0.002$) in AA formation potential. AA formation potential ranged between 495 and 990 ng g^{-1}. Especially, the cultivar Faro showed a relatively low AA formation potential together with a low Asn content when compared to the other tested cultivars. On average, AA potentials of 451 ng g^{-1} were found in amaranth, while quinoa indicated a slightly higher AA potential with an average of 613 ng g^{-1}. These values are close to NOEL (no observable effect level) at 500 ng g^{-1}, suggested by the Federal Institute of Risk Assessment, Berlin. Thus, it indicates a risk potential of AA formation in foodstuffs derived of amaranth and quinoa.

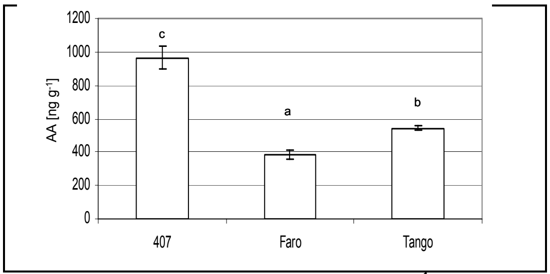

Figure 2: Acrylamide (AA) potential [ng g^{-1}] of investigated quinoa cultivars.

Further, AA potential of both amaranth and quinoa was 2-3 times higher than in cereal species and thus has to be evaluated in further studies, to estimate potential risks for consumers. Further studies are also required to investigate the role of other amino acids that are present in higher quantities such as aspartic acid, lysine, methionine and glutamine.

Conclusions

This study investigated acrylamide precursor contents and the potential of acrylamide formation in different amaranth and quinoa cultivars. The results indicated significant differences in the potential for acrylamide formation of quinoa cultivars and slight differences between the tested amaranth cultivars and genotypes. The results suggest that the use of cultivars with low levels of free asparagine and thus a low AA formation potential might be a feasible strategy to lower the risk of consuming acrylamide in foodstuffs derived of the two products described in this paper. In conclusion, to foster the expansion of amaranth and quinoa especially in organic production systems while ensuring premium quality foodstuffs, the selection of cultivars low in free asparagine seems to be an effective strategy.

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Bioactive compounds of organic plant products

Cultivation and analysis of anthocyanin containing types of potatoes in organic farming regarding cultivability and additional health benefits

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Key words: anthocyanin content, blue potatoes, additional health benefits, organic farming

Abstract

In a two year research project a representative spectrum of blue potato varieties were cultivated and tested in detail regarding disease infestation, yield potential and the influence of production systems (organic). Cultivation recommendations for blue potatoes could be deduced from this. Furthermore the varying anthocyanin content as well as the antioxidant capacity of the varieties used was analysed. Varieties with a particularly high content will undergo further tests to show the influence of the manner of preparation (boiling, steaming, frying) and determine their use for the processing industry. The combination of ecologically produced potatoes with „additional health benefits“ arouses the customers interest. The cultivation of high yield blue types can be an alternative to the cultivation of yellow fleshed high yield varieties in organic operating companies.

Introduction

Anthocyanin, the phytochemical which appears in various useful plants such as potatoes and cereal, known especially for its health promoting effects in red wine, have a health promoting effect with their antioxidant properties (KATSUBE et al. 2003, KÄHKÖNEN 2003, MURCOVIC 2002, WATZL et al. 2002). The health promoting properties of anthocyanin are determined by its antioxidant capacity. The health promoting features are for example protection against DNA damage, degenerative illnesses and boosting the immune system (WEISEL 2006). As the potato with a consumption of 60 kg/person/year (ANONYMOUS 2007) still has an important position as a basic food, it is increasingly in the interest of the consumer, nutritional medicine and the food processing industry (e.g. potato crisps production). The goal of the interdisciplinary AGIP research project is the compiling and evaluation of the influence of the organic cultivation system with various intensities (fertilisation/no fertilisation).

Materials and methods

Within the project a field test was carried out in Germany at the Waldhof experimental station at the FH [University of Applied Sciences] Osnabrück (organic farmed) in terms of a randomized block design with four repetitions. In the test a compilation and evaluation of the influence of various cultivation parameters on technically more favourable type features with the varieties: Blauer Schwede, Blauer Schwede, Blauer

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Schwede, Herrmanns Blaue, Blue Salad Potato, Olivia, Red Cardinal (2006), Highland Burgundy Red (2007), Blaue St. Galler, Vitelotte, Norika 4251 – 4254 (breeding strains) took place. The variety Blauer Schwede was tested with different nutrient levels of 70 kg N/ha and 105 kg N/ha to determine a positive or negative effect on anthocyanin content, all other varieties got no fertilization. The harvest took place at 2006-07-27 and 2007-07-25. The manner of storage has an influence on the anthocyane content and antioxidant capacity on the ready to consume end product, which will be analysed in the course of the project. To document the effect of storage, there are various time frames for analysis: a) after 4 weeks of storage: investigations into raw harvest crop = analysis of original content b) after 8 weeks of storage: investigation of raw harvest crops = determination of storage losses (raw); c) after 16 weeks of storage: investigations on raw harvest crop = determination of storage losses (raw). During the complete storage period the potatoes were kept dark and cool (8°C). For the determination of the anthocyanin potatoes were washed with water und cut in small slices (incl. potato peel). A mixture of water/acetonitrile/formic acid (87/3/10, v/v/v) was added and the suspension was stirred at room temperature overnight. After the potato pieces were separated from the extract by filtration, the clear filtrate was cleaned-up on Amberlite XAD-7 in order to remove sugars and organic acids. The quantitative determination of anthocyanins was performed by HPLC monitoring at 520 nm using a calibration curve obtained for standard cyanidin-3-glucoside. The determination of the antioxidant capacity was carried out using the Trolox Equivalent Antioxidant Capacity (TEAC) – Test at the FH Osnabrück (HILLEBRAND 2004). Statistical data concerning yield have been determined by ANOVA 2.3 using the LSD test.

Results

The selected varieties of potato display significant differences in yield in cultivation year 2006 and 2007, in organic cultivation procedures (Tab. 1). Vitelotte, Red Cardinal (2006) and Highland Burgundy Red (2007) only showed a very small yield in both cultivation years. Other varieties such as Blue Salad Potato or Olivia had higher yields in 2007 than in 2006.

Tab. 1: Yields of selected varieties of blue potatoes in the years 2006 and 2007 in organic farming

	Total yield (t ha^{-1}) (organic cultivation) 2006	Total yield (t ha^{-1}) (organic cultivation) 2007
Vitelotte	2,0 (a)	2,9 (a)
Red Cardinal (2006)/Highland Burgundy Red (2007)	2,9 (ad)	4,0 (ad)
Olivia	7,3 (b)	18,4 (b)
Blue Salad Potato	4,4 (c)	11,79 (c)
Test used: ANOVA 2.3; 2006 SD 5 % = LSD 2,29; 2007 SD 5 % = LSD 9,53 (significant differences between varieties). Different letters in brackets indicates statistical significant differences between the varieties.		

Figure 1 shows the anthocyanin content of selected varieties of blue potatoes after four, eight and sixteen weeks of storage: the anthocyanin content of Red Cardinals is partly increasing, but in Olivias and Blue Salad Potatoes it is decreasing.

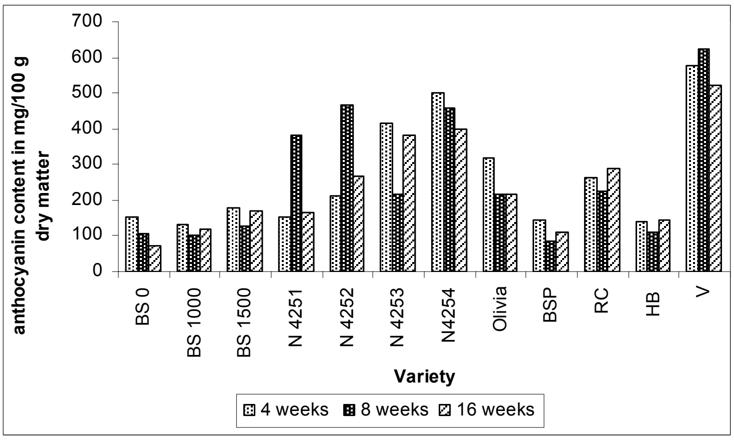

Figure 1: Anthocyanin content in mg/100g dry matter of different potato varieties after 4, 8 and 16 weeks of storage in 2006 (organic cultivation)

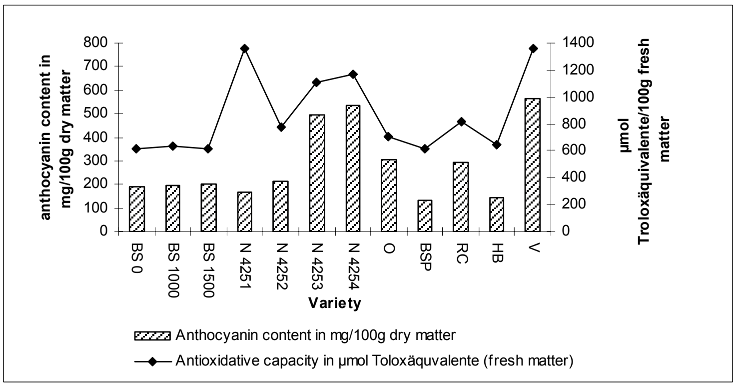

Figure 2: Relation between anthocyanin content and antioxidative capacity at different blue potato varieties 2006 (organic cultivation) **Abbreviations: BS 0 = Blauer Schwede, without fertilization; BS 1000 = Blauer Schwede, 70 kg/N/ha; BS 1500 = 105 kg/N/ha; N4251 – N 4254 = Norika breeding strains; O = Olivia; BSP = Blue Salad Potato; RC = Red Cardinal; HB = Herrmanns Blaue; V = Vitelotte**

Figure 2 illustrates the antioxidant capacity of the cultivated varieties in relation to the anthocyanin content. The investigations in 2006 showed that the level of anthocyanin influenced the antioxidant capacity and therefore the health promoting effects.

Discussion

The high temperatures and missing rainfall in June 2006 had a negative effect on the tuber growth. Layers and second shoots formed. As a result the exterior and interior quality of the potatoes was often not satisfactory (infestation with potato scurf (*Streptomyces scabies*)). The yields achieved could not be regarded as representative. In the investigations of 2007 it could be recognised that some of the old blue types preferred a relatively high nitrogen content (105 kg ha^{-1}). Vitelotte and Highland Burgundy Red as well as Red Cardinal could not achieve an adequate yield in organic cultivation, other varieties showed good harvest crop yields up to a total yield of e.g. 30.22 t ha^{-1} with the Olivia variety. The investigations in 2006 showed that the anthocyanin content has an influence on the antioxidant capacity and therefore on the health promoting effects. Anthocyanin content and antioxidant capacity are dependent on the variety and according to the results from 2006 are not influenced by the use of a nitrogen fertiliser.

Conclusions

The results of the research project show that sometimes it is possible to cultivate a particular variety e.g. old anthocyanin containing varieties of potatoes in organic farming, however a breeding process must take place for some types of potatoes concerning the needs of the user today regarding skin texture, shape or taste. Investigations in 2007 have not yet been completed at this point, but will be integrated into the contribution for the conference. This also applies to the investigations into the antioxidant capacity according to various methods of preparation.

Acknowledgments

Special thanks go to AGIP [work group innovative projects, ministry for economy and culture in Lower Saxony] as well as to DIL [German Institute for food technology], for their financial support in carrying out this project.

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The Content of Selected Antioxidant Compounds in Bell Pepper Varieties from Organic and Conventional Cultivation Before and After Freezing Process

Hallmann E. & Rembiałkowska E.[1]

Key words: bell pepper, antioxidant compounds, vitamin C, carotenoids, rutin

Abstract

Sweet bell pepper is one of the best sources of ascorbic acid and a fair source of carotenoids in human diets. The levels of vitamin C are very variable and may be affected by maturity, genotype and processing. Vegetable freezing is one of the most efficient and adequate preservation methods. Organic fresh vegetables contained more bioactive compounds than conventional ones. Two bell pepper cultivars (Roberta and Ożarowska) have been selected for analysis. Vegetables were cultivated on organic and conventional farms in Poland. Ripe bell peppers have been collected in the same week of ripening and were chemically analyzed twice: fresh before freezing and after six month of storage in -20°C. Vitamin C content, carotenoids also the total flavonols content have been determined in fruits. Organically produced bell peppers contained significantly more vitamin C and lutein than conventionally grown fruits. Processing with aid of freezing considerably decreases the content of the bioactive compounds in red bell peppers.

Introduction

Sweet bell pepper (*Capsicum annuum* L.) is an excellent source of ascorbic acid and a fair source of carotenoids as beta-carotene, capsantin and capsorubin (Haytowitz and Matthews 1984). In addition, peppers are rich in flavonoids (Lee et al.1995) and other phytochemicals (Duke 1992). The levels of vitamin C are very variable and may be affected by maturity, genotype and processing (Howard et al 1994). This vitamin acts as a protector of pigments preserving them from chemical and biochemical oxidation. During the paprika's production there are some steps which decrease the level of pigments (Carvajal et al. 1997). Vegetable freezing is one of the most efficient and adequate preservation methods. During freezing most of the liquid water changes into ice, which greatly reduces microbial and enzymatic activities. Oxidation and respiration are also weakened effectively by low temperature. However, freezing itself slightly decreases food quality (Haiying et al. 2007). Fresh organic red pepper contains more bioactive compounds than conventional one (Hallmann and Rembiałkowska 2007). Therefore it has been assumed that also frozen organic pepper would contain more bioactive compounds than conventional pepper.

Materials and methods

Experiments have been carried out in 2006. Two bell pepper cultivars, Roberta and Ożarowska (common in cultivation in Poland), have been selected to study. Plants were cultivated in certified organic and conventional farms in Mazovia region. The

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organic farm was located 40 km from the conventional farm. The geographical situation of farms was 52°41’ N and 20°92’ E. Red pepper plants were cultivated in semi-light loamy and sandy soil. In the organic system all recommended rules for fertilization and rotation were applied; compost at dose 30 t/ha has been used. Because of the absence of plant diseases fungicides and insecticides allowed in organic farming have been used.

In conventional cultivation the following mineral fertilizers have been used: ammonium nitrate with lime (450 kg/ha), granulated superphosphate (250 kg/ha), and potassium sulphate (450 kg/ha). Moreover, chemical plant protection (Bravo 500 SC) has been applied. Plants were growing in semi-heavy clay soil. The samples of fully ripe bell peppers have been collected in the same week of period and were chemically analyzed twice: fresh before freezing and after six month of storage in -20^{o}C. Vitamin C content was analyzed with Tillman’s method (PN-90 A -75101/11), carotenoids (beta-carotene, lycopene and lutein) have been determined by liquid column chromatography method (Saniawski and Czapski 1983). The total flavonols content have been determined by Christ – Müller’s method, described by Strzelecka, et al. (1978). All analyses were carried out in six replications. The results of those qualitative characteristics of fruit were statistically calculated using Statgraphics 5.1 program specifically ANOVA test at α = 0.05.

Results

The results of chemical analysis – content of lycopene, beta-carotene and lutein - are presented in a table 1. Results showed that the content of lycopene and beta-carotene in organic red pepper fruits wasn’t statistically different from that in conventional fruit, while the impact of the cultivar was significant (table 1). Only in the case of lutein was the level of this compound significantly higher in organic peppers than in the conventional fruit.

Tab. 1: Content of selected carotenoids in bell peppers from organic and conventional cultivation before and after freezing process

cultivation method	cultivar	lycopene (mg/100 g f.w.)		beta-carotene (mg/100 g f.w.)		lutein (mg/100 g f.w.)	
		fresh	after freezing	fresh	after freezing	fresh	after freezing
organic	Roberta	0.18	0.10	3.09	1.49	0.53	0.62
	Ożarowska	0.33	0.28	2.61	1.01	0.62	0.72
conventional	Roberta	0.22	0.19	2.85	1.17	0.29	0.25
	Ożarowska	0.36	0.23	2.58	0.96	0.56	0.72
p-value							
cultivation method		n.s		n.s.		0,04*	
cultivar		<0,0001*		0,0004*		<0,0001*	
freezing		0,0021*		<0,01*		<0,0001*	
* significant for p<0,05							

The freezing process had a significant decreasing effect on lycopene and beta-carotene content in red peppers, but it increased the content of lutein in peppers.

The level of vitamin C was significantly higher in organic vs. conventional fruits in both cultivars (fig.1), also it decreased considerably in peppers after freezing. In the Ożarowska cultivar the level of vitamin C was considerably higher than in the Roberta cultivar. The content of flavonols was slightly higher in organic vs. conventional peppers (fig.2), but differences weren't statistically significant. Also a decrease of the flavonols level in fruits after freezing wasn't significant. The level of flavonols in the Ożarowska cultivar was considerably higher than in the Roberta cultivar.

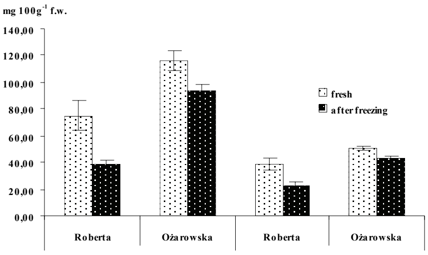

Figure 1: Vitamin C content in fresh and frozen bell pepper

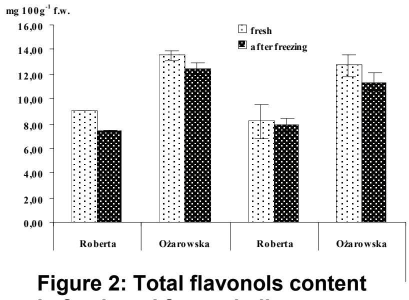

Figure 2: Total flavonols content in fresh and frozen bell pepper

Discussion

There are only few studies that compare the nutrition value of organic vs. conventional bell pepper. In the case of different vegetables from the Solanaceae family such as tomato, Pither and Hall (1990) found higher contents of vitamin C, vitamin A and potassium in organic tomatoes. Toor et al. (2006) found higher levels of vitamin C in organically produced tomatoes. Rembiałkowska et al. (2003) showed that organic red peppers and tomatoes contained more β-carotene, lutein, flavonoids and vitamin C than conventional fruits.

In this study, red peppers from organic cultivation were found to have clearly higher levels of vitamin C and lutein than those from conventional management. These results can be compared with similar results obtained in other experiments with sweet red pepper by the same authors (Hallmann and Rembialkowska 2007). The freezing process allows to keep better quality of the frozen products, but at the same time it decreases the bioactive compounds level in red peppers.

As described above, there is some evidence that organic vegetables (such as bell pepper) often contain more antioxidants compounds than conventional ones. Data presented in this paper, seem to confirm that evidence. The factors influencing organic red pepper and other vegetables quality are complicated and interrelated. Long-term studies are necessary to consolidate the knowledge about the real interdependences.

Conclusions

Organically produced bell peppers contained significantly more vitamin C and lutein than conventionally grown fruits. The Ożarowska cultivar contained significantly more bioactive compounds (lycopene, vitamin C and flavonols) than the Roberta cultivar, especially under organic cultivation. Processing with aid of freezing considerably decreases the content of the bioactive compounds in red bell peppers.

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Bioactive compounds in tomatoes: effect of organic vs conventional management in Parma in 2006

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Key words: organic tomato, nutritional quality, carotenoids, polyphenols, TEER

Abstract

External and internal factors such as variety, season, location, ripening, growing conditions, technological and domestic processes could affect the content of bioactive compounds in food. The aim of this study was to evaluate the influence of different agronomical practices (organic vs conventional) on the nutritional quality of tomatoes.

Fresh tomatoes (cv. Perfectpeel), cultivated under organic and conventional practices were analysed for vitamin C, lycopene, β-carotene, chlorogenic acid, caffeic acid, coumaric acid, naringenin, rutin, quercetin, Total Antioxidant Capacity (TAC) and Ferric Reducing Ability of Plasma (FRAP). $CaCO_2$ monolayer cell cultures were used for testing membrane damage by Trans Epithelial Electrical Resistance(TEER).

Results showed that for lycopene, naringenin and rutin no significant differences were observed. For β-carotene and coumaric acid significantly higher values were found in organic samples. Values of vitamin C, chlorogenic acid, caffeic acid, quercetin and TAC were significantly higher in conventional tomato, but the FRAP values were significantly higher in organic tomato. The observed TEER values were not significant different between organic and conventional tomato.

Introduction

Several external and internal factors could affect the composition and content of bioactive compounds in food, such as agricultural factors (e.g. genotype, variety, season, geographic location/climate, stage of maturity, growing conditions), technological processes, and domestic treatments.

The aim of this study was to evaluate the influence of different crop management practices (organic *vs* conventional) on the nutritional quality of tomato. The physiological properties of phytochemicals and their potential beneficial effects on human health are usually related to their antioxidant activities, that may protect tissues against oxygen free radicals, mutagenesis and lipid peroxidation.

Materials and methods

Samples: tomato fruits, cultivar Perfectpeel, were purchased as fruits from Stuard company (Parma, Italy), that has several years experience in cultivation of organic tomatoes. Organic and conventional products were cultivated in the same growing conditions: season, location, ripening and plant age. The tomato fruits were derived

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from field cultivation. The cultivation site was on a clay soil in the Emilia-Romagna Region, in particular the Po Valley, near Parma. Organic and conventional tomatoes were cultivated in two distinct plots (4 samples, 5 kg for each). Ripening stage of fruits was 100%.

Analysis of nutritional parameters: Vitamin C, lycopene, β-carotene, chlorogenic acid, caffeic acid, coumaric acid, naringenin, rutin, quercetin, total antioxidant capacity (TAC) and Ferric Reducing Ability of Plasma (FRAP)- were evaluated. CaCO2 monolayer was used for testing Trans Epithelial Electrical Resistance (TEER).

Lycopene and β-carotene were extracted from food matrix as described by Sharpless *et al.* (1999). The extracts were analyzed by HPLC system and the detection wavelength was set at 450 nm according to Maiani *et al.* (1995).

Determination of polyphenols such as flavonoids (naringenin, quercetin and rutin) and hydroxycinnamic acids (caffeic acid, chlorogenic acid, coumaric acid) from food matrix was carried out as described by Hertog *et al.* 1992. Quantitative analysis was performed using an ESA-HPLC system with colorimetric array detection.

Total ascorbic acid (AA+DHAA) was extracted and quantified as described by Margolis *et al.* (1997); chromatographic separation was carried using ESA-HPLC, equipped with colorimetric array detector (Serafini *et al.* 2002).

Total Antioxidant Capacity (TAC) was evaluated using two different assays, TEAC (Trolox Equivalent antioxidant capacity) and FRAP (Ferric Reducing-Antioxidant Power) assays. The procedure extraction reported by Pellegrini *et al.* (2003), was carried out for TEAC and FRAP determinations. The TEAC assay measures the ability of antioxidants to quench radical cation in both lipophilic and hydrophilic environments in accordance to Re *et al.* (1999). The FRAP assay evaluates the reducing power of the sample according to Benzie and Strain *et al*. (1996).

For Trans Epithelial Electrical Resistance (*TEER)* evaluation, the tomato extract was tested on a CaCo2 cell line in order to test the changes in tight junction permeability by TEER and the phenol red passage (Delie *et al.* 1997). Different increasing concentrations have been added on monolayer culture Caco-2 (cells from human adenocarcinoma). In the experiment the cells were seeded onto polycarbonate filter cell culture chamber inserts (diameter 6.5 mm; area 0.33 cm^2; pore diameter 0.4 μm), at density of $1.5x10^5$ cells per filter and placed in a multiwells Falcon; the filter divided the chamber in two parts: apical and basal that represent the lumen and the basal area of the gastroenteric system. In the two chambers, we have measured the TEER for assessment of tight-junction permeability; this test gives us information about cell damages. At the end of experiment, the permeability was also tested by phenol red: the amount of phenol red detected in the basal chamber confirmed the TEER test. These parameters were used to detect the early intestinal barrier function *in vivo* damages. Each analysis was performed in triplicate. Data are given as the mean and standard deviation. Statistical analysis was performed using the Statistica for Windows statistical package (release 4·5; StatSoft Inc., Vigonza PD, Italy).

Results

Tab 1 shows phenolics, vitamin C and carotenoids contents (mg/Kg) and TEAC (μMol/100g) and FRAP (mMol/Kg) values respect to organic and conventional tomato. For lycopene, naringenin and rutin content there were no significantly different between organic and conventional tomatoes, while β-carotene and coumaric acid levels were significantly higher in the organic samples. In contrast, values of vitamin C, chlorogenic acid, caffeic acid, quercetin and TEAC were significantly higher in conventional tomatoes, but the FRAP values were significantly higher in organic tomatoes. Figure 1 shows the antioxidant/pro-oxidant results obtained using vitro models expressed as TEER (Ohm/cm2) by time in conventional and organic samples respectively for three different concentrations of tomato polyphenolic extract. The observed TEER values were not significant different between organic and conventional tomato, but we have observed, in both samples, a decrease of tight-junction permeability at 17uM of polyphenol concentrations.

Tab. 1: Mean values±sd of tested nutritional parameters

	Organic	Conventional	Student T-test
Vitamin C mg/100g	17.73±1.41	20.29±1.49	P<0.03
Lycopene mg/Kg	2.13±0.45	2.40±0.50	n.s.
β-Carotene mg/Kg	0.61±0.09	0.47±0.12	P<0.03
Chlorogenic acid mg/Kg	2.82±0.92	3.52±0.74	P<0.02
Caffeic acid mg/Kg	3.29±0.33	3.61±0.71	P<0.006
Coumaric acid mg/Kg	3.35±0.48	2.79±0.42	P<0.02
Naringenin mg/Kg	41.52±17.71	34.56±11.16	n.s.
Rutin mg/Kg	36.66±17.72	37.06±6.68	n.s.
Quercetin mg/Kg	17.92±10.90	33.90±6.31	P<0.0004
TAC (TEAC) µMol/100g	352±71	485±34	P<0.0001
FRAP mMol/Kg	4.06±0.48	3.15±1.35	P<0.0001

Each value is the mean of three determinations, ± S.D.

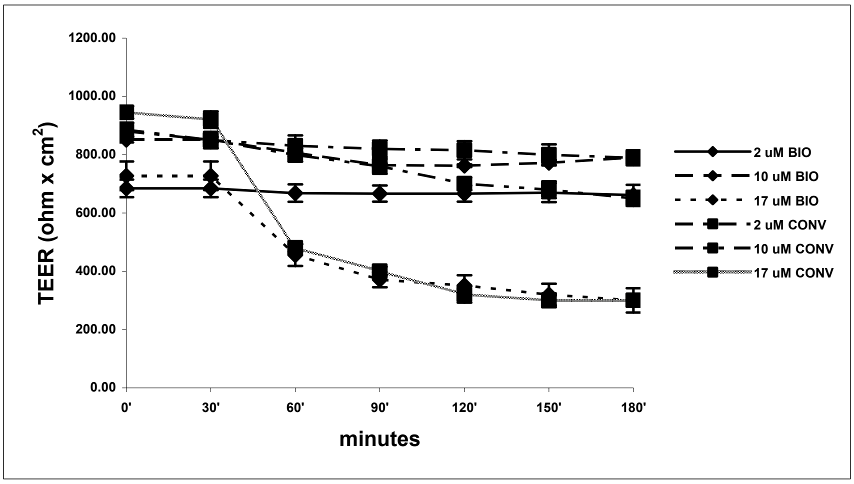

Figure 1: BIO and CONV tomato polyphenols extract at different concentration, *each value is the mean of three determinations, ± S.D.*

Discussion

The TEER results show that conventional and organic samples have same behaviour, and the monolayer system is able to resist until 17 µM of tomato polyphenols extract.

The main polyphenols in above mentioned extracts were quercetin (33.90±6.31 mg/kg in conventional extract; 17.92±10.9 mg/kg in organic extract), chlorogenic acid (3.52±0.74 mg/kg in conventional extract; 2.82±0.92 mg/kg in organic extract) and caffeic acid (3.61±0.71 mg/kg in conventional extract; 3.29±0.33 mg/kg in organic extract). Even if statistical differences were found between organic and conventional extracts in several target compounds, no difference in biological effect was observed in the cell model. Further researches are required to explain this mechanism of action.

Conclusions

As reported in literature data, there was no unidirectional trend of nutritional parameters towards organic or conventional product. In conclusion:

- the production system could affect the antioxidant content and so the food quality;
- the ripening stage could affect the bioactive molecule content;
- phenols, present in extract at high concentrations, could exert a pro-oxidant effect;
- modifications and alterations of monolayer, after phenolic extract exposition, could induce cellular damage by permeability cell changes.

Acknowledgments

This research was supported by MUR-FISR Simbio-Veg project (2005-08)

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The antioxidant compounds in rat experimental diets based on plant materials from organic, low-input and conventional agricultural systems

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Key words: rat feed, organic, conventional, low input, polyphenols

Abstract

Results presented in this paper are part of a study that investigates the effect of four production systems on health effects in rats. This study was aimed to evaluate differences in the levels of flavonols, total polyphenols, beta-carotene and lutein which are well known antioxidants in four rat feeds. Raw plant materials were produced according to four different agricultural systems: organic farming (without synthetic pesticides and mineral fertilizers), low-input 1 (organic plant protection was used in combination with mineral fertilizers), low input 2 (conventional pest management and organic fertilizers were used) and conventional farming (synthetic pesticides and mineral fertilizers were used). The results indicate that rat feed prepared from the organically produced plants contained more antioxidant compounds, especially total polyphenols, flavonols and lutein. Rat feed produced for feeding experiments varied significantly in a series of key phytochemicals and therefore have the potential to produce different health effects in the subsequent feeding trials.

Introduction

In opinion of many consumers organic farming may supply safer and healthier food products than conventional farming. There is quite a lot of evidence that organic plant products contain more vitamin C, polyphenols, iron, magnesium, phosphorus as well as less nitrates, nitrites and pesticides residues than conventional ones (Leclerc 1991, Rembiałkowska 2003). However, there are almost no papers about the composition of the processed organic foods and the presented experiment is the only one comparing the exact composition of the rat feed based on organic, low input and conventional crops. The analysed feeds are used in the experiment comparing the health parameters of rats; the results are published separately.

In 2006 a rat feeding trial was established at to assess the impact of four production systems and their two management components -fertility management and crop protection- on the general health and immune status in rats (Baranska et al 2007). Prerequisite for this trial is that food is supplied that varies in its properties depending on the management factors and that this variability is high enough to produce differences in the feeding experiment as well.

Several groups of plant metabolites are thought to contribute to the potential health effects of organic food. For instance polyphenols and especially flavonoids have a role in prevention of cardiovascular disease and carcinogenesis (Czeczot, 2000). Because organic production systems do not use synthetic pesticides plants have to rely on their own defense strategies against insects and pests. A common strategy is to produce more phytochemicals. Consequently, the use of organic agriculture may be a way to increase the phytochemical content of plant foods (National Organic Program 2004).

The aim of this study is to assess whether rat feed produced from grain and vegetables from four different management systems varied in key phytochemical that potentially affect health in the subsequent rat study.

Materials and methods

Barley, potatoes, carrots and onions were produced in the Nafferton factorial systems comparison (NFSC) at the University of Newcastle's Nafferton Experimental Farm, Northumberland, UK in 2006. Conventional crop protection was applied according to the British Farm Assured standards, and organic crop protection according to Soil Association organic farming standards. Under conventional fertility management mineral fertilizers are applied, and composted manure is used under organic fertility management. The combination of the two factors results in four factor combinations: organic fertility and crop protection management (OF-OP), organic fertility management and conventional crop protection (OF-CP), conventional fertility management and organic crop protection (CF-OP) and conventional fertility management and crop protection (CF-CP). Samples from these factors combinations (four replicates, n=16) were dried at moderate temperature in order to keep their nutritive value. Rat feed based on these materials was produced according to the nutritional recommendations for rat feeding trials. Compositional analysis of four above mentioned rat feeds were done in 2007 in the Division of Organic Foodstuff, Warsaw Agricultural University. They include: dry matter analysis by scale method (PN-91/R-87019), flavonols analysis by Christ – Müller methods described by Strzelecka et. al (1978), total polyphenols analysis by Folin – Ciocalteau colorimetric methods described by Singleton and Rossi (1965), beta-carotene and lutein analysis by liquid column chromatography described by Saniawski and Czapski (1983), antioxidant activity analysis by colorimetric method described by Re et al. (1999). The results of these qualitative characteristics of each of the different rat feeds were statistically evaluated using Statgraphics 5.1 program ANOVA.

Results and discussion

As shown in tab. 1, all examined rat feeds contained similar levels of dry matter and differences were not statistically significant. Organic vegetables often contained more dry matter then conventional ones (Rembialkowska 2003, Rembialkowska 2004). Obviously the preparation procedure of the feeds (drying, mixing, cooling, pelleting) reduced differences that might have been present previously.

Total polyphenols content of the rat feed varied considerably between the experimental treatments (Tab. 1). The highest level was observed in organic rat feed (OF-OP), and the lowest in conventional (CF-CP) rat feed. Feeds from low-input systems CF-OP and OF-CP have levels lower than the organic but higher than the conventional feed. Both the fertility management and crop protection as well as their interaction had an significant effect on the polyphenols status of the experimental diets. The low-input version with pesticides and without fertilizers contains slightly more polyphenols than that one with fertilizers. The lack of synthetic pesticides and mineral fertilizers seems to have stimulated the polyphenol production.

The total content of flavonol was the highest in the organic feed and the lowest in the CF-CP feed. Similar levels were observed in feeds from two low-input system (OF–CP, CP-OF). Both, fertility management and crop protection had an significant effect on the flavonol content of the feed. The results confirm a generally found tendency to higher flavonoids content in the organically produced plant materials (Rembialkowska 2004).

Tab. 1: The levels of: dry matter, polyphenols, flavonols, beta-carotene, lutein and antioxidant activity in rat feeds from four management systems

Parameter	Mean				ANOVA P-value		
	OF-OP	OF-CP	CF-OP	CF-CP	Main Effects		Inter-actions
					Fertilizer	Health	
Dry matter g/100g d.m.	90.02	89.85	89.66	89.95	0.76	0.56	0.29
Polyphenols mg/100g d.m.	2166.9	1575.6	1530.3	1137.8	< 0.0001	<0.0001	0.05
Flavonls mg/100g d.m.	3.39	3.00	2.97	2.31	0.03	0.02	0.55
Beta-carotene mg/100g d.m.	0.82	0.82	0.80	0.72	0.68	0.58	0.73
Lutein mg/100g d.m.	0.41	0.33	0.38	0.24	0.04	0.25	0.54
Antioxidant activity uM Trolox/1g.	28.59	28.06	28.16	27.71	0.07	0.13	0.91

There were no significant differences in beta-carotene concentration between the treatments.

Lutein was identified as an important carotenoid in the feeds. The highest level of lutein was found in organic rat feed (OF-OP) and the lowest level in the conventional one(CF-CP). The two other rat feeds were less abundant in this compound and similar in this respect (Tab. 1). Statistical analysis showed that the lutein content was only affected by the fertility management.

There were no significant differences in the antioxidant activities of rat feeds from the organic, conventional, and low-input cultivations.

The composite rat feed that contained barley, potatoes, carrots and onions produced in the four management systems contained significantly different levels of polyphenols, flavonols and lutein. Both, fertility management and crop protection caused these differences but fertility management seems to have a stronger impact. The results shown represent the second batch of rat feed used in the feeding trial and confirm trends observed in the first batch analysed (Rembialkowska et al 2007).

Conclusions

1) Rat feed produced for feeding experiments varied significantly in a series of key phytochemicals and therefore have the potential to produce different health effects in the subsequent feeding trials.

2) Rat feeds prepared from the organically produced plants contained more antioxidant compounds, especially flavonoids total polyphenols and lutein.

Acknowledgments

This study was supported by the EU project QualityLowInputFood FOOD-CT-2003-506358 and by the Polish Ministry of Science and Higher Education**.**

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Antioxidant Activity of Vegetables from Different Management Systems

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Key words: antioxidants, potato, escarole, tomato.

Abstract

In this paper we considered the relationship between organic farming and accumulation of functional metabolites with antioxidant activity. The level of these molecules, with high nutritional value, usually increases in response to various environmental stresses and, consequently, it may be higher in organic crops that are generally more exposed to environmental stressors compared to conventional crops. Here we provide evidence that organic farming may enhance the antioxidant capacity of 10-15 % in tomato and potato. We also demonstrate that the absence of mulching may cause a 15% increase of the antioxidant activity in organic escarole, indicating that different cultivation techniques may also affect the accumulation of these metabolites. Based on these results, we conclude that organically grown products may also be considered and marketed as potential functional foods.

Introduction

There is an increasing interest for organic foods, which are generally perceived by the consumers as healthier and environmentally safer than conventionally grown products. Nevertheless, substantial differences in terms of nutritional value of organic vs. conventional foods have never been proven (Bourn and Prescott, 2002). Although such differences may indeed be minimal or irrelevant for major nutritional components, many secondary metabolites with a recognized nutritional value may significantly change under both different cultivation regimes and various environmental stresses (Maggio et al., 2007a; 2007b). These molecules mostly include antioxidants and radical scavengers that have been shown to be involved in the prevention of several pathologies, including cardio-vascular disease and cancer. Considering that organically grown crops are more exposed to both biotic and abiotic stresses because of a reduced chemical control of the overall cultivation process, we hypothesized that organic crops may actually have a constitutively higher level of functional metabolites. By using a combination of different cultural techniques, here we demonstrate that organic farming may enhance the antioxidant capacity of escarole, tomatoes and potatoes. Consequently, these products will possess intrinsic functional properties that may confer an additional commercial value.

Materials and Methods

The research was carried out at the experimental fields of the University of Naples Federico II. The results presented in this communication refer to three independent experiments and report only the analysis on the antioxidant activity. Details on the experimental set-up for each species here considered can be found in Maggio et al.

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(2007b) and Paradiso et al. (2007a, 2007b). Briefly, for *ESCAROLE* (*Cichorium endivia* L.), organic (OF) and conventional farming (CF) were compared respect to 1) two soil types (Sandy and Clay); 2) presence/absence of PE mulching film and 3) three N levels (N0 = 0 Kg N ha^{-1}, N100 = 100 Kg N ha^{-1}, N200= 200 Kg ha^{-1}). In OF, nitrogen fertilization was accomplished by combining 3 organic fertilizers (A: N 4% and P_2O_5 4%; B: manure-based, N 3.1% and P_2O_5 3%; C: slow release, N 6%) all allowed by the EU regulation. The experimental design was a split-plot with 3 replications, with the soil type assigned to the main plots, the organic/conventional regimes assigned to the sub-plots, different N levels assigned to the sub-sub-plots and finally the presence/absence of mulching assigned to the elementary plots. For *TOMATO* (*Lycopersicon esculentum* Mill.), two hybrids for processing, *DRI 5390* (High Lycopene) and *Joy,* were compared in combination with three irrigation levels [replenishment of 100% EvapoTranspiration (ET) (W100), replenishment of 50% ET(W50); no-irrigation (W0)]. Pre-transplanting fertilization was accomplished with 150 kg ha^{-1} of N, 40 kg of P_2O_5 and 37 kg of K_2O, using a complex fertilizer (N:P:K 12:12:12) and ammonium nitrate (33% N) under CF, whereas in OF we used a mix of seeds meal, manure and hoof/horn meal (N 7%); a mix of organic humus (N 3%) and manure (N 12.5%). In the experiment with *POTATO* (*Solanum tuberosum* Mill.), two *cultivar,* Agria and Merit, were compared respect to two planting dates, April 8 (I) and May 19 (II) 2004. Fertilization (top-dressing) was accomplished with dried blood (N 14%) in OF and ammonium nitrate (N 34%) under CF. For both tomato and potato, the experimental design was a split-plot with three replications, in which the organic vs. conventional treatments were assigned to the main plots, whereas the combinations "cv x irrigation" (tomato) and "cv x planting date" (potato) were assigned to the sub-plots. For all three experiments, data were analyzed by ANOVA and means, when significant, were compared by the Least Significant Difference (LSD) test. The Lypophilic and Hydrophilic Antioxidant Activities of the commercial product were determined for escarole as described in De Pascale et al., (2001). The antioxidant activity of tomato and potato was assessed based on the auto-oxidation test described in Gasparoli et al. (1995) and was expressed as the tomato/potato extracts capacity, on a 0-1 scale, of inhibiting the oxidation of a soy oil sample (0=no oxidation inhibition; 1=complete inhibition of the oxidation process).

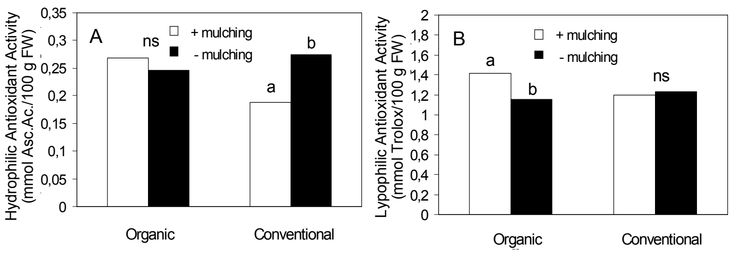
Results

As previously mentioned, in this report we will focus only on the antioxidant activity of the commercial product for the three different species and we refer to Maggio et al. (2007) and Paradiso et al. (2007a; 2007b) for yield results and treatment effects of different cultivation variables. *ESCAROLE:* In organic farming, plastic mulching did not significantly affect the hydrophilic antioxidant activity (Fig. 1A) whereas under conventional farming, the hydrophilic antioxidant activity was reduced of 30% in absence of mulching. An opposite response was observed for the Lypophilic antioxidant activity (Fig. 1B). The absence of mulching caused a 15% increase of the antioxidant activity in organic regime, whereas no differences were observed under conventional farming. *TOMATO:* The average antioxidant activity was higher in organic farming (+10% compared to conventional tomatoes) and for the DRI 5390 hybrid with high lycopene (+20% compared to *Joy*) (data not shown). Specifically, the two hybrids had a different response to the irrigation treatment (Fig. 2). While the antioxidant activity was not affected in DRI 5390, either by the cultivation regime or the water availability, the cultivar *Joy* revealed a relatively higher antioxidant activity in organic farming with a slight decay at 100% replenishment of the ET (max water availability). *POTATO:* The antioxidant activity in potato tubers had a remarkable variability from the outer to the inner tuber portions (Fig. 3). A significantly higher activity was observed for both cultivars grown under organic regime only in the cortical region (CR), at the first planting date (Fig. 3A, top panel). Whereas the cultivar Merit grown in organic farming had a significantly increase of the antioxidant capacity of the inner tuber region (IR) at both planting dates (Fig. 3A, bottom panel).

Discussion and conclusions

For all the species considered in this work, we observed a positive effect of organic farming on the antioxidant capacity of the commercial products. Indeed, organic farming affected the antioxidant properties of escarole, tomato and potato, indicating that this cultivation regime may in some respect increase the nutritional value of these products. This response was often associated to other variables such as the presence of mulching for escarole (Fig. 1), a cultivar effect in tomato (Fig. 2) or some specificity of the commercial plant organ as we observed in potato (Fig. 3), suggesting that there are margins to identify specific cultivation protocols that may cause a targeted accumulation of functional metabolites in the commercial product. It is worth pointing out that, in the literature, the accumulation of antioxidant molecules has been reported to be associated to diverse stress responses. In this respect, organic farming may partially activate stress adaptation mechanisms and, consequently, it may *constitutively* increase the level of these molecule. Some peculiarities specific to the cultivation procedures exist, however. For example the Hydrophilic antioxidant activity decreased in non-mulched conventional escarole, whereas the Lypophilic antioxidant activity increased in non-mulched organic escarole. These results suggest that the two cultivation systems may have initiated the synthesis (or inhibited the degradation) of different antioxidant pools that likely respond to different environmental stimuli (De Pascale et al., 2001). Improving our knowledge on the physiological mechanisms that mediate the accumulation of these molecules is therefore critical to identify cultivation protocols that may enhance the accumulation of these high nutritional value compounds. Organic farming seems to *predispose* crops to synthesize these functional metabolites. Therefore organic products may also be considered and marketed as *natural functional foods*.

Figure 1: Hydrophilic Antioxidant Activity (A) and Lypophilic Antioxidant Activity (B) in escarole leaves (within each cultivation regime, different letters indicate significant differences at P< 0.05).



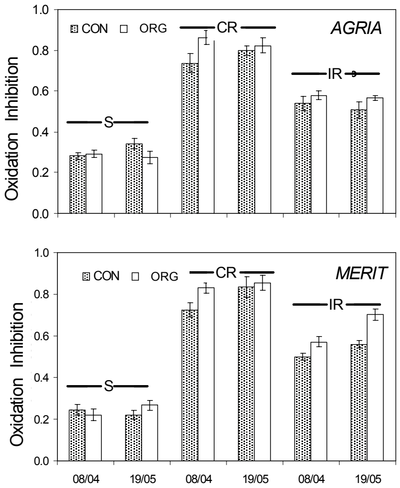


Figure 3: Antioxidant activity in potato. S= tuber Skin; CR= tuber Cortical Region; IR= tuber Inner Region (Values are means ± SE).

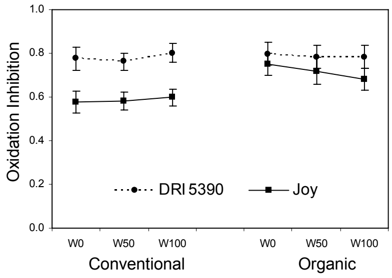


Figure. 2: Antioxidant Activity of tomatoes in response to cultivation regime and irrigation level (Values are mean ± SE).

Acknowledgments

This research was partially funded by Centro Regionale di Competenza Produzioni Agroalimentari (Regione Campania) and by CRAA (Regione Campania).

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The impact of medium term feeding diets from four management systems on body composition and plasma corticosterone concentration in male rats

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Key words: bioactive compounds, conventional diet, corticosterone, low input diet, organic diet

Abstract

The aim of the study was to analyse the influence of feed from different production systems (organic, conventional and two low input systems) on food intake, body chemical composition and plasma corticosterone (Cs) concentrations in rats. The experiment was conducted in 104 Wistar male rats divided into 4 dietary experimental diets (OF-OP, OF-CP, CF-OP and CF-CP, each in four replicates) and one control group consuming feed ad libitum for three months. Plasma Cs levels by RIA, body composition by standard chemical methods and body weight gain were determined.

Results show statistically significant lower plasma Cs concentrations in rats fed on CF-CP (P<0.05) and standard (P<0.001) diets. Body chemical composition also varied depending on the fertility management of the crops used for the rat feed.

Introduction

Corticosterone is the major natural glucocorticoid in rodents. Glucocorticoids (GCs) are stress hormones that modulate a large number of physiological actions involved in metabolic, inflammatory, cardiovascular and behavioral processes. GCs predominantly affect the metabolism of carbohydrates, fats and proteins and have other effects on organism functions (Simson & Walker, 2007). GCs also modulate inflammatory cell survival, a process important for the successful resolution of inflammation (McColl et al., 2007).

The hypothesis is that consuming diets based on crops from four different production systems that contain different levels of bioactive compounds affects GCs secretion and thus metabolism regulation, as well as body weight gain and body composition in model animals. Therefore, the aim of the study was to analyse the influence of feed from different production systems (organic, conventional and two low input systems) on body composition and plasma corticosterone concentrations in rats.

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Materials and methods

Barley, potatoes, carrots and onions were produced in the Nafferton factorial systems comparison (NFSC) at the University of Newcastle's Nafferton Experimental Farm, Northumberland, UK in 2006. Conventional crop protection was applied according to the British Farm Assured standards, and organic crop protection according to Soil Association organic farming standards. Under conventional fertility management mineral fertilizers are applied, and composted manure is used under organic fertility management. The combination of the two factors results in four factor combinations (management systems): organic fertility and crop protection management (OF-OP), organic fertility management and conventional crop protection (OF-CP), conventional fertility management and organic crop protection (CF-OP) and conventional fertility management and crop protection (CF-CP). Samples from these factors combinations (four replicates, n=16) were dried at moderate temperature in order to keep their nutritive value. Rat feed based on these materials was produced according to the nutritional recommendations for rat feeding trials. Analysis of the rat feed confirmed that it contained significantly differed level of key phytochemicals (see Rembiałkowska et al 2007). One animal group was fed with standard feed for breeding laboratory animals – Labofeed H (Andrzej Morawski Feed Production Plant, Kcynia near Bydgoszcz, Poland). At the beginning of the experiment 32 female and 16 male Wistar rats were fed on experimental diets (two females and one male on each diet) for two weeks before mating and during pregnancy and lactation period (8 weeks together). Two females and one male were fed on Labofeed H. Six male pubs from each familiar group (96 animals) were selected for the subsequent experiment at weaning. The animals were kept in individual polycarbonate cages in steady environmental conditions for three months. They were given free access to food and water throughout the study. Throughout the experiment, all rats were weighed every week and consumption of experimental diets was controlled daily. All procedures were approved by the Local Animal Care and Use Committee in Warsaw. At the end of the experiment, blood was sampled from the heart. Carcasses and plasma were stored at – 23^{o}C for subsequent analyses. Corticosterone analysis was performed using Rat Corticosterone RIA Kit (Diagnostic Systems Laboratories, Inc). After autoclavation and homogenization, the percentage of water, ash, protein and fat in carcasses were determined by standard analytical methods (AOAC, 1960). Data was analysed by multi-factor analysis of variance (ANOVA) with crop protection and fertility management as a discriminating factors followed by the Fisher's least significant difference post-hoc test and by the linear regression method. A difference with $p \leq 0.05$ was considered as significant. All statistical analyses were performed with the computer program STATGRAPHICS®Plus 4.0.

Results

The final body weight was significantly influenced by the fertility management (ANOVA, P= 0.004) which resulted in a higher body weight in rats that had organically fertilised diets (OF-OP and OF-CP). Also, the body weight of rats fed with Labofeed H was considerably lower (Table 1). Body dry matter contents in rats fed on Labofeed H were considerably lower than in animals fed with any of the experimental diets (P<0.01; Fisher t-test), but no significant differences between the experimental groups were observed (Table 1). Among the carcass composition parameters only the protein content with slightly higher values in the OF groups was significantly influenced by the fertiliser used to produce the samples.

Plasma CS concentrations were significantly higher in animals fed on experimental diets compared to rats fed on Labofeed H (*P*<0.01, Fisher t-test) (Fig. 1). Lower plasma Cs concentrations were found In rats consuming the conventional (CF-CP) diet, but neither of the experimental factors had an significant effect when data were analysed by ANOVA.

Tab. 1: Chemical body composition (%) and final body weight (g) in rats fed on experimental diets over 3 months

Dietary group	Fat (Mean ± SE)	Dry matter (Mean ± SE)	Ash (Mean ± SE)	Protein (Mean ± SE)	Final body weight (Mean ± SE)
OF-OP	21,94±0,16	16,27±0,59	41,66±0,44	3,59±0,04	367,5±7,36
OF-CP	22,03±0,13	14,69±0,54	40,71±0,40	3,60±0,04	391,5±6,22
CF-OP	21,38±0,25	15,40±0,61	40,36±0,75	3,54±0,04	349,1±11,1
CF-CP	21,71±0,15	16,12±0,60	41,29±0,32	3,49±0,03	374,4±4,04
Labofeed	22,54±0,10	8,14±0,34	35,94±0,45	3,66±0,07	286,3±8,90

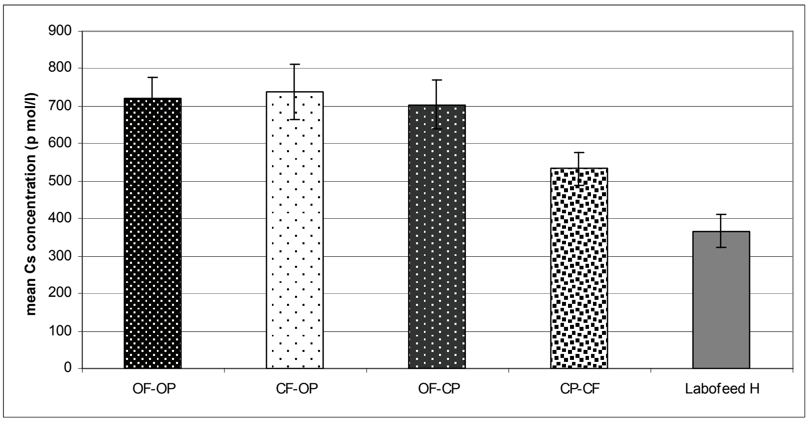

Figure 1: Plasma corticosterone concentraction in rats fed on feed from different production systems and laboratory animals pellets Labofeed H over 3 months (mean ± SE)

Discussion

The hypothesis of this paper was that consuming diets based on organically grown plants that contain more bioactive compounds might affect GCs secretion and thus metabolism regulation, as well as body weight gain and body composition in rats. Obtained results showed considerably lower plasma Cs concentration in rats raised on feeds made from conventionally produced crops (CF-CP diet) compared to rats raised on diets made from crops produced in organic and ‘low input’ systems. However, when ANOVA was used to test for the effect of crop protection and fertilization systems on Cs plasma level no significant effect could be detected. In a short-time feeding trial with male rats (Królikowski, in preparation) we found a similar pattern of higher Cs levels in rats fed on organic feed in comparison with those fed with feed from conventional production system. As was stated by other authors, certain bioactive dietary compounds alter Cs secretion and HPA (hypothalamus-pituitary-adrenal) axis activity with decreasing of plasma Cs concentration (Butterweck et al., 2004). On the other hand this effect seems to be dependent not only on the chemical nature of these compounds, but also on their dose and the duration of an organism's exposure (Ziołkowska et al., 2006). Butterweck et al. (2004) gave flavonoids at different concentrations to rats for a period of two weeks and observed down-regulated circulating plasma levels of ACTH and Cs by 40 - 70 %. However, none of the tested compounds had a significant effect on plasma ACTH and Cs levels after chronic treatment (given daily for 8 weeks). After 10 weeks in our study moderate effects of the different composition of the experimental diets on the Cs levels were detected. To summarize, although the intake of several bioactive compounds was significantly influenced by the fertilizer type and crop protection, the Cs concentration in rat's plasma showed only moderate, non-significant effects.

Conclusions

There is some evidence that differences in the chemical composition of rat feed that was produced under four production systems were reflected in the body weight, protein content and plasma corticosterone (Cs) concentrations in rats.

Acknowledgments

This study was supported by the EU project QualityLowInputFood FOOD-CT-2003-506358.

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Influence of fertilisation on furanocoumarins content in two celeriac varieties

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Key words: celeriac, fertilisation system, furanocoumarins, food safety, anaerobically fermented pig slurry

Abstract

The aim of this study was to investigate the effect of the way of celeriac cultivation on the content of naturally occurring toxicants - furanocoumarins. Their levels have been shown to be strongly affected by an individual variety and also fertilization method. Organic farming using anaerobically fermented pig slurry was compared with mineral, combined, and non-fertilized farming. The climatic conditions in particular crop years play an important role in the furanocoumarins occurrence.

Introduction

Besides of various biologically active constituents such as vitamins and phenolic antioxidants, many cultivated plants contain specific secondary metabolites which are classified as toxicants or antinutrients in humans and/or farm animals. Risk associated with an occurrence of natural toxicant in human diet is of growing concern both to scientists and regulators.

Furanocoumarins are natural toxic chemicals occurring in edible food plants such as celery, parsnip, parsley, carrot etc. belonging to the *Apiaceae* family, lower levels of these phytochemicals are also contained in citrus fruits and other crops representing the *Rutaceae* family (Søborg, 1996). Since their presence in human diet represents food safety issue of concern, more knowledge is needed to reduce consumers´ exposure. More than 50 plant furanocoumarins are known at present (Søborg, 1996), considering their chemical structure, two subgroups can be recognised. The first one involves linear furanocoumarins - psoralen, bergapten, xanthotoxin, trioxsalen, isopimpinellin and bergamottin etc.; the second one is represented by angular furanocoumarins such as angelicin, pimpinellin, sphondin, isobergapten etc. Typical levels of furanocoumarins in root vegetable are in celeriac 4 - 40 mg/kg, in parsnip 3 - 60 mg/kg and in carrot <0.004 - 2 mg/kg. Concentrations as high as 45 mg/kg, 145 mg/kg and 112 mg/kg were found in celery, parsnip and parsley, respectively (Schulzova, 2007). Furanocoumarins are phototoxic compounds, yielding reactive intermediates under UV light irradiation, formation of adducts with DNA can take place (Llano, 2003; Søborg, 1996). In addition, mutagenic and carcinogenic effects have been demonstrated in experimental animals when exposed to high doses of furanocoumarins. The lowest observed adverse effect level (LOAEL) was estimated in the range 0.14 – 0.38 mg/kg body weight. The only information on the average daily

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dietary intake of phototoxic furanocoumarins from vegetables was provided by Nordic group who estimated it 0.5 mg/kg body weight (Søborg, 1996). In any case, dietary furanocoumarins should be considered as potentially health risk for consumers´, therefore their intake should be minimised.

Organic farming represents an alternative way of agriculture replacing conventional mineral fertilizing methods by organic fertilizers. Anaerobically fermented pig slurry as a fermentation residue of biogas plants can be used for vegetables fertilization as an optimal replacement of industrial mineral fertilizers. Because furanocumarins occurs as a result of the plant stress, their level could be different in organic and conventional farming methods. One example of stress conditions is lack of water and/or nutritional deficit during the growing.

Materials and methods

Celeriac samples (*Apium graveolens rapaceum*) were obtained from field trials managed by Czech University of Life Sciences Prague in years 2005 and 2006. Two varieties of celeriac Albin (A) and Kompakt (K) were examined. Plants were grown from pre-plant seedlings either of variety was grown in each variants of farming in four repetitions (farming sites 0.5 x 0.4 m) on sandy loam brown soil. No pesticide treatment was used. Representative samples consisting of 8 bulbs were taken for the analysis.

The fertilization regimes employed in this experiment were as follows:

N - control farming (not fertilized with mineral and/or organic fertilizers)

O - organic farming (9.1 L m^{-2} of anaerobically fermented pig slurry before planting and 9.1 L m^{-2} 43 days after planting). It represents 10 g of nitrogen, 4.5 g of phosphorous and 18 g of potassium per m^2.

M - mineral farming (22.7 g m^{-2} of ammonium sulphate, 52 g m^{-2} of superphosphate and 4.8 g m^{-2} of potassium chloride before planting and 22,7 g m^{-2} of ammonium sulphate 43 after planting). It represents 10 g of nitrogen, 4.2 g of phosphorous and 2.4 g of potassium per m^2.

C - combined (50% of organic and 50% of mineral way) farming (4.5 L m^{-2} of anaerobically fermented pig slurry, 11.4 g m^{-2} of ammonium sulphate, 26 g m^{-2} of superphosphate and 2.4 g m^{-2} of potassium chloride before planting and 4.5 $L.m^{-2}$ of anaerobically fermented pig slurry and 11.4 g m^{-2} of superphosphate 43 days after planting)

Applied anaerobically fermented pig slurry had this composition: 595 mg L^{-1} of nitrogen in ammonia form, 755 mg L^{-1} of phosphates, 1.10 - 1.25 g L^{-1} of potassium oxide.

Gas chromatography coupled with mass spectrometry (GC/MS) operated in an electron impact ionisation mode was employed for determination of furanocoumarins in ethyl acetate extract of celeriac. Furanocoumarins were separated on capillary column DB-5MS (60m x 0.25mm x 0.25µm). Quantification (selected ion monitoring) was achieved by comparing peak areas of the target analytes with the corresponding standard calibration plot. Detection limits (LODs) of angelicin, psoralen, bergapten, xanthotoxin, trioxsalen, isopimpinellin, sphondin, pimpinellin and isobergapten obtained by this analytical method were in the range 0.01-0.08 µg g^{-1}, recovery 89-97 % (spiking level 10 mg/kg), the repeatability of measurements expressed as relative standard deviation was in the range 3.9 - 4.7 % (for detail information see Peroutka, 2007).

Results and discussion

While in all analysed celeriac samples the presence of linear furanocoumarins psoralen, bergapten, xanthotoxin and isopimpinellin was documented, none of angular furanocoumarins (angelicin, sphondin, isobergapten) and linear trioxalen was detected. The total furanocoumarins content was relatively low, corresponding with literature data. Higher levels (approximately 2 times) were found in celeriac harvested in 2006 (2.4 – 23.5 mg/kg) compared to 2005 (1.7-13.0 mg/kg). Maximum furanocoumarins content was found in variety Kompakt grown in combined farming system (Figure 1).

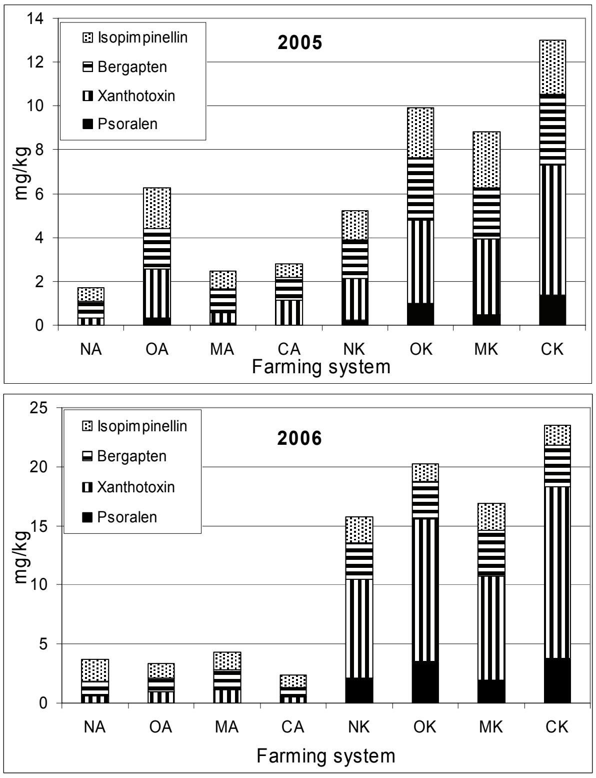

Figure 1: Content of furanocoumarins in two celeriac varieties grown in four farming systems in crop years 2005 and 2006 (mg/kg fresh weight) (A - Albin , K - Kompakt , N - control, O – organic, M – mineral, C - combined)

In 2005 mean furanocoumarin levels were 3.3 mg/kg for variety Albin and 9.3 for variety Kompakt. Next year, the levels were (2006) 3.5 mg/kg for Albin and 19.1 mg/kg for Kompakt. Total furanocoumarins content was significantly lower (t-test, $\alpha=0.05$) in variety Albin (3 times in crop year 2005 and 5 times in crop year 2006). The average temperature in crop year 2006 was higher than in 2005. Rainfall was higher in 2005. Variety Albin was more resistant for climatic changes between individual crop years.

It should be noted mechanical injury or any other stress factors cause large increase of furanocoumarin levels. Interestingly this effect is more pronounced in conventional farming crops (Schulzova, 2002).

Conclusions

Differences between celeriac varieties in inherent furanocoumarin levels were shown in our study. Inter annual variation is mainly due to climatic conditions in particular crop year. The average levels of furanocoumarins determined in hardy fresh celeriac roots were 8.8 mg/kg, ranging from 1.7 to 23.5 mg/kg. Content of targeted toxicants was relatively low and obviously do not present health risk for consumers.

Anaerobically fermented pig slurry, organic fertilizer with high fertilization efficiency, is a good alternative to mineral fertilization in terms of certain agricultural parameters such as crop yield. However the distinct impact on furanocoumarin levels was not found i.e. no significant relationships between the levels of monitored toxic compounds and the way of fertilization were observed.

Follow up experiments have been initiated since only long term studies may provide information needed for unambiguous assessment of the influence of farming practices on furanocoumarin levels in particular celeriac variety and other similar vegetable. Field experiments have been running also in 2007.

Acknowledgments

This study was carried out with support from the Ministry of Education, Youth and Sports, Czech Republic - partly from the project MSM 6046137305, partly within the project COST OC 924.

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Workshops of the 4th QLIF Congress

In conjunction with the 2nd ISOFAR Conference, the Integrated European Project 'Quality Low Input Food'[1] (QLIF, www.qlif.org)1 conducted their 4th congress.

In addition to presentations in the ISOFAR program, QLIF offered a series of workshops that summarized the results and data gained during the first four years of the project. Workshop themes were: product quality; safety of foods; crop productivity; livestock productivity and resource efficiency.

The full papers of the workshops, finalized after the congress in order to include the workshop results, will be made available at QLIF homepage www.qlif.org and the Organic Eprints Archive at www.orgprints.org/view/projects/int-conf-2008-qlif4.html.

[1] The Integrated Project 'Quality Low Input Food' aims to improve quality, ensure safety and reduce cost along the organic and ,low input' food supply chains through research, dissemination, and training activities. The project focuses on increasing value to both consumers and producers using a farm to fork approach. The project is funded by the European Union and will be running from 2004 to 2009. The research involves 35 research institutions, companies and universities throughout Europe and beyond.

QLIF Workshop 1: Product quality in organic and low input farming systems[1]

Lueck, L.[2], Brandt, K.[2], Seal, C.[2], Rembialkowska, E.[3], Huber, M.[4], Butler, B.[2], Bennett, R.[5], Oughton, L.[2], Nicholas, P.[6], Kretzschmar, U.[7], Sundrum, A.[8] and Leifert, C.[2]

Key words: quality, crops, livestock, primary production, processing

Abstract

There is increasing evidence for organic and 'low input' farming practices resulting in an improved nutritional composition of foods. QLIF workshop 1 will critically evaluate the current scientific knowledge about relative nutritional composition of foods from organic and conventional production systems and the agronomic and processing factors affecting food quality. A summary of major QLIF results and recent literature reviews on the topic is provided in this paper.

Introduction

The intensification of agricultural production in the last century has resulted in loss of biodiversity, environmental problems and associated societal costs (Niggli & Leifert 2007; Cooper et al. 2007). Agronomic changes introduced during the intensification of agricultural production were also suspected to have caused with negative effects on food quality. However, until recently there was very little quantitative information to underpin this hypothesis (Cooper et al. 2007). Over the last 10 years a wide range of studies have compared the composition of foods from intensive and organic/'low input' systems and several recent literature reviews concluded that there are higher levels of nutritionally desirable compounds (e.g. vitamins, antioxidants, polyunsaturated fatty acids) and lower levels of undesirable compound (e.g. pesticides, growth regulators) in foods from organic and 'low input' production systems compared to food from conventional systems (Cooper et al. 2007; Brandt 2007; Benbrook et al. 2008).

Also the increasing demand and current price premiums achieved by foods from 'low input' and especially organic production systems were shown to be closely linked to consumer perceptions about nutritional and health benefits of such foods.

However, the exact reasons for these differences in food composition are poorly understood. The QLIF project (www.qlif.org) therefore carried out factorial field experiments and surveys to identify the effect of individual production system

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[1] The full version of this paper is available at www.orgprints.org/13376

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components (e.g. animal and crop genetics, nutrition, health management and husbandry) on food composition. It also carried out pilot dietary intervention studies to test the effect of organic food consumption on immune system, behaviour and hormonal regulation using experimental rat models.

Quality of Foods from organic livestock systems

A major focus of livestock production under QLIF was to study the effect of (a) dairy genotype/breed, (b) husbandry methods and especially feeding regimes on milk composition. They demonstrated that milk from organic and 'low input' production systems contained higher levels of nutritionally desirable unsaturated fatty acids (e.g. omega 3, CLA) and antioxidants (α-tocopherol, β-carotene, lutein and zeaxanthine) than milk from intensive conventional dairy production systems. In other studies the levels of nutritionally desirable fatty acids and fat soluble vitamins and/or the sensory quality of organic meat and egg quality parameters were also reported to be higher than (Hirt et al. 2007; Sundrum 2007). The improved nutritional composition of meat, milk and eggs was often linked to outdoor grazing based husbandry and high forage feeding regimes in the case of dairy cows and/or the use of more robust and/or slower growing livestock genotypes in the case of poultry (Hirt et al. 2007; Butler et al. 2008). Surveys also showed that levels of antibiotic use in organic and 'low input' dairy cow herds were significantly lower than those of conventional high input herds (Hoyle et al. 2004; Cooper et al 2007).

Standard processing practices (e.g. pasteurisation of milk; cheese and yogurt making processes, standard slaughter and meat conservation practices) appear to have limited effects on relevant parameters (e.g. fat composition, fat soluble vitamin content) between organic and conventionally systems (e.g. Bergamo et al. 2003).

The introduction of strategies to improve product quality (e.g. the introducing of grazing based feeding regimes is also likely to reduce farm costs in many regions of the EU, especially given the rapidly rising costs of concentrate feeds, but economic analyses under QLIF are still ongoing.

Crop production systems

QLIF crop production focused studies focused mainly on the effect of **(a)** fertilisation regimes (type and level of mineral NPK fertilisers and/or animal and green manures used), **(b)** crop rotation design and **(c)** crop protection protocols (type and level of chemosynthetic pesticides and other crop protection methods) on a range of nutritionally desirable secondary plant metabolites (e.g. vitamins, antioxidants, proteins, phenolics, glycosinolates, vitamins). To a lesser extent the effect of **(d)** crop genotype/variety, **(e)** rootstock type and **(f)** ripening stage at harvest was also investigated in selected commodities (e.g. tomato).

In selected commodities (e.g. wheat and potato) metabolic profiling was supplemented with protein and gene profiling. These profiling studies showed that plant metabolism is affected most by variety choice and fertility management, while rotations position and crop protection have less of an effect in most crops. Where the effect of agronomic methods on total antioxidant activity (e.g. tomato) was compared in soil (as opposed to synthetic growth media), variety and/or rootstock choice and specific organic matter based fertilisation regimes significantly increased antioxidant activity. In addition, the ripening stage at harvest and the age of the tomato plant at harvest had a significant effect on tomato quality, indicating that harvesting immature fruit and the use of long season tomato production systems reduce the antioxidant content of tomato. These studies clearly indicated that organic soil based and short season tomato production protocols, and the use of short supply chains, which allow the delivery of fully ripe fruit to local markets, will increase antioxidant levels in tomato.

For most other crops a range of specific secondary metabolite groups associated with potential beneficial health effects were monitored under QLIF and field trials and analyses are still ongoing. However, studies from the first 3 seasons indicate that while there is often a trend for more of the nutritionally desirable secondary metabolites to be found at higher levels when organic fertilisation regimes and/or crop protection regimes were applied, some compounds were unaffected and some were increased when conventional fertilisation and/or crop protection regimes were applied (Niggli & Leifert 2007). Recent literature reviews (e.g. Brandt 2007; Benbrook et al. 2008) reported higher levels of nutritionally desirable compounds in organic crops when compared to conventional crops, but were mainly based on research papers, which focused on individual or small numbers of commodities and secondary metabolites. The more differentiated set of results from the QLIF project are therefore likely to make it more challenging to interpret the existing comparative crop composition data with respect to both **(a)** agronomic recommendations with respect to further improving crop quality and **(b)** potential beneficial impacts of secondary metabolite profiles in organic foods on human health.

Conclusions

The generally beneficial impact of extensive organic production protocols on livestock foods (meat, milk and eggs) composition is becoming increasingly clear and the first studies showing positive health impacts of organic milk consumption have recently been published (Rist et al. 2008; Kummeling et al 2008).

A more differentiated picture has emerged for crop foods, with **(a)** an overall trend for higher levels of nutritionally desirable compounds being detected in organic compared to conventional foods being confirmed by most studies, but **(b)** certain agronomic practices (e.g. netting to protect crops against pests) being linked to negative effects on specific groups of secondary metabolites. Recently published dietary intervention study indicated increased immunological responsiveness and robustness in chicken raised on organic diets based on a mixture of grains and legumes (Huber 2007) and effects on body weight and the immune system in rats and mice raised on organic feed stuff (Lauridsen 2007, Finamore 2004). These studies indicate positive trends of organic food consumption and should be explored further in the future.

Quality expectations of consumers always radiate around four central concepts **(a)** taste (and other sensory characteristics), **(b)** health, **(c)** convenience, and for some consumers **(d)** process characteristics (e.g. organic production, natural production, animal welfare, GMO-free) (Grunert 2005).To what extent improvements in food composition satisfy consumer preferences and hence their willingness to pay for that improved quality is currently being studied under QLIF. Alignments may be needed between consumer expectations and quality improvements to achieve the maximum socio-economic benefits. Alignment could be influenced by governmental policy, marketing strategies and consumer education.

Acknowledgments

The authors gratefully acknowledge funding from the European Community financial participation under the Sixth Framework Programme for Research, Technological Development and Demonstration Activities, for the Integrated Project QUALITYLOWINPUTFOOD, FP6-FOOD-CT-2003- 506358.

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QLIF Workshop 2: Safety of foods from organic and low input farming systems[1]

Leifert, C.[2], Köpke, U.[3], Bonde, M.[4], Stanley, R.[5], Hamm, U.[6], Wyss, G.[7], Ölmez, H.[8], Benbrook, C.[9], Hajslova, J.[10], Lueck, L.[2] & Cooper, J.[2]

Key words: food pathogens, mycotoxins, heavy metals, pesticides, antibiotics, growth regulators.

Abstract

A range of food safety issues have been raise with respect to organic primary production and processing. These include concerns about enteric pathogen, mycotoxin and heavy metal and agrochemical residues. QLIF workshop 2 will critically evaluate the current scientific knowledge about relative food safety risks in organic and conventional production systems and the agronomic and processing factors affecting contamination levels in foods. A summary of major QLIF results and the recent literature reviews is provided in this paper.

Introduction

Important food safety issues relating to primary food production include contamination with **(a)** enteric pathogens, **(b)** mycotoxins, **(c)** heavy metal and **(d)** agrochemical residues (especially pesticides, plant growth regulators, antibiotics and other veterinary medicines).

It is widely accepted that agrochemical residues are absent or significantly lower in foods from organic production systems. However, it has been hypothesised by some scientists that **(a)** the risks of enteric pathogen and heavy metal contamination is higher for organic foods (because of the more widespread use of organic fertilisers) and **(b)** organic foods contain higher levels of mycotoxins than conventional foods (Avery 1998; Trewavas 2001). Several work packages of the QLIF project investigated the effect of agronomic practices used in organic, low input and conventional systems on these four main food safety issues.

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Enteric pathogens

For enteric pathogens (where studies focused on pathogen shedding in pigs and enteric pathogen transfer from organic fertilisers onto lettuce) no difference in risk between organic and conventional systems could be detected, as long as farmers complied with “good agricultural practice” standards for manure use. Based on QLIF and other results, a HACCP-based quality assurance scheme for organic and ‘low input’ systems was developed to provide guidelines for producers allowing food safety risks to be further minimised (Köpke et al. 2007a; Leifert et al. 2008). The scheme is based on 6 main **risk reduction point** (**RRPs**).

At **RRP1** (livestock production system) the focus should be on animal health and husbandry methods that reduce pathogen levels in animal faeces and manure. For example WP2.2.2 of QLIF has clearly shown that outdoor pig production significantly reduces *Salmonella* shedding at slaughter. However, it also showed that the transport time for pigs from organic and low input outdoor systems is longer than that of intensively indoor reared pigs, due to the smaller number of abattoirs processing pigs from low input systems. Since enteric pathogen shedding is known to increase pathogen shedding in pigs due to the stress associated with transport, further improvements can be made. Outdoor livestock management (**RRP2**) can be optimized to eliminate the risk of faecal material entering irrigation water (Leifert et al. 2008).

Manure storage and processing is another important risk reduction point (**RRP3**). For example WP4.4 confirmed that the risk of using non-composted raw manure increases the enteric pathogen transfer risk, while the use of composted manure was not significantly different to that of mineral fertilisers. Soil management practices (**RRP4**), and timing of manure application (**RRP5**), can also be adjusted to reduce the survival of pathogens originating from manure. During irrigation (**RRP6**) pathogen risks can be reduced by choosing a clean water source and minimizing the chances of faecal material splashing the growing crop (Leifert et al. 2008).

A HACCP-based quality assurance manual to minimise enteric pathogen contamination in organic and low input production systems is currently being developed under WP6.2 under QLIF.

Mycotoxins

For mycotoxins (where QLIF studies focused on wheat, the main European food crop in which mycotoxins are an issue) no major differences in risk between organic, low input and conventional production systems could be detected. In 6 out of seven trials levels of *Fusarium* mycotoxins were similar under organic and conventional management and in 2005 levels were significantly higher in conventional than organic systems. A meta-analyses of the available literature showed that *Fusarium* mycotoxin levels tend to be higher under conventional compared to organic management (Brandt et al. in preparation). Several management practices that are exclusively or mainly used in conventional farming (e.g. maize and wheat as a pre-crop, minimum tillage, high mineral nitrogen inputs and certain fungicides) were shown to increase mycotoxin contamination in both wheat and maize. Where such practices are introduced into organic systems (e.g. 2nd wheat crops and late slurry applications increasingly used in organic arable rotations in the UK) the risk of mycotoxin contamination risk is also likely to increase. Guidelines for the minimisation of mycotoxin contamination in organic systems were produced as part of the QLIF Project (Köpke et al. 2007b). A HACCP-based quality assurance manual to minimise mycotoxin contamination in organic and low input cereals production is currently being developed under WP6.2 under QLIF.

Heavy metals

For heavy metals (which were studied in a wide range of crops under QLIF) no major differences could be detected between organic and conventional systems and no specific WPs therefore focused on reducing heavy metal loads in 'low input' farming. However, the long term impacts of high manure inputs on heavy metal balances should be further investigated in the future.

Antibiotics and veterinary medicine use

For antibiotic use QLIF studies (WPs 2.2.1 and 4.5) focused on dairy production systems, where >60% of antibiotics are used in organic systems. Organic and 'low input' grazing based cattle production systems were shown to be associated with **(a)** significantly lower levels of antibiotic use and **(b)** lower levels of antibiotic resistant faecal *E. coli* in calves than intensive conventional systems under QLIF WP2.2.1. Guidelines to further reduce antibiotic and other veterinary medicine use in organic and low input systems were also developed (Klocke et al. 2007, Maurer et al 2007, Biavati et al 2007)

Pesticides and plant growth regulators

The prohibition of chemosynthetic pesticide use under organic crop production standards has been shown in a range of scientific studies to result in no or lower residue levels in organic foods compared to conventional foods (Baker et al. 2002). Low input farming systems which minimise agrochemical inputs were also shown to result in reduced pesticide residues compared to intensive conventional production. This was confirmed by the residue analyses carried out as part of the QLIF project (Lueck et al 2007). However, in certain commodities (e.g. cereals) fertility management practices were shown to affect chemical residue levels. For example, when the same pesticide spraying regime was used, levels of the plant growth regulator CCC were 3 times higher (and close to the permitted maximum residue levels) in a 'low mineral fertiliser input' conventional system than in a standard 'high input' conventional system (3rd annual QLIF-report, unpublished). This indicates that certain pesticide safety issues may arise when farmers switch to organic matter based fertilisation regimes without reducing pesticide input levels.

Conclusions

Overall it can be concluded that there is no evidence that organic and 'low input' production systems pose higher food safety risks than food from conventional systems as claimed in articles by Avery and Trewevas (Avery 1998; Trewavas 2001). In fact agronomic practices used in organic farming were shown repeatedly to reduce risks associated with agrochemical and veterinary medicine, mycotoxin residues and the development of antibiotic resistant pathogenic microorganisms in food. However, it is important to stress that risks can never be excluded 100% at the primary production stage. For example, for poultry meat microbiological safety relies on control measures during processing (heat treatment during cooking), since the complete absence of pathogens such as Campylobacter cannot be assured during primary production, especially under outdoor conditions. It is therefore essential to establish efficient food safety focused quality assurance protocols for both primary production and processing of organic and low input foods (Leifert et al. 2008). This objective will be addressed under the ongoing WP6.2 of QLIF which focuses on the development of improved HACCP based food safety and quality assurance manuals and training programmes.

Acknowledgments

The authors gratefully acknowledge funding from the European Community financial participation under the Sixth Framework Programme for Research, Technological Development and Demonstration Activities, for the Integrated Project QUALITYLOWINPUTFOOD,FP6-FOOD-CT-2003- 506358.

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QLIF Workshop 3: Performance of Organic and Low Input Crop Production Systems[1]

Köpke, U.[2], Cooper, J.[3], Petersen, H.L.[4], van der Burgt, G.J.H.M.[5] & Tamm, L.[6]

Key words: crop yield, wheat productivity, potato productivity, intensive agriculture, conventional agriculture, ecosystem services

Abstract

Yields in organic and low input production systems tend to be lower than those obtained in intensive conventional systems. To narrow the productivity differences a range of challenges associated with organic and other 'low input' systems have been identified. These include the need to ***(a)*** *develop improved organic matter-based soil management and fertilisation protocols,* ***(b)*** *address key crop protection challenges via improved management, variety selection, and alternative treatment approaches and* ***(c)*** *address food safety concerns raised about organic and low input production. QLIF workshop 4 will summarise results from the crop production focused subproject (SP3) of the QualityLowInputFood IP. This paper summarises crop productivity focused QLIF results from SP3 (and to a lesser extent SP2) in the context of current scientific knowledge.*

Introduction

Compared with intensive mainstream agriculture, marketable yields per hectare of most field crops of organic agriculture systems under conditions of European temperate climate are generally lower (Tab.1).

Table 1: Yields of field crops produced in central European temperate climates relative to conventional reference yields (rel.=100) (Offermann and Nieberg 2000, Niggli et al., 2007)

	Country[z]				
Crop	**DE**	**AT**	**CH**	**FR**	**IT**
Wheat	58-63	62-67	64-75	44-55	78-98
Barley	62-68	58-70	65-84	70-80	55-94
Oats		56-75	73-94		88
Grain maize	70		85-88	66-80	55-93
Oilseeds	60-67	78-88	83	67-80	48-50
Potatoes	54-69	39-54	62-68	68-79	62-99
Pulses	**49-73**	**83-85**	**88**	**83**	**73-100**

[z]DE=Germany; AT=Austria; CH=Switzerland; FR=France; IT=Italy

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Clearly improvements in yield need to be a major target under organic and low input production systems in the context of an increasing world population, predicted reductions in the global land area available for agricultural production due to climate change and increasing use of crops as animal feeds and for energy production.

The aims of workshop 3 are therefore:

1. To identify productivity limiting factors in organic and low input systems in comparison with intensive agriculture.
2. To measure the impact of the QLIF project on the yields of organic and low input systems.
3. To discuss further approaches to increase productivity and yield stability of organic and low input systems.

Output and contribution of the QLIF project to the state-of-the-art

Effect of crop management practices on yield of wheat

A recent review of the literature on conventional and organic management systems for wheat identified soil nutrient deficiencies (especially phosphorus and nitrogen) and competition from weeds, as the main reasons for lower yields in organic grain production. (Mason and Spaner, 2006). Declining soil fertility under organically grown wheat has also been reported, with P levels often deficient, especially at sites managed organically for 30 to 70 years (Entz et al., 2001). Reduced yields in organic and low-input production may also be caused by a higher incidence of certain diseases. For example, Poveda et al. (2006) reported higher incidences of *Septoria* in organically managed wheat than conventional wheat. Studies under WP2.1.1 of QLIF showed that foliar *Septoria* disease is the only yield limiting disease in organic production systems, while other diseases such as mildew and lodging only had a negative effect on yield in conventional systems (Leifert et al. unpublished). Studies under WP3.5.4 of QLIF indicate that two of the main problems relating to the sustainability of the current organic wheat production methods (lower yields and protein contents) can be addressed by changes in cultivar choice, fertility management and pre-crop management practices (Wilkinson et al. 2007).

Effect of crop management practices on yield of potato

Previous studies (e.g. those carried out as part of the EU FP5 Blight-MOP project showed that **(a)** potato blight is a major factor affecting yields and **(b)** the impact of the disease on yield can be significantly reduced by improved variety choice and management practices (e.g. Speiser et al. 2006). However, even in years with low blight incidence yields in organic production often remain 30-40% lower than those in intensive conventional production. Studies under WP2.1.2 of QLIF showed that productivity and the differential in yield between organically and conventionally managed plots increased from approx 30% in years 1 and 2 after conversion to 50% four years after conversion. Thus, insufficient supply of macro-nutrients is a further reason identified for lower yields in organic potato. Potato have very shallow root systems and are associated with high nutrient (N, P and K) losses. The development of **(i.)** more N and P-efficient potato cultivars and **(ii.)** organic matter based fertilisation regimes that improve nutrient supply (especially N) at key development stages of potato (e.g. tuber initiation) are therefore thought to be the main approaches to increase potato yields in organic and ‘low input’ systems.

Effect of crop management practices on yield of field vegetable crops
Yield differentials between conventional and organic/'low input' vary significantly among different vegetables. Studies under WP2.1 of QLIF showed significantly lower (usually between 20-40%) yields for cabbage (linked to fertility management practices), while yields for organic onion and lettuce were similar or only slightly reduced (10-20%) compared to conventional crops. In cabbage protective netting was significantly more efficient than pesticides for controlling cabbage root flies and resulted in an increase in yield in organic systems. Also, in lettuce the higher *Sclerotinia* incidence in conventional crops (associated with the use of mineral fertilisers) resulted in a reduction in marketable yield. Improvements in field vegetable crops should therefore focus on improving fertilisation protocols that do not simultaneously exacerbate problems from crop pests and diseases.

Conclusions

Crop productivity in organic and low input systems is based on key pillars, i.e.

1. a fertile soil which provides sufficient capacity to allow for plant growth while preventing soil-borne diseases,
2. high quality, disease-free seeds and plant material,
3. a crop-specific soil fertility management plan to provide sufficient nutrients for optimum plant growth,
4. adequate varieties/cultivars,
5. crop protection techniques to prevent damage due to noxious organisms (Tamm et al., 2007).

The QLIF project has developed improved component strategies to overcome technological bottlenecks in annual (wheat, lettuce, tomato) and perennial (apple, results not discussed here) crop production systems further. Improvements in productivity were very clearly shown to be possible under the precondition of:

- favourable soil structure and soil chemical fertility as well as weather conditions
- high availability of nutrients (especially N and P), due to high amounts of soil-borne as well as added nitrogen.

More than in any other production systems the term 'productivity' in Organic Agriculture is strongly related to product quality, an overall aim of Organic Agriculture from the beginning. Thus, the term productivity in Organic Agriculture *per se* includes the production of a marketable yield of highest quality and therefore contrasts with the traditional term of productivity measured in yields or Megajoule output per hectare, only.

Lower *per se* productivity opens niches for higher product quality and ecological services and benefits (Brandt and Møldgaard 2001; Cooper et al. 2007). For example

1. Lower nitrogen inputs can potentially reduce N leaching, thus, resulting in higher groundwater quality
2. Lower density of cereal stands resulting from lower N availability may cause higher density of wild flora and endangered wild plants.
3. As a function of planned (crop rotation) and associated biodiversity in crops and wild plants, favourable habitats for insects, soil microbes, and wild and endangered animals are provided. Thus, Organic Agriculture offers benefits by on-site nature conservation.

4. Since lower productivity generally results in conditions enabling a multifunctional agriculture approach (i.e. the provision of ecosystem services), we strongly discourage using the words ‘productivity gap of organic and low input systems in comparison with intensive agriculture’, because this suggests a shortcoming of Organic Agriculture needing correction. The overall aim is system optimisation in the framework of Organic Agriculture’s multifunctional approach, rather than realising yields equivalent to conventional farming at the expense of the environmental services provided by Organic Agriculture.

Acknowledgments

The authors gratefully acknowledge funding from the European Community financial participation under the Sixth Framework Programme for Research, Technological Development and Demonstration Activities, for the Integrated Project QUALITYLOWINPUTFOOD,FP6-FOOD-CT-2003- 506358.

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QLIF Workshop 4: Performance of organic and low input livestock systems: a matter of sound design?[1]

Spoolder, H.[2], Biavati, B.[3], Borgsteede, B.[2], Davies, D.[4], Klocke, P.[5], Maurer, V.[5], Nagel, P.[6], Nicholas, P.[4], van Krimpen, M.[2], Mejer, H.[7], Modesto, M. [3], Strozzi, G.P.[8], Thamsborg, S.M.[7], Vermeer, H.[2], Wagenaar, J.-P.[9], Zollitsch, W.[6] & Sundrum, A.[10]

Key words: endoparasites, ectoparasites, enteric pathogens, sensory quality, amino acid balances

Abstract

A range of challenges associated with organic and other 'low input' (especially outdoor) livestock production systems have been identified. These include the need to identify alternative approaches for the control of parasites and gastrointestinal diseases to further reduce veterinary medicine use and antibiotic/anthelmintic resistance development. QLIF workshop 4 will summarise the fourth year's results of the livestock subproject (SP4) of the QualityLowInputFood IP. At the same time, it will contribute to the discussion on how organic livestock farming systems are being evaluated: by their design (input) or by their performance (output). This paper summarises QLIF results from SP4 in the context of current scientific knowledge.

Introduction

Organic production systems aim to provide various benefits to society. These benefits are associated with the four main principles of IFOAM: Health, Ecology, Fairness and Care (IFOAM, 2005). Implementation of these principles into organic livestock systems involves careful study on how housing and management factors affect the health and welfare of animals, the environment we live in and the farmer's income. This is not an easy task, as the underlying housing and management techniques used to make the principles operational do not always complement each other (Hovi et al 2003; Cooper et al 2007). This is the main reason why there are still a number of technological restraints in organic livestock production systems, which affect quality

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and safety of organic and "low input" foods as well as the cost of production (Spoolder et al. 2007). The QualityLowInputFood (QLIF) project aims to address some of the most relevant gaps in our knowledge when taking up this challenge. The gaps relate to: **(a)** the control of endo- and ecto-parasites (WPs 4.1 and 4.2, **(b)** alternatives to antibiotics for the control of gastrointestinal infections and mastitis (WPs 4.3 and 4.5), **(c)** feeding regimes which improve meat quality and minimise amino acid imbalances in monogastric production systems (WP4.4) and **(d)** the problem of negative energy balances in dairy systems, while improving milk quality (WP4.5).

Output and contribution of the QLIF project to the state-of-the-art

WP4.1 Improved preventive strategies for controlling endo- and ectoparasites and bacterial zoonoses of pigs and poultry.

POULTRY The risk of parasitic infections is increased in hens in free-range systems compared to systems without outdoor access (Permin et al, 1999). Improvements in run management and reducing the stocking density from 5m^2 / hen to 10 m^2 / hen can significantly reduce faecal egg counts FEC of the two helminth species of poultry (*Ascaridia galli* and *Heterakis gallinarum*) on outdoor runs. Experiments on the effect of litter management on litter infectivity and transmission of *A. galli* and *H. gallinarum* as well as feeding trials with potential anthelmintic plants are ongoing.

PIGS - *Ascaris suum* is the most prevalent helminth on organic pig farms (Carstensen et al., 2002) and is transmitted mainly via the faeces. A first study therefore focused on assessing the efficacy of different protocols for cleaning the dunging area of pigs on *Ascaris suum* transmission to pigs. Experiments are ongoing, but preliminary results suggest that improved cleaning protocols alone are not able to reduce *Ascaris* infections, but should be part of a package of measures against *Ascaris*. A second study quantified the effect of dietary inclusion of dried chicory roots on Oesophagostomum spp. infections in naturally infected sows and boars, since pilot studies had shown that dietary inclusion of dried chicory roots may reduce infection and egg excretion levels in pigs (Spoolder et al., 2007). Dried chicory abolished egg excretion within 2-6 days, but after withdrawal of the chicory faecal egg counts increased. Nevertheless, overall egg excretion remained significantly below that of the control animals in both trials and can therefore be recommended for use strategic use in organic and 'low input' pig production systems.

WP4.2 Alternative treatment strategies for controlling endo- and ectoparasites of pigs and poultry.

POULTRY Control of the poultry red mite *Dermanyssus gallinae* is a challenge for organic as well as conventional egg producers. A range of alternative treatments including diatomaceous earth supplemented with pyrethrum and essential oils, a liquid formulation of silica were tested *in vitro* and tests with plant extracts and different oil types are ongoing. In on farm experiments, diatomaceous earth was effective during a limited period only, whereas 2 liquid formulations of silicas had a very good residual effect against red mite.

PIGS In organic pig farms, this percentage of pig livers that need to be condemned due to *Ascaris suum* is often higher than in conventional pig farms. To reduce the use of synthetic drugs (e.g. benzimidazoles, levamisole and macrocyclic lactones) herbal preparations were tested for the prevention and control of a mild infection of *Ascaris suum* in growing and finishing pigs. While not decreasing the number of infected pigs some herbal treatment reduced the average number of worms in the gastro intestinal tract. Studies currently focus on identifying the suitable period to supply this herb mixture to sows and the potential of combining herbal remedies with reduced doses of veterinary drugs.

WP4.3 Methods to augment non-immune system based defence mechanisms against gastrointestinal diseases in the pig.

Probiotic *Bifidobacterium* strains, prebiotic and acidified nitrite supplements were assessed for their potential to control gastrointestinal pathogens causing diarrhoea in pigs. The ability of microencapsulated probiotic strains to pass through the acid barrier of the stomach and establish increased population density in the intestine was demonstrated. However, although antimicrobial activity of acidified nitrite treatments and the ability of probiotic strains to inhibit enteric pathogens was demonstrated *in vitro* (Biavati et al. 2007), this could not so far be confirmed in experiments *in vivo*. Also supplementing organic growing-finishing pigs with maize silage, grass silage or a probiotic preparation did not significantly affect performance and carcass traits.

WP4.4 Strategies to improve sensory quality and food safety of pork without the use of amino-acid supplements, while improving production efficiency within organic farming conditions.

Due to the restricted availability of limited amino acids in organic livestock production protein accretion capacity is limited compared to conventional production. Sensory quality of pork is to a high degree influenced by the intramuscular fat (IMF) content and previous studies showed that pig diets were the main source of variation for the IMF content in pork. In on-farm trials the effect of the implementation of a specific feeding strategy using a high portion of home-grown grain legumes on the IMF content of pork, was assessed under different conditions on German and Austrian organic farms. Results showed that different to previous feeding regimes had no significant influence on the IMF but that there was great variation between the farms for IMF. It was therefore concluded that there is a need for a direct assessment of IMF-content of pork at the abattoir to fulfil the expectations of consumers with regard to a high eating quality of organic pork.

WP4.5 Efficient farm/farmer group specific mastitis prevention plans.

The objective of this ongoing study is to identify the main factors influencing udder health in organic dairy farms under different climatic and structural conditions. Results show that improvement of housing/environmental conditions and farmers' skills allow a partial conversion to a non-antibiotic treatment scheme based on teat sealant dry-off prophylaxis. Also, calves reared with their mother were shown to grow faster, while no negative effect of suckling on the somatic cell count or a negative impact on animal health status were observed. The effect of suckling calves on the resistance of adult animals to mastitis and the overall results of the mastitis prevention plan programme will be known at the beginning of 2009.

WP4.6 Bovine feeding regimes which improve production efficiency, microbiological safety and/or sensory quality of milk.

Preliminary observations at IGER showed that feeding clover silages (CS) increases the polyunsaturated fatty acid content of milk. However, the effect of CS based diets on faecal shedding of enteric pathogens was not previously investigated. Studies at IGER gave no clear indications that feeding red clover silage affects faecal shedding of *L. monocytogenes* or *E. coli*. However studies demonstrated that milk and milk protein yields can be significantly improved by feeding red clover silage (RCS) as 1:1 mix with maize silage, but that the efficiency of utilisation of forage N was reduced when diets contained more than 10% RCS.

Conclusions

The results obtained in the QLIF project over the last four years have provided recommendations to farmers and other stakeholders on how to improve organic livestock farming. Significant progress was made in areas of housing, feeding and management. Often the recommendations are straightforward, and ready for implementation, e.g. the recommendation to provide roughage to pigs (WP4.4) to improve gut health, or the inclusion of dried chicory to combat *Oesophagostomum* (WP4.1). In other areas challenges remain. For example, reducing endoparasitic burden and keeping the use of conventional anthelmintics to zero appears to be rather difficult (WP4.2). In some cases, progress with respect to one objective have created new challenges. For example, under WP4.5 the maternal rearing of calves increased calf live weights at weaning, but resulted in unacceptable levels of cow, calf and farm stress at weaning. In these cases it is difficult to decide whether or not a change is an overall improvement or not.

To facilitated decision making the following key questions will be discussed as part QLIF workshop 3 at the Modena IFOAM/ISOFAR congress

1. What constitutes a high performance organic livestock system (consider the various stakeholders - farmer, animal, consumer, certification body, broader society, etc)?
2. Given answers to the above question - what are the key indicators of organic livestock system performance?
3. How do we measure these indicators?
4. Are there any major conflicts when trying to achieve high levels of system performance – what are they, who do they affect and can we reduce them?

Acknowledgments

The authors gratefully acknowledge funding from the European Community financial participation under the Sixth Framework Programme for Research, Technological Development and Demonstration Activities, for the Integrated Project QUALITYLOWINPUTFOOD,FP6-FOOD-CT-2003- 506358.

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QLIF Workshop 5: Resource efficiency of organic and low input systems in comparison to intensive agriculture: Extended summary [1]

Thorup-Kristensen, K.[2], Brennan, M.[3], Halberg, N.[4], Cooper, J.[5], Lampkin, N.[6] & Niggli, U.[7]

The results from the QLIF project and other results presented here show that organic crop production systems are normally superior to conventional systems in terms of energy use and greenhouse gas emissions whether this is calculated on a per area basis or on the basis of kg of food produced. As the productivity of organic systems is lower than that of conventional systems, the comparison is most favorable when calculated on the basis of the area of land.

With animal production systems this is more variable. Where ruminant animals can use extensive areas, or where much feed production can be based on ley crops in the rotation with legumes to supply N, organic production may come out with clearly better energy balances than conventional systems. However, the feed use efficiency in organic production is often lower than in conventional production, and if the production is based on cereals and other products from annual crops, this leads to a somewhat better energy balance in the conventional systems.

There are some examples where organic production is found to use clearly more energy than conventional production. This is mainly related to the more intensive productions. As an example, organic pork production can have less energy efficiency and lead to larger loss of N by leaching and N_2O by denitrification because of the free range systems employed. In production systems where the manure can be collected and later applied to fields at an optimal time and amount, the environmental load can be reduced. In this case, the requirements for improved animal welfare lead to a less environmentally friendly system in terms of N losses, energy balance, and green house gas emissions.

A special point is that organic animal production may lead to reduced ammonia gas losses. As ammonia gas from agriculture adds N to the near surroundings, this can be a major advantage. In areas with intensive agricultural production, ammonia losses lead to eutrophication and thereby loss of species living in nutrient poor ecosystems.

Also in the field, intensive productions can lead to environmental problems in organic production. When horticultural crops are grown, the production value per hectare is very high compared to arable crops, and the economic loss to the farmer if yield or quality is reduced is very big. Therefore horticultural producers often choose to err on

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the side of caution and choose safer options sometimes using methods which are less than ideal from an organic point of view, while still adhering to rule governing horticultural production without chemical fertilizers, pesticides, or herbicides. Net covering against insect pests or flaming against weeds are two examples of such energy demanding practices. In fertilization vegetable farmers tend to also err on the side of caution combining green manure effects and high application rates of organic manures. This can lead to significant risks of N leaching losses, and as these manures could have replaced chemical fertilizers elsewhere, it is also a problem in terms of energy balance.

The conclusion that organic farming methods show similar or improved energy balances and tend to contribute less to green house gas emissions is based on a number of key assumptions which should be kept in mind when interpreting such results.

One is that energy input is compared to food output. But crop and food production can also be expressed in terms of energy. Crop production normally represents a clear net energy production (production of crops in heated greenhouses is an exception here). Even though the amount of energy produced per kJ of energy used may be better in the organic systems, the higher productivity of the conventional systems mean that conventional system tend to have a higher net energy production per hectare.

The significance of the area used for crop production is another open question when comparing different production systems. While the organic systems may have the highest productivity per amount of invested energy, they have a lower production per area. What is most important here investment of energy or area? Our area for crop production is not unlimited, and the extra land we need for organic food production could be used for other purposes. Growing a hectare of green manure for a year or two may cost little energy, but what is the significance of the land area it takes up?

We tend to compare organic systems with conventional systems producing the same commodities. However, if we compare commodities, the differences we find are much larger. Cereals and some vegetables show high net food energy production per hectare, whereas low yielding crops as lettuce and some other vegetables show much lower net food energy production. Greenhouse production of vegetables show a net energy cost, at least if production is continued during cold winter periods. Conversion of plant products into animal products such as milk or eggs includes the loss of most of the energy from the plant products, and to the release of greenhouse gasses as CO_2, CH_4 and N_2O. Thus, the environmental footprint varies strongly among products, and animal based products are in most comparisons much worse than plant based food products.

Another problem is the C which circulates in the system. When calculating the energy balance or green house gas release due to organic or conventional cropping, we obviously include the C released from fossil fuels when producing fertilizers or pesticides, or when doing mechanical field operations. However, within the systems a lot of C “bound in energy rich compounds” is circulating, and the way we take this into account on our calculations is not very clear or consistent. As already mentioned, food production can also be expressed in energy equivalents, but so can the C and energy content of crop residues, organic manures and of soil organic matter accumulated or lost due to the production systems is relevant. The assumption that organic manures have no energy value, though they contain a lot of C and organic matter is determining the outcome of many of the comparisons. These comparisons could look very different if the manure energy content was included. The inclusion of the energy content in manures and crop residues become increasingly relevant as the energy prices go up, and the attempts to use these resources for bio-energy production are increasing.

Storage or loss of C and energy from the soil organic matter pool can also be important. Here organic systems tend to have a better effect than conventional systems, especially if they can add more ley crops and cover crops to their rotations that the conventional systems they are compared with.

Taking into account some of the aspects mentioned here could significantly alter comparisons between systems and between commodities in many cases. Therefore, a discussion about which aspects are really relevant to include in the comparisons is needed. There will certainly not be one clear set of answers for this, but depending on the question we ask, the aspects we should include in the analyses will differ. We need to discuss what inclusion of various aspects of energy balance, greenhouse gas emissions, nutrient or pesticide loads means for the conclusions we can draw from the comparisons we make.

Analyses made as part of the QLIF project indicate that consumers consider both the quality, safety and environmental attributes of organic food as important when making decisions about whether to, and for what price they are willing to buy organic products. As a result, from a consumer and marketing perspective, it is very important that the real environmental advantages of organic production for different products are calculated. This will allow for better, more accurate and credible communications on the real environmental footprint of organic production systems to be developed. Analyses showing environmentally weak aspects of some current organic production methods are also important, to help us develop better organic production methods for the future. Communicating the environmental value of organic products will play an important role in encouraging those consumers motivated primarily by environmental concerns to make better consumption choices that result in a shift in their consumption away from products that have been scientifically shown to have an adverse impact on the environment.

Acknowledgments

The authors gratefully acknowledge funding from the European Community financial participation under the Sixth Framework Programme for Research, Technological Development and Demonstration Activities, for the Integrated Project QUALITYLOWINPUTFOOD, FP6-FOOD-CT-2003- 506358.

Workshop

Food, Fairness & Ecology: An organic research agenda for a sustainable future

Food, Fairness & Ecology: An organic research agenda for a sustainable future

Niggli, U.[1], Slabe, A.[2], Schmid, O.[3], Halberg, N.[4] and Schlüter M.[5]

Key words: Organic research agenda, sustainability, food security, ecosystem services

Abstract

The European Union Group of the International Federation of Organic Agriculture Movements (IFOAM EU Group) and the International Society of Organic Agriculture Research (ISOFAR) are developing a strategic research agenda focussing on ecological intensification, on sustainable rural regions, on high quality food for healthy nutrition and on ethical values of people vis-à-vis technology development in food production. The strategic research agenda (currently in its second draft, Niggli et al., 2008a) invites farmers, processors, traders, NGOs and scientists to debate on how practice and science should co-operate on future innovation. The final goal of the debate is a widely supported technology platform for organic agriculture and beyond.

Introduction

Organic food and farming is a constantly growing sector in the European Union (EU) and globally. It has a good potential to respond to the big challenges the EU and the world will face in the next decades, both in the area of environment (mitigation of and adaptation to climate change, including soil, water and biodiversity management and conservation) as well as in the area of food (sustainable productivity and high quality), rural development and animal welfare.

Innovation generated by the organic sector has considerably driven general agriculture and food production towards sustainability, high quality foods and low risk technologies in the past. Thus, strengthening research activities will have an impact far beyond the certified organic sector.

Technology platforms are permanent, industry-led schemes, involving the research community, public authorities and civil society.

General situation of the organic sector in the EU

In 2006, the European organic market grew by more than 10 percent, and it was worth approximately 14 billion €. In many old member states, production accounted for up to 13 % of the total agricultural land; more than 6.8 million hectares were under organic management in the EU.

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Until the 1980s, research was mainly carried out by private initiatives. In 1982, the first universities took organic farming on their curricula, in the 1990s, the first EU-funded projects on organic farming started, and a growing number of national state research institutes became involved in organic farming projects.

Many national action plans include special programs for organic farming research. With the ERA-Net project CORE Organic, the cooperation among funding agencies of research programmes led to a joint call of 11 countries in 2006. The total national funding for organic research in these 11 countries was 54 million Euros in 2005.

From the 5th EU research framework programme to the 6th, project funding increased from 15.4 million € to 22.1 million (without national co-funding).

Long-term observations and a shift from a multidisciplinary to an interdisciplinary research culture are characteristic for organic farming. Increasing emphasis is given to trans-disciplinarity where researchers, practitioners and stakeholders cooperate in order to address complex challenges of the society and find feasible solutions.

Strengths and weaknesses of organic agriculture and food chains

Analysing the strengths and weaknesses of organic agriculture is the first step towards identifying future research priorities. Such a critical analysis also helps to dynamically optimize the framework of organic agriculture, looking at its principles and standards, implementation rules and indicators which are used in the quality management system. For references used for assessing organic systems see Niggli et al., 2008a.

Among the ecological and environmental strengths of organic agricultural are to be found: i) reduced pollution (nitrates, pesticides), ii) improved biological and physical qualities of soils and iii) strongly increased diversity at landscape, farm, field, species and genome level. Furthermore, organic farming systems are likely to be better able to cope with climate change, as they are more resilient and have inherent techniques which reduce greenhouse gas (GHG) emissions (Niggli et al., 2008b).

The socio-economic situation of organic agriculture is inconsistent. Therefore, state direct payments are vital for organic farms in order to compensate for the fact that, in organic farming, negative environmental and social costs are externalized to a lesser degree. Organic farming combines similar or higher incomes with the creation of higher employment, as it contributes to rural economic development through value-adding activities such as direct marketing, local processing of specialities and tourism.

Generally, consumers attribute positive characteristics to organic foods and they perceive them as healthy, tasty, authentic, local, highly diverse, fresh, minimally processed, natural, free of undesirable residues and safe. Several meta-studies confirm not all but many of these quality claims. Health claims, however, are generally only poorly substantiated by scientific research, mainly because intervention and cohort studies are very expensive.

When designing future research programs, it is, however, more interesting to know the weaknesses of organic agriculture and the organic food chain. Among these, the most pressing ones are the productivity and yield stability gaps, both caused by severe deficits in the knowledge of how agro-ecological systems work and the lack of appropriate technologies for organic systems. These gaps need to be addressed in a consequent way in order to fully exploit the positive impacts of this farming method on the environment, on biodiversity and on climate change mitigation and adaptation.

Vision for research and strategic priorities for 2025

The strategic research priorities are based on i) the principles of organic agriculture, ii) scientific innovation and iii) best integration of indigenous knowledge of farmers. The priorities focus particularly on the conflicts between economy, ecology and social cohesion/harmony inherent in most concepts for sustainable agriculture and food production, and they propose research activities and insightful learning concepts far beyond the niche that organic farming currently still represents. Each of the four research priorities (see figure 1) is underpinned with examples of possible research activities (see Niggli et al., 2008) which are not outlined here.

Figure 1: Vision for research and strategic priorities for organic systems.

The magnitude of challenges outlined by foresight studies (e.g. SCAR, 2007) indicate that agriculture is based upon distinctive ethical values. This is especially true for questions like rural development, decentralised food production, the quality of the landscape, the conservation of biodiversity, the sustainable use of natural resources as well as fair trade, livelihood of farm families and animal welfare.

The ethical value system of organic agriculture is described by the principles of health, ecology, fairness and care (IFOAM, 2005). It provides a unique basis for developing complex assessment and decision tools and for modelling future sustainable food and farming systems in a practical context where stakeholders along the whole food chain can participate and where civil society is strongly involved into technology development and innovation.

Locally produced raw materials with specific qualities will increase the diversity of European food in a considerable way and will keep agriculture, food production, culinary culture and tourism very competitive. Wellness, high quality food, locally processed foods from traditional recipes and geographical denomination will create jobs and wealth in rural areas and will add to their attractiveness. Organic farming has taken up very early this concept of multifunctionality. This forerunner role is very fruitful for the society and helps to adjust technology development and innovation.

In this regard, organic agriculture represents one of the best developed multifunctional strategies in agriculture so far. Therefore, it is an excellent starting point for an ecologically and environmentally sound intensification in balance with ecological goods and services, nature protection, animal welfare and social objectives.

The weakness of organic agriculture, so far, is its currently insufficient productivity and stability of the yields (especially of intensive cash crops). This may be solved by an appropriate “ecological intensification”, i.e. via a better and more efficient use of natural resources, improved nutrient recycling techniques and agro-ecological methods for the enhancement of diversity and health of soils, crops and livestock. Successful research strategies are i) the clever integration of leguminous plants into cropping, ii) the better use the nitrogen (and other nutrients), derived from livestock production, iii) reversing the separation of crop and livestock production, which has often resulted in soil degradation on croplands and in nutrient excess in livestock operations with yet unsolved environmental problems, iv) the exploitation of eco-system services via clever habitat design and v) the use of novel technologies (such as sensors, robots, information technology and smart breeding).

Individual and social well-being strongly depend on both the quantity and quality of the food we eat, the composition of the diets and how it is processed and prepared. The power to choose foods that meet the highest standards of ethics and craftsmanship, is a manifestation of every citizen’s everyday’s control of his life circumstances, the key prerequisite for a long and healthy life. Therefore, an improved quality of life is intricately linked with an increasing demand for foods of the highest standards such as organic food. Food quality research includes a whole chain approach and will address the most critical steps which influence the quality of the food from primary production to processing, transportation, packaging and consumption.

Conclusions

A sustainable approach to agriculture and food production means coping with trade-offs between ecosystem services while not reducing some of them in favour of others. The rationale behind organic agriculture is providing sufficient food and fibre while increasing *regulating* services (e.g. increasing the adaptive capacity of farming systems to climate change) and maintaining or restoring *cultural* (e.g. pleasant landscape) and *supporting* services (e.g. soil fertility). As human well-being depends not only on the quantity of food but also on its quality and diversity, the vision also addresses food, nutrition and health aspects. Organic farmers practise a pragmatically optimised equilibrium between the services the society expects agriculture to deliver. It is therefore an excellent starting point for truly sustainable food systems.

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Workshop

Research carried out in the Sixth Framework Programme on organic and low-input agriculture

EU supported organic and low-input agriculture research in the Framework Programmes (FP6 and FP7): scientific support to policies and quality products

Tissot, D.[1]

As part of the Organic World Congress held in Modena in June 2008, the European Commission, DG Research, organised a specific session to give an overview of the research carried out in the Sixth Framework Programme on organic and low-input agriculture, together with a presentation of the results of some of the supported projects. The session has included a panel discussion to highlight success stories and identify areas where priority for future research should be given.

The status of Organic Food and Farming Research in Europe has been assessed primarily in 2002 and was followed in 2004 by a seminar in Brussels with the main objective of stimulating trans-national cooperation. The main outcome of the 2004 seminar was a list of recommendations and priorities for trans-national research co-operation in organic food and farming in Europe directed towards the Commission for uptake in the 7th Framework programme. Within the areas of research identified more specific topics can be listed. Some of them have been addressed in the 6th Framework programme (FP6), while others will be taken into consideration in the *Knowledge-Based Bio-Economy* (KBBE) to be developed in Theme 2 "Food, agriculture and fisheries, and Biotechnology of the 7th Framework programme (FP7).

The different priorities can be broken down into three main strategic areas:

Promoting technical innovation and methodological development to overcome producers' problems

Crop protection with methods acceptable to organic/low-input farming and environmentally friendly practices is one of the main problems encountered by producers. In particular, protection against fungal diseases in seeds, fruit and vegetable is difficult to ensure without the use of strong chemical treatments. The project **REPCO** (Replacement of copper fungicides in organic production of grapevine and apple in Europe) has produced exploitable knowledge on the use of several potentiators of resistance and organically based fungicides in organic production of grapevine or apple. Such novel products showed promising activity against downy mildew of grapevine (*Plasmopara viticola*) and/or apple scab (*Venturia inaequalis*) and may have a potential in controlling other plant diseases. Implementation by end-users and industry has been emphasised and transfer of the knowledge of integrated use of control measures to growers can be delivered. The **ENDURE** network has the objective to optimise and reduce pesticide use. It also aims at designing innovative crop protection strategies while improving basic knowledge of crop-pest systems.

Innovative processing methods respecting consumer expectations on organic products while preserving the quality of the products along the food chain have been explored in the **QualityLowInputFood** integrated project. In particular chlorine replacement strategies for fresh cut vegetable have been assessed as well as strategies that may improve the composition of dairy products. The **ORWINE** project is

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currently exploring alternative methods to sulphite addition in the winemaking process coupled with improved management practices and on-farm application of innovative methods.

Future research is already planned and prepared on **breeding and management practices** in livestock production systems through a project that will be funded after the second call of FP7 and a call will be open soon to a similar approach for crop production systems.

A Commission strategy paper for future calls in FP7 is currently being discussed and will consider among other priorities specific techniques for aquaculture and alternatives to chemicals for veterinary treatment of animals.

The **Welfare Quality**® Integrated Project is addressing the improvement of **husbandry systems with respect to animal welfare** covering in particular welfare monitoring and assessment in order to establish standardised animal-based measures for a list of parameters appropriate to each species. In addition practical strategies to improve specific aspects of animal welfare are being identified.

Supporting the production of high quality organic food and feed for better impact on human and animal health

This is the ambitious objective of the **QualityLowInputFood** (QLIF) Integrated project. It is the first time that such a large-scale project on organic and low-input agriculture has been funded at EU level. Research executed by a multidisciplinary consortium from all over Europe represents the best option to guarantee unbiased results over such a sensitive issue as organic farming and other low input production systems when compared with conventional farming. The QLIF project has been running for more than after 4 years and addressed the **impact of organic foods on nutritional, sensory, microbiological and toxicological quality and safety of foods**. By collecting sound scientific data the project is giving a strong scientifically based and informed perception of differences in the quality and safety between foods produced in different production systems (conventional, low-input, organic).

Increased co-ordination and communication, infrastructures network and training and demonstration:

An efficient co-ordination between Member States has been achieved by the **CORE-Organic ERA-Net**. The project draws on public funds from 11 countries. There is a clearly identifiable interest in national research programmes to co-operate more actively in the area of organic farming, which the Commission is considering proposals to open a new ERA-Net building upon the results of the CORE-Organic project while extending its scope and geographical area, possibly through multilateral joint programming.

Specific developments of organic farming policy have generated needs for **scientific research in support to** the revision of the organic farming regulation (**EEC/2092/91 revision** project) and to the European Action Plan for Organic Food and Farming (**ORGAP** project). In addition the opening of channels of communication between the Accession and Candidate Countries and the EU in ecological farming has been ensured by the **CHANNEL** project.

In conclusion the increased visibility of European research as described above in organic and low-input farming, and at international, and member state level is likely to contribute to the development and the competitiveness of organic agriculture in Europe.

Index of authors