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Edited by Ulrich Köpke, Urs Niggli, Daniel Neuhoff
Peter Cornish, William Lockeretz, Helga Willer

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International Society of Organic Agriculture Research (ISOFAR)

Institute of Organic Agriculture (IOL),
Secretariat
Katzenburgweg 3
D-53115 Bonn, Germany
Tel. +49 228 735616
Fax +49 228 735617
E-mail info@isofar.org
Internet www.isofar.org

Research Institute of
Organic Agriculture (FiBL)
Ackerstrasse
CH-5070 Frick, Switzerland
Tel. +41 62 8657272
Fax +41 62 8657273
E-mail info@fibl.org
Internet www.fibl.org

Ulrich Köpke, Urs Niggli, Daniel Neuhoff, Peter Cornish, William Lockeretz, Helga Willer (Editors)

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PREFACE

The genesis of the First International Scientific Conference of ISOFAR, held from September 21–23, 2005 in Adelaide, South Australia, can be traced back to ISOFAR's launch at the Berlin-Brandenburg Academy of Sciences and Humanities in Berlin, on 20th June 2003. Thus, once presentations will have been displayed at Adelaide's Convention Center, these Conference Proceedings have had a gestation period of no longer than 27 months, with a first call for papers no older than 11 months.

The progeny of this process - some of you may now tangibly carry it, others might access it electronically - consists of more than 150 papers covering various aspects of Organic Crop Production (49%), Animal Husbandry (11%), Agricultural Economics, Rural Sociology as well as Organic Food Marketing and Sustainability (40%). Thus, a well balanced mixture represents the current relevance of each area whilst paying particular attention to the increasing importance of economics, a trend that may have a positive impact also on the scientifically based development of Organic Agriculture.

Researchers from over 30 countries covering all continents are contributing to the present conference transcript. We are proud and happy to present you a wide range of worldwide research activities focussing on Organic Agriculture. There is, however, still a strong dominance of European researchers representing more than 75% of all published papers. This fact reflects the history of organic agricultural research, yet it underlines the necessity of one of ISOFAR's key aims: to bring more scientists from other parts of the globe to the job.

In contrast to common conference proceedings, this volume basically contains short scientific papers of four pages maximum. All contributions have passed a stringent referee system. The revised papers may, however, later be extended and delivered as full papers to recognised international scientific journals. Some selected contributions shall later be published in a special volume of an international journal.

When preparing this volume, the Editorial Board had to cope with some unexpected problems, resulting for example from different technical standards in the world-wide e-mail communication system. We apologize for any inconvenience our authors may have experienced - they find themselves in good company with those people who had to overcome manifold obstacles when preparing this conference as well as its proceedings.

We are greatly indebted to the benefactors, the overall organising committee that enabled the scientific module 'Researching Sustainable Systems' under the umbrella of IFOAM's 15th World Congress and the institutional hosts, our partners of NASAA. For the secretarial help in ISOFAR's Bonn office, thanks are due especially to Anke Dunsche and Christin Streichardt, thoughtfully guided by Daniel Neuhoff. We are grateful to all our unnamed referees for revising all the papers which were received early enough. Judith Neuhoff did a very good job in checking our non-native speakers' English. We are deeply indebted to the Swiss Agency for Development and Cooperation (DEZA) for their generous funding. Invaluable assistance in diverse forms was given by staff members of FiBL where again Helga Willer was the successful 'spider in the net'.

For all that: we are not perfect. Thus, critical readers are asked to excuse any mistake they might spot, or the odd sentence written in less-than-perfect English. We realise that we might be repeating ourselves when concluding that *considering all those circumstances editors may be confronted with, criticism is nevertheless welcome and will not lead us to the conclusion that this job has been one of those not to be repeated in the present incarnation*.

For the Editors

Ulrich Köpke — Urs Niggli

President — Vice-President

ISOFAR

ARABLE CROP ROTATIONS AND INTERCROPPING

EFFECT OF ANNUAL SELF-RESEEDING LEGUMES ON SUBSEQUENT CROPS IN ORGANIC ROTATION PROGRAMME

Lina Al-Bitar

Mediterranean Agronomic Institute of Bari, Via Ceglie 9, 70010 Valenzano (BA), Italy,
Tel +39 080 4606254, albitar@iamb.it, www.iamb.it

Key Words: Biological nitrogen fixation, annual self-reseeding legumes, nitrogen uptake, rotation programme, green manure, organic agriculture, Mediterranean region and climate.

Abstract

Soil fertility management is a critical issue in organic agriculture, and nitrogen supply is the most important aspect, especially in the Mediterranean region. Biological nitrogen fixation by legumes seems to be a successful strategy in that nitrogen-fixing legumes can provide most of the nitrogen used in Mediterranean agriculture in a form not readily leached. According to Pimentel et al., 1992, in the U.S., an estimated $50 billion worth of nitrogen is provided by biological N fixation. Thus, the inputs of nitrogen into Mediterranean agricultural systems by biological fixation in modulated legumes are fundamental to obtain sustainable and economic production.

This study aimed at evaluating the impact of annual self-reseeding legumes on subsequent crops performances in a rotation programme in organic farming.

15 cultivars of annual self-reseeding legumes belonging to the genera *Trifolium*, *Medicago, Ornithopus* and *Biserrula* were grown over two cropping cycles as green manures followed by lettuce and corn.

All legume treatments had significant positive effects on both subsequent crops.. In fact, marketable yield of lettuce increased an average of 55% over the control and yield of maize grain was an average of 15% over the control. *Medicago sphaerocarpa* cv Orion, *Trifolium subterraneum* cv York, *T. glanduliferum* cv Prima, and *T. spumosum* cv WCT36 gave the best results with both crops.

Introduction

Over the past 40 years, agricultural activity has become increasingly dependent on chemical fertilizers and pesticides for the achievement and maintenance of the high yields characterising modern cropping systems. In fact, it is estimated that globally, at 2 to 5% of all fuel is used for the production of synthetic nitrogen fertilizers (Grignani *et al*., 2002). Kennedy and Cocking (1997) report that every ton of nitrogen fertiliser manufactured consumes 1.3 tons of oil equivalents.

Since Mediterranean soil is heavily dependent on external input supply, suffers from a lack of macro and micronutrients, and is characterised by a high mineralisation rate, it is necessary to set up alternative sustainable strategies. The challenge is to build up fertile soil and balanced organic agro-ecosystems that are able to feed a healthy plant producing a high quality organic product appreciated by consumers.

Annual self-reseeding legumes are able to accumulate substantial quantities of N, while the soil's population of microbes has an enormous capacity to recycle this N under the right conditions (Jarvis *et al.,* 1996). Legumes are an essential component of Mediterranean agro-ecosystem; they not only are useful to exploit atmospheric N, which is a native renewable resource, but they also contribute to recycle the organic matter and enhance biodiversity that has a direct effect on pest management. Therefore, they contribute to enhance a closed farming system, which is the main goal of organic farming.

This trial is part of broader long-term research at the Mediterranean Agronomic Institute of Bari (IAMB), Italy, that foresees a rotation programme scheduled over various years aiming at replacing perennial species with annual self-reseeding legumes. Perennial species are not suitable for areas characterised by a long and dry summer, such as the Mediterranean region. Annual self-reseeding legumes possess the ability, through their re-germination capacity, to act as a perennial species within a crop sequence.

The aim of this trial was to study the impact of annual self-reseeding legumes on subsequent crops in a rotation programme in organic farming.

Methodology

Fifteen cultivars of annual self-reseeding legumes (*Medicago sphaerocarpa* cv Orion, *Trifolium subterraneum* cvs York and Dalkeith, *T. glanduliferum* cv Prima, *T. hirtum* cv Hykon, *T. incarnatum* cv Caprera, *T. vesiculosum* cv Cefalu, *T. spumosum* cv WCT36, *T. michelianum* cvs Bolta and Paradana, *Biserrula pelecinus* cv Mauro and Casbah, *Ornithopus compressus* cvs Santorini and Avila, Ornithopus sativus cv Cadiz) and a control (fallow) were arranged in a Randomised Completely Block Design with three replicates. Each block was formed of 16 plots of 5 m x 2 m. Seeds were inoculated by the suitable *rhizobium* species and sown at a rate depending on the species and ranging between 10 to 20 kg ha^{-1}.

Legumes were sown in December 2002, and the first growth cycle extended over seven months until June 2003. They were then left over the summer on the field (fallow). In the beginning of autumn (September 2003), legumes regenerated and were left to grow for seven months as in the first cropping cycle until March 2005, where they were green manured and followed by two consecutive crops: lettuce (April – May) and maize (June –October).

Lettuce (variety *Faustina)* was transplanted on 1 April at a density of 7 plants m^{-2} (30 cm spacing between plants and 50 cm between rows) on the same plots of annual self-reseeding legumes (considered as treatments).

The growth rate of lettuce plant was assessed at 12-day intervals by evaluating plant height, number of leaves, leaf area index, dry matter, N uptake, and marketable yield.

After harvest, maize was established to verify the effect of annual self-reseeding legumes in the medium term. This crop is characterized by a deep root system, in contrast to lettuce's shallow root system, and is capable of taking up nutrients from a deeper level.

Maize was sown on 1 July at a density of 8 plants m^{-2}. Parameters studied were plant height, dry matter production, plant N content, grain yield and weed infestation.

Results and brief discussion

All legume treatments had significant positive effects on subsequent crops (lettuce and maize) compared to the control. In the case of lettuce (Table 1), uptake of N ranged from 26 to 87% more than with the control. This confirms previous results obtained by Thorup-Kristensen (1994); Thorup-Kristensen and Bertelsen (1996); Ogren *et al.* (1998), although large differences in experimental design and general conditions occurred in these studies.

In the present study, N uptaken by lettuce increased as the plant approached maturity, as was demonstrated by Thorup-Kristensen and Bertelsen (1996). N taken up by lettuce was likely provided partly by mineralisation of soil organic matter and partly by the leguminous green manure.

Lettuce yield also increased significantly in all treatments compared to the control (on average 92%). This is in agreement with results obtained by Henry (1995), where the subsequent crop was a cereal. The increase in crop yield following legumes is also confirmed by other experiments carried out by Breland (1996) and Schroder *et al.*(1997).

Moreover, in the case of maize (Table 2), yields also were significantly higher when legume cultivars preceded the crop compared with the control. This means that all legume cultivars, significantly benefited the agronomic performances of maize and its production.

Table 1. Effect of legume treatments on lettuce (at harvest time)

Treatments	Leaves (number)	Plant height (cm)	LA (cm^2)	Dry matter (t ha^{-1})	Plant N uptake (kg ha^{-1})	Yield (t ha^{-1})
T.s. Cv York	35 a	18.3 a	5759.4 a	2.31 a	40.99 a	34.90 a
T.m. Cv Bolta	33 ab	16.9 ab	4748.4 ab	2.26 ab	39.38 a	29.56 a
O.s. Cv Cadiz	28 ab	16.7 ab	3852.3 bc	2.10 ab	39.39 a	30.72 a
O.c. Cv Avila	37 a	16.8 ab	4125.6 bc	2.05 ab	38.42 a	27.92 ab
T.i. Cv Caprera	34 a	18.8 a	4792.7 ab	2.06 ab	32.46 ab	30.68 a
T.h. Cv Hykon	33 a	18.5 a	4666.6 ab	2.08 ab	32.48 ab	34.38 a

Treatments	Leaves (number)	Plant height (cm)	LA (cm^2)	Dry matter ($t\ ha^{-1}$)	Plant N uptake ($kg\ ha^{-1}$)	Yield ($t\ ha^{-1}$)
T.sp. Cv WCT36	35 a	14.1 ab	4306.3 abc	2.20 ab	35.40 ab	29.73 a
O.c. Cv Santorini	32 ab	17.6 ab	4102.2 bc	2.05 ab	35.21 ab	29.98 a
B.p. Cv Mauro	32 ab	16.6 ab	4006.4 bc	2.20 ab	28.93 ab	31.33 a
T.g. Cv Prima	31 ab	16.6 ab	4506.0 ab	2.15 ab	33.99 ab	31.23 a
M.s. Cv Orion	32 ab	15.1 ab	4610.6 ab	1.97 abc	27.62 ab	29.73 a
B.p. Cv Casbah	33 ab	17.6 ab	4216.3 bc	2.10 ab	28.23 ab	26.48 ab
T.m. Cv Paradana	36 a	15.3 ab	4291.3 abc	2.06 ab	34.86 ab	27.81 ab
T.s. Cv Dalkeith	34 a	16.5 ab	4263.0 abc	1.71 bc	30.42 ab	22.34 ab
T.v. Cv Cefalu	33 ab	16.0 ab	2943.6 cd	1.86 abc	30.82 ab	22.69 ab
Control	24 b	13.1 b	2.461.7 d	1.49 c	21.82 b	15.21 b

LA: Leaf Area

However, the two crops showed different behaviours in terms of yield and N uptake. In the case of lettuce, yield increased an average of 92% compared with the control, while with maize it increased only by 15%. However, the uptake of N increased an average of 55% in lettuce and 113 % with maize. This means that legume treatments had a better effect on the yield of the first subsequent crop while N N was made more available for the second crop.

This could be explained either by the mineralisation effect of nitrogen that occurred during the cropping period of maize or by the root system of maize able to take nitrogen from a deeper level.

Table 2. Effect of legume treatments on maize (at harvest time)

Treatments	**Plant height (m)** (m))	Dry matter ($g\ m^{-2}$)	Plant N uptake ($kg\ hs^{-1}$)	Grain yield ($t\ ha^{-1}$)	Weed control (m^2)
T.s. Cv York	2.48 de	106.76 a	154.33 b	9.09 a	5 a
M.s. Cv Orion	2.64 bcde	110.97 a	205.16 a	7.61 bcd	5 a
T.s. Cv Dalkeith	3.04 a	78.30 bc	131.88 d	8.09 b	4 a
T.i. Cv Caprera	2.78 abcd	74.49 bc	112.99 e	7.83 bc	4 a
T.v. Cv Cefalu	2.68 abcd	55.50 d	100.97 e	7.67 bc	6 a
T.g. Cv Prima	2.93 ab	97.62 b	150.35 bc	8.15 b	5 a
T.sp. Cv WCT36	2.97 ab	62.40 d	137.32 cd	7.63 bcd	8 a
T.m. Cv Bolta	2.88 ab	43.95 d	84.87 f	7.32 bcd	4 a
O.c. Cv Santorini	2.87 abc	52.48 d	102.87 e	7.24 bcd	6 a
B.p. Cv Casbah	2.84 abcd	72.65 bc	129.74 d	6.91 cd	5 a
T.h. Cv Hykon	2.82 abcd	79.20 bc	140.69 bcd	7.48 bcd	6 a
T.m. Cv Paradana	2.77 abcd	38.37 d	65.25 h	7.12 bcd	7 a
B.p. Cv Mauro	2.75 abcd	70.69 bc	128.62 d	7.53 bcd	5 a
O.c. Cv Avila	2.62 bcde	49.83 d	81.18 fg	7.00 cd	5 a
O.s. Cv Cadiz	2.49 cde	48.91 d	68.08 gh	7.71 bc	6 a
Control	2.3 e	29.04 e	55.93 h	6.61 d	17 b

The results also showed that legume green manure had a positive impact on weed control; in fact, the number of weed plants was very limited in plots where legume cultivars preceded maize compared to the control (by 70% on average). Through their competitive ability legume cultivars may have limited weed growth and then the production of weed seeds.

Conclusions

Annual self-reseeding legumes had positive effects on the performance of both subsequent crops (lettuce and maize). *Medicago sphaerocarpa* cv Orion, *Trifolium subterraneum* cv York, *T. glanduliferum* cv Prima, and *T. spumosum* cv WCT36 gave the best results on both crops and seem most interesting to be integrated into a rotation programme, although this conclusion should be further verified. It would be interesting to explore further the effect of N fertilisation by legume on crops over a longer term. It is also of great importance to note the effect of legumes on weed control in maize production, which is a particularly important issue in organic farming.

It can be concluded that the integration of annual self-reseeding legumes into Mediterranean organic cropping systems may contribute substantially to sustaining long-term soil fertility, satisfying cash crops' N needs, and markedly increasing production. Nevertheless, although the results are very promising, they still are very preliminary considering the short duration of the experiment, and should be explored further.

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INTERCROPPING – THE PRACTICAL APPLICATION OF DIVERSITY, COMPETITION AND FACILITATION IN ARABLE ORGANIC CROPPING SYSTEMS

Erik Steen Jensen (1), Henrik Hauggaard-Nielsen (1), Julia Kinane (1), Mette Klindt Andersen (1,2) and Bjarne Jørnsgaard (2)

(1) Risø National Laboratory, DK-4000, Roskilde, Denmak, +454677 4108, erik.s.jensen@risoe.dk
(2) The Royal Veterinary and Agricultural University, DK-2630, Taastrup, Denmark.

Key Words: Intercropping, grain legumes, cereals, yield advantage, resource use, nitrogen fixation, leaf diseases, weeds, grain quality.

Abstract

Intercropping (IC) is the simultaneous cultivation of more than one crop species on the same piece of land. The IC practice offers many advantages to organic agriculture in terms of resource , yield stability, weed management, and increased diversification of agroecosystem. Field experiments carried out at two sites in Denmark over three consecutive cropping seasons showed that IC of cereals and grain legumes higher yields, less weeds, lower infection with plant diseases, and higher grain quality compared to corresponding sole crops.

Introduction

Planned diversity in time through crop rotation is a key element in an organic cropping system. Arable crop rotations consist mainly of sole crops (monocrops, pure stands), the more diverse pastures being an exception. Prior to the mechanization of agriculture and the introduction of pesticides and synthetic fertilisers, the cultivation of crop mixtures (intercrops) was common; today, however, most crops are grown as sole crops. Organic crops are commonly assumed to be more diverse, but in most arable organic systems this is not the case. Cropping systems are based on rotations of single genotype crops, although crop diversity is known to be a strong management tool (Altieri 1999). Intercropping, the simultaneous cultivation of more than one species in the same field (Willey 1979) is the practical application of basic ecological principles such as diversity, competition, and facilitation. Intercropping has been reported to enhance yield and yield stability (Willey 1979), increase resource use efficiency, especially of nitrogen (Jensen 1996), and reduce weed infestation (Hauggaard-Nielsen *et al*. 2001) and the occurrence of plant diseases and pests (Altieri 1999). Intercropping may also influence subsequent nutrient losses e.g. by reducing the nitrate leaching potential after grain legumes (Hauggaard-Nielsen *et al*. 2003). The aim of this three-year study was to determine how intercropping barley (*Hordeum vulgare*) and grain legumes (pea [*Pisum sativum*], faba bean [*Vicia faba*], narrow-leaved lupin [*Lupinus angustifolius*]) in organic systems on two soil types in Denmark affects yield performance, nitrogen (N) use, weed growth, leaf diseases, and grain quality.

Methodology

The field experiments were carried out in 2001-2003 at two different sites in Denmark: on a sandy loam soil and a sandy soil. The temperatures were comparable at the two sites, whereas a higher rainfall was measures at the sandy soil site during the growing season, especially in June. Two field pea cultivars (Agadir (A) and Bohatyr (B)), faba bean (Columbo) and narrow-leafed lupin (Prima) were grown as sole crops (SC) and in two-species intercrops with two spring barley cultivars (Otira (O) and Lysiba (L)). The experimental plots were laid out in complete one-factorial randomized block designs in four replicates. The intercrop design was based on the proportional replacement principle, with mixed grain legume and barley grain sown at the same depth in the same rows 12.8 cm apart at relative frequencies of 50:50. An extra barley sole crop treatment fertilized with 5 g N m^{-2} in the form of urea was included. In some years additional ICs consisting of three- (33:33:33) and four-species (25:25:25:25) intercrops were included. Crops were cultivated according to organic management practice. Diseases were scored following natural inoculation from surrounding areas. The crops were hand harvested at maturity ($1m^2$), in early August, and separated into three fractions, i.e. grain legume, barley, and weeds. The samples were dried at 70°C to constant weight, and dry matter (DM) production was determined. Total N and ^{15}N contents were determined using an elemental analyzer coupled to an isotope ratio mass spectrometer, and the acquisition of N from different sources was estimated using the natural abundance method (Peoples *et al*. 1997). Data was analyzed statistically using analysis of variance; and $LSD_{0.05}$ was used for comparison when main effects or interactions were statistically significant.

Results and brief discussion

Combined intercrop grain yields were comparable to grain yields of sole cropped pea, but significantly greater than sole cropped lupin, faba bean and barley yields (Fig. 1). In descending order, the greatest grain yields were obtained for intercrops containing pea, faba bean, and lupin. Pea was the dominant intercrop component on both soil types with no significant difference between cultivars. Faba bean dominated in the intercrop on the sandy loam soil, but not on the sandy soil. Lupin was suppressed by barley at both sites. Land Equivalent Ratios (LER) (Willey 1979) varied between 1.09 and 1.36, indicating strong complementarity and advantage from intercropping. In contrast to results from Jensen (1996), yield stability of intercrops was not greater than that of grain legume sole crops, with the exception of the intercrops that included faba bean (Fig. 1).

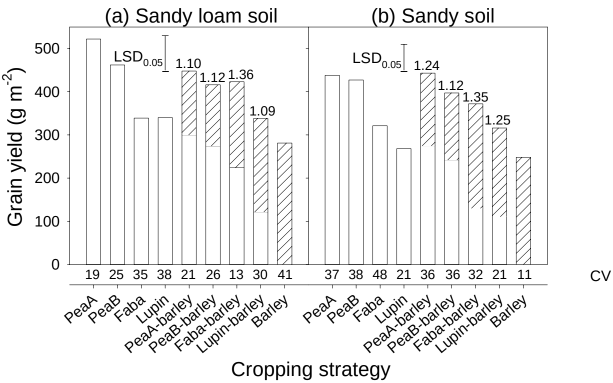

Figure 1. Average grain yields, yield stability (indicated below the x-axis as %CV on average yields) of sole (SC) and intercrops (IC) of two pea cultivars (Agadir and Bohatyr), barley (Otira), faba bean and lupin, grown at two study sites (a and b) during 2001-2003. Measures of intercropping advantage estimated using the Land Equivalent ratio (LER) are given on the top of IC bars. $LSD_{0.05}$ between crop treatments is given by floating bars

The proportion of plant N derived from N2 fixation by the grain legumes was on average 10% greater when intercropped compared to sole cropped (Table 1), with faba bean and lupin increasing the proportion up to 20% (data not shown). Intercropped barley was able to take up a more than proportional share of available soil N, thus forcing the grain legumes to to fulfill their N demand through atmospheric N_2 fixation. In the intercrops, N_2 fixation per area decreased with increasing barley suppression of the pea, indicating that the barley L cultivar is better suited for intercropping than the O cultivar. The N_2 fixation of faba bean and lupin was reduced by competition from barley to a greater extent than was the case for both pea cultivars (data not shown). Intercrops utilized the soil N sources as efficiently as did the sole crops. Soil N balances showed that in the long term grain legume-cereal intercrops are not likely to increase soil inorganic N levels, but rather deplete them, although at a slower rate than in barley sole cropping (Table 1). Weed infestation levels in the intercrops were comparable to the barley SCs, pea SCs and pea ICs but decreased compared to the faba bean and lupin ICs grown on the sandy loam soil (Fig. 2). The data confirm that intercropping may be a means to reduce weed infestation in grain legumes on soils with high weed pressure. Barley–grain legume intercropping affected disease severity compared to sole cropping. Net blotch (*Pyrenophora teres*) was the most serious disease on barley during all three years (up to 25% leaf area affected). Up to 10% Ascochyta blight was observed on pea. Chocolate spot was the most serious disease on faba bean (up to 25% leaf area affected). Botrytis and brown spot were observed on lupin in the sandy soil, but at very low levels. A general reduction (by a minimum of 20%) in disease was observed in all intercrop systems compared to the corresponding sole crop (data not shown). The magnitude of the reduction varied according to 1) dispersal mechanism of the diseases, 2) height of the crops, and 3) anatomy of the accompanying crop, e.g. full leaf pea gave a larger reduction than semi-leafless pea. For net blotch we analyzed whether increasing the crop diversity up to four species would further reduce net blotch in barley, but there was no effect of increasing diversity beyond two-species ICs (Fig 3).

Table 1. Total nitrogen and soil N uptake in sole and intercrops of two barley (Otira and Lysiba) and two pea cultivars (Agadir and Bohatyr). N_2 fixation and the %N derived from N_2 fixation by the corresponding legumes. Soil N balance for each crop treatment calculated as N inputs from sown seeds and N_2 fixation by pea minus grain N output. For further information see figure 1.

Cropping strategy	Total N	Soil N	N_2 fixation	% N derived from N_2 fixation	Soil N balance g N m^{-2}
	g N m^{-2}				
SC Barley O	5.0	5.0	-	-	-3.8
SC Barley L	4.5	4.5	-	-	-3.3
SC Pea A	20.5	6.0	14.5	61	1.9
SC Pea B	19.2	5.7	13.5	62	2.0
IC Barley O x Pea A	14.6	5.1	9.5	68	-0.3
IC Barley O x Pea B	14.1	5.5	8.6	68	-0.6
IC Barley L x Pea A	17.5	5.0	12.5	72	0.6
IC Barley L x Pea A	17.7	4.6	13.1	70	1.3
$LSD_{0.05}$	3.6	1.8	2.9	-	1.4

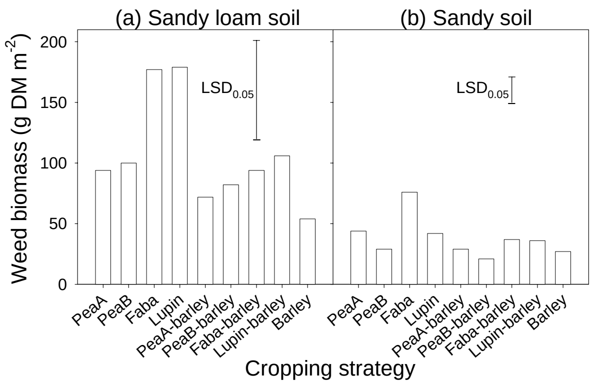

Figure 2. Weed biomass in sole and intercrops of pea, barley, faba bean and lupin (see also fig. 1).

The effects of intercropping with faba bean and lupin did generally not influence the grain quality of barley; however, the grain N concentration of barley intercropped with pea was significantly higher than that of the comparable sole crops, an intercropping effect that was greater than the effect of N fertilization (Fig. 4). This effect on protein concentration is likely the result of competition between species. Since grain legumes compete less efficiently for soil N sources than cereals, relatively more soil N is available to the cereal, but since grain legumes compete for other growth factors, such as light, water, and non-N nutrients, cereals may not increase their yield in direct proportion to the amount of N available. Thus, the N concentration in DM is enhanced. Intercropping seems to be a interesting method for securing higher levels of protein in cereals grown in low input agriculture.

Conclusions

We conclude that the intercropping of arable crops has great potential in organic cropping systems. Intercropping may enhance and stabilize yields, reduce weeds, and plant diseases and improve resource use. Improved understanding of the ecological mechanisms associated with planned spatial diversity, including additional benefits with associated diversity, will potentially enhance the benefits achieved from intercropping.

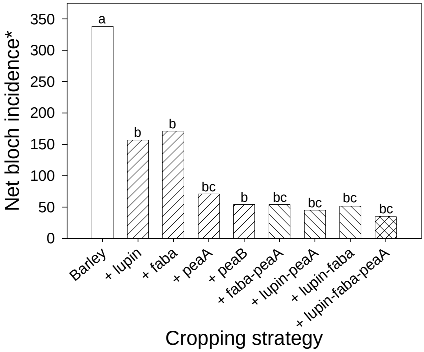

Figure 3. Effect of two-, three- and four-component intercrops of barley, lupin, faba bean and pea on incidence of barley net blotch.* Disease incidence measured as Area Under Disease progress Curve (AUDPC). Different letters indicate significant (P<0.05) differences using the Kruskal-Wallis test. For further information see figure 1.

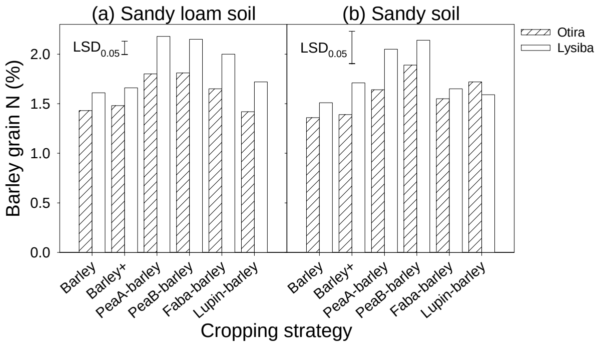

Figure 4. Nitrogen concentration of grain from barley grown as sole and in intercrop with pea, faba bean or lupin. Barley + indicates treatments of sole crop barley with addition of 5 g N m^{-2}. For further information see figure 1.

Acknowledgement

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NO-TILL ORGANIC SOYBEAN PRODUCTION FOLLOWING - A FALL-PLANTED RYE COVER CROP

Paul Porter (1), Gary Feyereisen (2), Jason De Bruin (3), Gregg Johnson (4)

(1) Univ. of Minnesota, 1994 Buford Circle, St. Paul MN, USA, Tel. 612-625-6719, E-mail: pporter@umn.edu

(2) USDA-ARS,2316 Rainwater Rd, Tifton GA USA 31793 Tel. 229-386-3504, gfeyereisen@tifton.usda.gov

(3) Iowa State Univ., 2104 Agron. Hall, Ames IA USA 50011, Tel 515-294-6869, E-mail: jsndbrn@iastate.edu

(4) Univ. of Minnesota Southern-ROC, Waseca MN USA, Tel. 507-837-5617, E-mail: johns510@umn.edu

Key Words: no-till organic soybean production, rye, cover crop, nitrogen scavenging, RyeGro model

Abstract

The conventional corn-soybean rotation in the United States (USA) is a leaky system with respect to nitrate-nitrogen (nitrate-N), in part because these crops grow only five months of the year. Ecosystem functioning can be improved with the use of an appropriate fall-planted cover crop, but this practice is not common. Organic soybean production in the USA typically relies on delayed planting, crop rotation, intensive harrowing and interrow cultivation for weed control. Research on timing of shredding of a fall-planted winter rye (*Secale cereale L)*, cover crop in the spring after soybean have been no-till planted into the standing rye has shown this practice can work for organic producers. On-farm and on-station research in Minnesota (MN) has documented the importance of rye sowing date, proper field equipment, and timely field operations. A newly developed rye growth model (RyeGro) predicts rye biomass accumulation and nitrate-N scavenging capabilities of this system.

Introduction/Problem

The corn (*Zea mays* L.) – soybean (*Glycine max* [L.] Merr.) rotation is the predominate rotation in much of the Midwestern USA. In many counties of this region over eighty percent of the total landscape in a given year is planted to one of these two crops (Porter, 2000). Nitrate-N leaching from this landscape is known to be associated with the hypoxic zone in the northern Gulf of Mexico just beyond the mouth of the Mississippi River (Rabalais *et al*., 2001). There is recognition of the need to reduce the nitrate-N loss from conventional production fields (Randall *et al*., 1997).

The majority of organic soybean production in the USA occurs in the Midwestern states of MN, Iowa, Wisconsin, Michigan, and Ohio. In 2001 these 5 states accounted for sixty-two percent of the total USA certified organic soybean acreage (Greene and Kremen, 2003). The majority of this acreage is planted on 76-cm rows with a combination of rotary hoeing/harrowing and inter-row cultivation for weed control. Intensive cultivation is one of the major criticisms of organic production because of its detrimental impact on some soil quality parameters. Agronomic practices that reduce the need for cultivation are important. Lengthening the crop rotation to include perennial crops such as alfalfa (*Medicago sativa* L.) is one method of reducing cultivation intensity. The benefits of a four-year rotation with respect to yield and economic returns in organic production systems in this region have been documented (Mahoney *et al*., 2004; Porter *et al*., 2003). Planting soybean into a standing winter rye cover crop provides another method of reducing cultivation intensity in organic production systems. The practice of no-till drilling conventional soybean into a fall-planted winter rye cover crop has been shown to reduce nitrate-N leaching from artificial subsurface tile drainage; a water management practice that is common in the region (Strock *et al*., 2004).

Methodology

Over the past six years researchers and graduate students at the Univ. of MN have evaluated growing no-till soybean after a rye cover crop following conventional and organic production practices. Our research has focused on monitoring nitrate-N and flow characteristics of subsurface water with and without a rye cover crop; rye variety selection for increased early season biomass and earlier anthesis; timing and method of rye management where the subsequent crop is soybean; site-specific variability in rye biomass and soybean yield; and modeling the potential for a rye cover crop to reduce field nitrate-N loss. These research efforts have involved replicated trials conducted on Univ. of MN Agriculture Experiment Stations. Simultaneously, on-farm research / demonstrations have been conducted in collaboration with conventional and organic producers. These production-scale sites involved the use of a rye cover following corn or wheat (*Triticum aestivum* L.) and preceding no-till soybeans.

Results and discussion

Field research has documented the capability of a rye cover crop to scavenge excess nitrogen and moisture from the soil profile (Strock *et al*., 2004). In a study conducted at the Southwest Research and Outreach Center (SWROC) near Lamberton, MN subsurface tile-drainage discharge was reduced 11% and nitrate-N loss was reduced 13% for a corn-soybean cropping system with a rye cover crop following corn than with no rye cover crop over a three-year period. The environmental benefits from this practice can have important agricultural policy implications.

As a follow-up to the Strock *et al*. (2004) study, a soil-plant-atmosphere simulation model, RyeGro, was developed to quantify the probability that a winter rye cover crop reduces nitrate-N losses in southwestern MN (Fig. 1, Feyereisen, 2005). Long-term (2500-yr) simulations using a stochastic weather generator were used to represent climatic variability of the region. The goal was to provide estimates of seasonal cumulative subsurface drainage flow and nitrate-N losses to within ±20%. The model was calibrated and validated with local data from sites at the SWROC and St. Paul, MN. Mean nitrate-N losses with and without rye were 11 and 25 kg-N ha^{-1}, respectively, from 15 Sept. (rye sowing date) through 30 May (rye kill date), a reduction of 44%. Fall sowing date dramatically affected rye biomass (Fig. 2) and efficacy of the practice: sowing dates of 1, 15, and 30 Oct. resulted in mean reductions of 31, 21, and 18%, respectively. The model inputs are relatively few and simple to obtain, facilitating use of the model for other locations in the upper Midwest (Feyereisen, 2005).

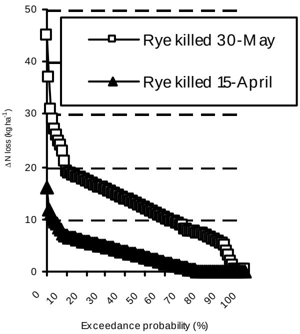

Figure 1. Exceedance probability of the difference in subsurface drainage nitrate-N losses between a corn/soybean and a corn/rye-soybean rotation (Δ N loss) for two spring kill dates when sown on 15 Sept. at Lamberton MN using the RyeGro model.

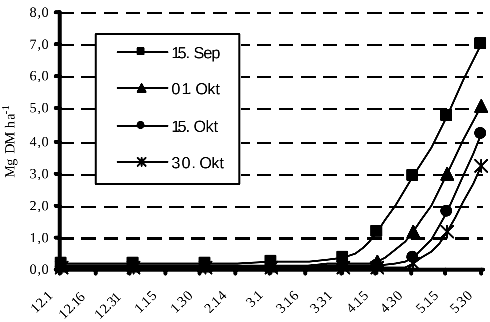

Figure 2. Cumulative rye aboveground biomass (dry matter, DM) for four fall sowing dates. The data represent mean values after 2,500 simulation years at Lamberton MN using the RyeGro model.

In a concurrent study, a corn-soybean rotation that included a rye cover crop was studied at two locations in 2002 and 2003 to evaluate rye removal timing for no-till soybean production. Fall-planted rye following corn harvest was managed the next spring by five rye and weed management strategies: (i) mowing once, (ii) mowing twice, (iii) one glyphosate herbicide application, (iv) two herbicide applications, and (v) mowing once followed by a herbicide application, with four initial mow dates beginning 1 May separated by approximately one week. Timing of rye removal influenced subsequent rye regrowth, weed growth and soybean yields (De Bruin, 2004; De Bruin *et al.*, 2005). Regrowth after mowing prior to stem elongation in early to mid-May was similar to growth of uncut rye, but decreased dramatically when rye was mowed at anthesis in early June. At Rosemount in both years low weed populations and the presence of the rye cover crop, when properly managed, had only a minimal affect on soybean yield, resulting in the one-pass mowing system being equally profitable as the no-rye two-pass herbicide system. At Waseca, where weed populations were high for several species the rye cover crop treatments without subsequent herbicide application did not provide adequate control, making these systems less profitable. Our research indicated soybean yields following a rye cover crop were often comparable to yields where no rye cover crop was grown, but economic returns were usually reduced due to cost and planting of rye seed.

Rye historically has been bred as a grain crop, not as a cover crop. Organic producers are interested in using rye as a cover crop for weed control. However, timing of rye removal is critical and must be managed in a way that provides the greatest level of weed suppression without impacting soybean yield. Trials were conducted at five locations across MN to evaluate five rye varieties for (i) increased early season biomass, and (ii) earliness to anthesis compared with common rye varieties grown in MN ('Rymin' and 'Prima') (Porter, 2001). Increased early season biomass would add ground cover and quicken canopy closure, thereby reducing weed seed germination and weed seedling vigor. When rye is removed too early, vegetative regrowth can act as a weed thus increasing the potential for reduced soybean yield. There is less potential for rye regrowth when mowed at or near anthesis (DeBruin, 2004). Typical rye varieties in MN reach anthesis in early June. A rye variety that reaches anthesis in mid- to late-May would be advantageous because it would allow for a slightly longer soybean growing season. Results indicate that there is little variation in date to anthesis among currently available rye cultivars. There was variation in early season biomass production; however, year-to-year climatic variability greatly over-shadows this variation (Table 2). A breeding program for the desired traits of earliness to anthesis and increased early-season biomass production is recommended.

In addition to year-to year variability, there can also be significant within-field variability in early-season rye biomass. Site-specific research on a certified organic field at the Southern ROC near Waseca in 2003 documented tremendous variation (as much as 100%) in rye biomass and soybean yields across the field. Variation in rye biomass and soybean grain yield was attributed to differences in soil type and soil fertility. These results suggest that site-specific knowledge about soils and pest populations is an important consideration when implementing a rye cover crop system.

On-farm research and demonstrations evaluated a number of rye varieties and agronomic management characteristics utilizing field scale equipment. Rye seeding rate and seeding date comparisons suggested that a doubling of the seeding rate from 65 to 130 kg ha^{-1} resulted in slightly more spring biomass and validated the importance of early fall seeding. Various techniques have been evaluated to manage rye prior to or following soybean seeding. Planting soybeans first, then shredding the rye reduces the likelihood of 'hair-pinning' the residue in the seed furrow with the seed and provides for better weed control. Typically in this region soybean is planted mid- to late-May and the rye is shredded at anthesis in early June, just above the soybean canopy. One drawback is that the climatic conditions don't always cooperate, and field conditions can be too wet for timely field operations.

The production of certified organic no-till soybeans following a rye cover crop is not common in the USA, but several producers have been successful with this cropping system. Reasons for their success include using proper equipment, timely field operations and proper variety choice (Porter, 2004). Seeding rye early and at a sufficient rate for good fall ground cover helps ensure better weed control. Reasons for failure include poor rye stands resulting in poor weed control, poor management timing, and equipment problems. If the rye stand is poor and the weed pressure is large, it may be advisable to use tillage to remove rye prior to stem elongation, plant wide-row soybeans, and cultivate. The impulse and desire to plant the soybean and shred the rye too quickly in the spring should be avoided.

Table 1. Rye aboveground biomass, % N in tissue, and total N uptake in early spring from five rye varieties planted at five Minnesota locations in 2001 and 2002

	---------------------------------- Location ----------------------------------					Avg. over	% of
	Morris	Lamberton	Waseca	Roseau	St. Paul	locations	Homil21
Spring 2001 rye biomass							
Rye planted:	10-Oct-00	5-Oct-00	26-Sep-00	15-Sep-00	18-Sep-00	--	--
Rye sampled:	6-May-01	6-May-01	6-May-01	30-Apr-01	7-May-01	--	--
Variety:	-- kg ha-1 --						
Rymin	79	103	238	984	2320	745	75
Dakota	48	91	200	593	2200	627	63
Homil21	118	234	471	1190	2950	994	100
Homil22	101	217	280	936	1920	692	70
Dacold	97	217	370	1210	2440	867	87
Avg.	79	154	278	878	2110	700	--
Avg. % N	3.22	3.79	4.10	2.50	2.23	3.17	--
Avg. kg N ha^{-1}	2.8	6.4	12.4	23.8	52.5	19.6	--
Spring 2002 rye biomass							
Rye planted:	27-Sep-01	28-Sep-01	18-Oct-01	6-Sep-01	27-Sep-01	--	--
Rye sampled:	15-May-02	15-May-02	15-May-02	17-May-02	10-May-02	--	--
Variety:	-- kg ha-1 --						
Rymin	872	1930	1180	1870	3390	1850	86
Dakota	969	1480	619	1690	2960	1540	71
Homil21	1110	2470	1320	1970	3930	2160	100
Homil22	1160	1980	1530	1920	3830	2080	96
Dacold	810	1810	1310	1940	3290	1830	85
Avg.	983	1930	1190	1880	3480	1890	--
Avg. % N	4.35	3.30	3.09	3.18	2.94	3.37	--
Avg. kg N ha^{-1}	43.0	63.9	36.2	59.6	101.9	60.9	--

Conclusions

The need for utilizing a winter cover crop in Midwestern USA cropping systems has been documented with respect to reducing nitrate-N loss from the landscape. In organic production systems it is possible to produce optimum soybean yields when planted no-till into a fall-planted rye cover crop. Rye is an excellent cover crop because of its winter hardiness, ability to grow at relatively low temperatures, and weed suppressing capabilities. Although there has been some evaluation of rye varieties for their early-season biomass production and reduced time to anthesis, more breeding research is necessary. The soil-plant-atmosphere simulation model RyeGro predicts spring rye biomass and nitrate-N scavenging capabilities. Timely rye fall planting and spring shredding, coupled with timely soybean planting and appropriate equipment, are necessary for this production system to work successfully.

Acknowledgments

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EFFECTS OF INTERCROPPING AND FERTILIZATION ON WEED ABUNDANCE, DIVERSITY AND RESISTANCE TO INVASION

F. X. Sans (1) , M. A. Altieri (2)

(1) Departament de Biologia Vegetal, Universitat de Barcelona. Avda. Diagonal 645, 08028, Barcelona, Spain. E-mail, fsans@ub.edu

(2) ESPM, University of California, 201 Wellman Hall 3112, Berkeley, California 94720 -3112, USA. E-mail: agroeco3@nature.berkeley.edu

Key Words: cover crop, weeds, diversity, evenness, invasion.

Abstract

This paper aims to evaluate the effects of the cover crop type *(Vicia villosa* monoculture *vs. V. villosa* and *Hodeum vulgare* polyculture) and the type of fertilization (organic *vs.* chemical) on the structure of the weed community (biomass, number of species, diversity and evenness) and its invasibility through the experimental introduction of *Brassica* sp. seeds as a target invader species. Results show that weed biomass, species richness and diversity of the weed community are significantly reduced by inter-cropping, but are not affected by the type of fertilization. In organic plots, the density increases and the complementary pattern of polyculture resource use reduces weed abundance and *Brassica* sp. invasion, while the rapid emergence and fast growth of weeds can explain the *Brassica* sp. invasion resistance in monoculture. In contrast, chemical fertilization favours *Brassica* growth.

Introduction

Cover crops have a wide variety of uses, including erosion control, improvement of the soil's physical properties, maintenance or increase of nutrient availability, pest management by attracting beneficial insects or disturbing pest life-cycles, and weed management. Cover crops can be incorporated into the soil through tillage, which is called *green manuring*, or, alternatively, cover crop residue can be retained on the soil surface through no-tillage and zone tillage techniques and used as *mulch*. The purpose of using cover crops for weed control is to replace unmanageable weed populations with a manageable cover crop. Weed suppression will be effective when crop establishment occurs before weeds appear. Furthermore, harvest and deposition onto the soil also facilitates weed control because of the germination inhibition of cover vegetal residues. Atmospheric nitrogen-fixing legumes are the main cover crop species; however, several grasses and crucifers (usually sowed together) are also used (Liebman *et al.*, 2001).

The use of hairy vetch (*Vicia villosa* Roth) as a sole crop and the addition of common barley (*Hordeum vulgare* L.) to manage weeds is studied in this experiment. Slow establishment and rapid decomposition are the main constraints of the *V. villosa* sole crop. However, the addition of *H. vulgare* means that the total biomass increases, the barley grows faster and contains allelopathic chemicals, and it adds structure for the *V. villosa* to grow on. Because of the combination of plants, the barley has a higher nitrogen content than it would if it was grown alone. The left-over biomass has a C/N ratio low enough to prevent immobilization of nitrogen and the decomposition rate decreases when it is incorporated into the soil.

While the effects of intercropping and sowing density on weed suppression have been studied by several authors (Liebman & Dyck, 1993; Mohler & Liebman, 1987; Hauggaard-Nielsen et al., 2001), few studies have evaluated the structural changes of weed communities related to intercropping and density increase (Palmer & Maurer, 1997). Taking into account that the resources use of V. villosa and H. vulgare for intercropping is higher, we hypothesise that intercropping leads to better weed population suppression and consequently to a decrease in species number and diversity and an increase of evenness. The pattern of resource availability is important to weed population management because it can affect density, emergence time and weed-crop interactions (Liebman et al., 2001). Generally, the rate of nutrient release in organic fertilization is slower than in inorganic fertilization. Several authors indicate that inorganic fertilization decreases crop competition and consequently decreases weed population suppression (Liebman & Robichaux, 1990).

The relationship between complexity and stability has attracted the interest of ecologists for a long time. Empirical and theoretical studies of invasion processes have led to the hypothesis that a high level of biodiversity may increase the resistance of a community to invasion (Elton, 1958; Rejmánek, 1989). Several studies of plant invasions, however, find little support for this hypothesis and argue strongly against it. Nonetheless, the lack of control of extrinsic factors (e.g. disturbance, climate, or soil fertility) that co-vary with biodiversity and invasion in most studies makes it difficult to determine if their findings truly refute Elton's hypothesis (Naeem et al., 2000).

Methodology

The effect of intercropping and fertilization on the structure of the weed community. The experiments were carried out simultaneously in Berkeley and Barcelona, both areas with a Mediterranean climate. Homogeneous fields at the Gill Track (Berkeley) and at the Experimental Station of the University of Barcelona were selected. At the Gill Track, three 5m x 5m areas (replicates) were delimited and four equidistant 2m x 2m plots were established, while three 3m x 7.5m areas with four equidistant 3m x 1.5m plots were delimited in Barcelona. Two randomly selected plots were fertilized with compost (500 g m^{-2}, 10.35 g N), and the other two were chemically fertilized (50 g m^{-2} de NH_3SO_4, 10 g N). Within each fertilization type, one randomly selected plot was sown with *V. villosa* (28.3 g m^{-2}) and the other with *V. villosa* and *H. vulgare* (28.3 g m^{-2} and 42.5 g m^{-2} for *V. villosa* and *H. vulgare* respectively). Aboveground biomass was periodically collected from each plot to evaluate crop and weed vegetation growth. Biomass of *V. villosa*, *H. vulgare* and weeds was evaluated in both experiments, whereas weed biomass was sorted by species in the Barcelona experiment. Biomass was dried at 60ºC for 48h to calculate aboveground dry weight.

The effect of intercropping and fertilization on resistance to invasion. The experiment was carried out at the Gill Track. Three 5 m x 5 m areas were selected and four equidistant 2m x 2m plots were established. Two randomly selected plots were organically fertilized and the other two were inorganically fertilized. One organically fertilized plot and another, inorganically fertilized, were sown with *V. villosa*, whereas the other two plots were sown with *V. villosa* and *H. vulgare*. Seeds of *Brassica* sp. (36 seeds m^{-2}) were sown 15 days after crop emergence. Aboveground biomass was periodically collected from each plot to evaluate crop and weed vegetation growth. Biomass of *V. villosa*, *H. vulgare*, *Brassica* sp. and weeds was evaluated periodically. Biomass was dried at 60ºC for 48h to calculate aboveground dry weight.

Statistical analysis. The effects of crop type (sole *vs.* intercrop) and fertilization (organic *vs*. chemical) on the crop and weed biomass, weed suppression and resistance to invasion were studied by an analysis of variance. The structure of weed vegetation was evaluated in terms of species richness, Shannon diversity index (H') and evenness (J). The effects of crop type and fertilization on species richness, diversity and evenness were also studied by an analysis of variance. Data were transformed where necessary to achieve normality and homoscedasticity of residuals. A non-parametric Kruskal-Wallis test was used when transformed data were not normalised. Analyses were carried out using the SPSS Statistical Package (2002).

Results and brief discussion

The effect of intercropping and fertilization on the structure of the weed community. Crop biomass was significantly greater in intercropping than sole crop plots (Barcelona: $F1,11 = 35.08$, $p \leq 0.001$); Berkeley: $\chi 2 = 8.396$, d.f. = 1, p = 0.004). Weed biomass was significantly greater in monoculture than polyculture plots (Barcelona: $F1,11 = 62.25$, $p \leq 0.001$; Berkeley: $\chi 2 = 8.396$, p = 0.004). Weed suppression, assessed as the relationship between weed biomass and total biomass, was significantly higher in polyculture than monoculture in the Barcelona ($F1,11 = 47.39$, $p \leq 0.001$) and Berkeley ($F1,11 = 53.27$, $p \leq 0.001$) experiments, whereas weed suppression was not related to fertilization (Barcelona: $F1,11 = 1.50$, p = 0,255; Berkeley: $F1,11 = 1,60$, p = 0,246). Species richness was significantly higher in monoculture than polyculture plots ($F1,11 = 20.45$, p = 0.002). The number of species did not vary significantly with the fertilization type ($F1,11 = 0.16$, p = 0.705). Diversity was significantly higher in monoculture than polyculture plots ($\chi 2 = 5.66$, d.f. = 1, p 0.017). Furthermore, diversity was significantly higher in organically fertilized monoculture plots than in inorganically fertilized monoculture plots ($F1,5 = 36.00$, p = 0.004). Evenness was significantly higher in organically fertilized ($F1,9 = 66.39$, $p \leq 0.001$) and polyculture plots ($F1,9 = 9.31$, $p \leq 0.023$).

Our results show that cover crops are an important component in several rotation systems and offer the possibility of suppressing weed populations through competition. Both cover crops pre-empt resources and consequently reduce weed population growth. However, weed suppression was lower in V. villosa sole crop. The inability to suppress weeds in plots sowed with V. villosa in Berkeley was due to slow establishment of the crop and the rapid emergence and growth of weeds (Figure 1). Mohler and Liebman (1987), Hauggaard-Nielsen et al. (2001) and Haymes & Lee (1999) also found that cereal addition to legume monocultures increases weed suppression. No differences in the competitive ability of crops related to fertilization treatment can be explained by the chemical fertilizer used because ammonium sulphate mimics the organic fertilizers because the ammonium goes though nitrification to nitrate before most plants can uptake it.

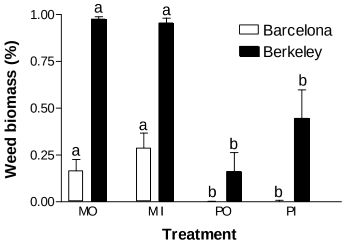

Figure 1. Weed suppression, assessed as the relationship between weed biomass and total biomass, related to the cover crop type, monoculture of *Vicia villosa* (M) and polyculture of *V. villosa* and *Hordeum vulgare* (P), and the fertilization type, organic (O) and inorganic (I). For each experimental station, columns with a different letter indicate significant differences between treatments with the LSD test, p ≤ 0.05.

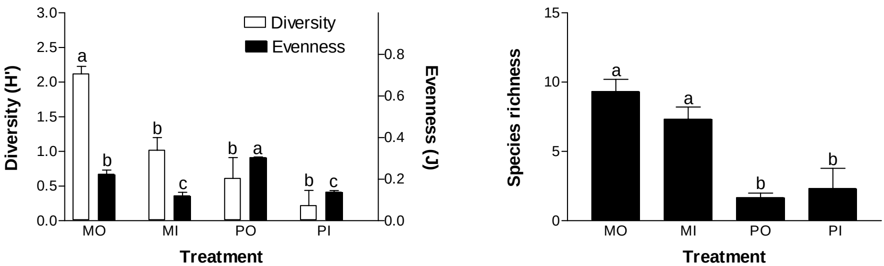

Figure 2. Species number (right), diversity and evenness (left) related to the cover crop type, monoculture of *Vicia villosa* (M) and polyculture of *V. villosa* and *Hordeum vulgare* (P), and the fertilization type, organic (O) and inorganic (I). Columns with a different letter indicate significant differences between treatments, p ≤ 0.05.

Competition intensity was more important in controlling species richness and relative abundance than crop species diversity. The density increase and complementary resource use of the intercrop minimizes niche overlapping and competition among species, making it possible to pre-empt a greater amount and wider range of resources than sole crops (Vandermeer, 1989). These results are in accordance with the hypothesis that intercropping suppresses weed populations and consequently decreases species richness and diversity and increases evenness. Mohler & Liebman (1987) also found that more productive crops have lower weed biomass and species number and also reduce the relative importance of dominant species. Complementary studies by substitution series at different densities make it possible to separate effects of density and crop diversity.

<u>The effect of intercropping and fertilization on resistance to invasion.</u> Crop growth was significantly higher in polyculture than monoculture ($F_{1,11}$ = 17.07, p = 0.003) with regard to barley because the biomass of hairy vetch did not vary ($F_{3,11}$ = 0.25, p = 0.859). The poor growth of hairy vetch in monoculture plots led to an important increase of weed biomass (χ^2 = 8.196, p = 0.004). *Brassica* sp. biomass was higher in inorganically than organically fertilized plots, although only marginally ($F_{1,11}$ = 4.176, p = 0.075). The importance of invasion, evaluated as the relationships between the *Brassica* biomass and the total biomass, was significantly higher in inorganically fertilized plots ($F_{1,11}$ = 5.57, p < 0.05). Our results show that

organic fertilization increased the resistance to invasion in the *V. villosa* sole crop and *V. villosa* / *H. vulgare* intercropping. In organically fertilised plots, the density increase and complementary pattern of resource use in the intercrop reduced the establishment of weed populations and *Brassica* sp. invasion, whilst rapid emergence and fast growth of weed populations can explain the invasion resistance in the *V. villosa* sole crop. In contrast, chemical fertilization favours *Brassica* growth. Liebman (1989) and Liebman and Robichaux (1990) indicate that fertilization by ammonium sulphate decreases a crop's ability to compete for light and nitrogen and consequently increases leaf area, photosynthetic rate and growth of *Brassica hirta*. As indicated by Liebman *et al.* (2001) the fast nutrient release of chemically fertilised conventional systems is usually of advantage to weeds because their nutrient uptake during the early phases is faster and more efficient than that of crops and consequently offers competitive advantages, particularly at high density.

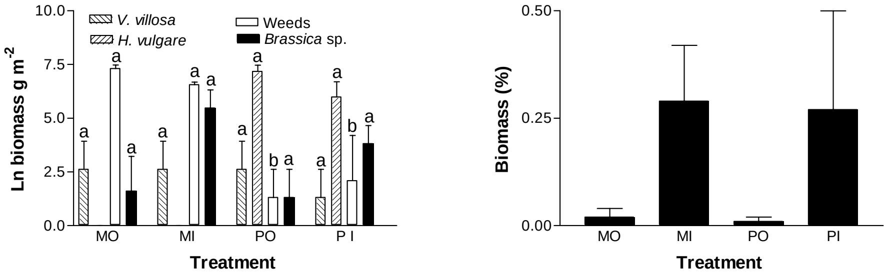

Figure 3. Biomass of Vicia villosa, Hordeum vulgare, weeds and Brassica sp. (left) and invasion success (right), assessed as the relationships between the Brassica sp. biomass and total biomass, related to the cover crop type, monoculture of V. villosa (M) and polyculture of V. villosa and H. vulgare (P), and the fertilization type, organic (O) and inorganic (I). For each biomass compartment, columns with a different letter indicate significant differences between treatments, $p \leq 0.05$.

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NUTRIENT MANAGEMENT OF ARABLE CROPS IN CLOSED CYCLES

NITROGEN MANAGEMENT OF ORGANIC WINTER WHEAT: DECISION-MAKING THROUGH MODEL-BASED EXPLORATIONS

C David (1), MH Jeuffroy (2), JM Meynard (3)

(1) ISARA Lyon , 31 place Bellecour Cedex 02, 69288 Lyon, France, davidc@isara.fr
(2) U.M.R. d'Agronomie INRA-INA PG, BP01, 78 850 Thiverval Grignon, France, jeuffroy@grignon.inra.fr
(3) INRA SAD, BP01, 78 850 Thiverval Grignon, France, meynard@grignon.inra.fr

Key words: Organic wheat, N management, decision-tool, model

Introduction

In organic wheat, nitrogen is one of the key limiting factors responsible for irregular productivity and low quality (David et al, 2005b), 5 to 50 % less than conventionally managed crops (Nieberg and Schulze Pals, 1996). On arable farms, the decreasing use of N-organic sources such as forage legumes, manures and composts relative to mixed-farms requires the development of suitable fertility strategies based on the use of off-farm organic fertilizers. Numerous mechanistic crop models simulating the dynamics of crop requirements and N supply in the soil (e.g. CERES, EPIC, APSIM, ARCWHEAT STICS) have previously been developed (Whisler et al, 1996). Although these models are highly used in research, their complexity and input requirements have limited their practical use for farmers and advisers. The aim of this study was to develop an engineering approach (Passioura, 1996) by the development of a decision-making tool for assessing N management of organic wheat on commercial farms. Azodyn-Org crop model was developed in organic agriculture to predict the influence of spring N fertilization strategies on grain yield, grain protein content, mineral N in the soil at harvest and gross margin (David et al., 2004). This simpler model requires little input data, which are easily measured in farmers' fields (soil characteristics, climatic data, crop biomass and mineral N in the soil at the end of winter). The performance of Azodyn-Org was relevant for selecting appropriate strategies in a large range of environment and crop management conditions (David et al., 2005a). This paper focuses on the potential contribution of model-based explorations from Azodyn-Org for managing N fertilization in organic wheat crops at the regional scale.

Materials and methods

A scenario analysis exercise was conducted within the collecting areas located in the Rhône-Alpes region (France) under different cropping systems. The collecting areas were characterized by weather and soil conditions defining 12 different situations. In this illustration, two farming systems were compared - mixed farms *vs* arable farms. The mixed farm was characterized by a lucerne (3yr)-cereal (3yr) crop rotation and regular bovine manure N application of 30 t.ha-1 (every 2yr). The arable farm was characterized by a cereal crop rotation (4yr) without organic manure application.

Rule-based simulations (Rossing et al, 1997) were developed to (1) determine the influence of cropping systems and crop management on yield performance and grain protein content, (2) evaluate the benefits of an organic N application and (3) define optimal spring fertilization strategies (N amount, and timing of application and frequency) according to farmers' conditions. First, the incidence of N amount from 0 to 180 kg. N.ha-1 was evaluated under three reference stages of application (Zadocks 25, 30 and 32). Secondly, the optimal stage of application and frequency was defined, for the optimal N amount, from tillering stage to the last leaf emergence. The simulations were done over 15 years historical weather information.

The fertilization strategies were evaluated according to the gross margin, calculated as :

GM pred = CAPs + (Y pred * Pip) - Vc

CAPs : Community Agricultural Policy subsidy fixed at 275 €.ha-1

Y pred : Predicted yield in t.ha-1

Pip : Price in €.t-1considering the predicted protein level

The references, based on existing prices, defined the values of 21.3 €.t-1 under 9 g per 100 g and 29 €.t-1 at 9 g per 100 g. Above 9 g per 100 g, 0.8 €.t-1 was added for each 0.5 g per 100 g in protein concentration to reach 33.5 €.t-1 above 12 g per 100 g.

Vc : Variable costs in €.ha-1 with Vc = Vo + (Ni*Pf + a*10)

Vo : other costs including labour force and equipment (soil preparation, weed control and harvesting) as 198 €.ha-1

Ni : Nitrogen input in kg N.ha-1

Pf : Organic fertilizer price as 3.5 € per kg.N-1

a : number of N applications

The fertilization strategies were selected and ranked when the relative gross margin compared to non-fertilized treatment was above 75 €.ha-1; this threshold was defined to represent the mean significant difference (test with LSD<0.05) on gross margin between two treatments (David et al, 2005a).

Results and brief discussion

Influence of environmental conditions on N management

The first goal of the model-based approach was to determine the influence of soil and weather conditions on yield performance and protein content. Figure 1 illustrates the incidence of soil and weather conditions on an unfertilized wheat crop. This approach can be used to draw quality territories within the collecting area, taking into consideration existing farming systems and fertilization practices (information easily obtained through farm enquiries, advisers' expertise or statistical data).

Influence of farming systems on N management

Another goal of our approach was to evaluate the N contribution of the cropping systems to yield performance, grain protein content, and gross margin. Figure 2 illustrates the incidence of farming systems on gross margin; On mixed farms, N contribution from lucerne and organic manures induced yields that frequently were above 4.5 t.ha-1 linked with variable protein content from 9 to 11.5 g per 100g. On arable farms, yield was frequently under 4.5 t.ha-1 linked with protein content around 10 g per 100g.

Agronomic and economic interest of spring N application

Rule-based simulations allow one to define optimal fertilization strategies according to agronomic conditions (soil and weather conditions, influence of other limiting factors, cropping systems); For instance, the optimal rate of N applied varied from 30 to 150 kg N ha-1 and timing of N application varied from Feekes 5 to Feekes 7 on a wheat crop where limiting factors were controlled (data not shown). Thus Azodyn-Org helps to define agronomic conditions where spring N application was of economic interest or guaranteed improvement of the grain protein content above the millers' requirement (i.e; 10.5% in France).

Influence of limiting factors

David et al, (2005a) concluded that Azodyn-Org was relevant for selecting appropriate strategies only if the effects of major limiting factors (e.g. weeds, diseases, soil compaction) on yield were well known (the model could accept an estimation error around 20%). Figure 3 illustrates the effect of limiting factors (weed competition, soil compaction, water stress, etc.) on relative gross margin given by optimal strategies. The relative gross margin was between 100 and 300 €.ha-1 under controlled situations, while it was under 150 €.ha-1 under uncontrolled situations. The development of an early risk-assessment method to predict the effect of major limiting factors is required before this tool is provided to users (David et al, 2005b).

Conclusion

This model-based approach could help users to adapt the farmer's production according to their agronomic conditions (weather and soil conditions, farming systems, control of limiting factors) and to optimize segregation of harvested organic wheat related to agro-industrial requirements (millers, biscuit, noodles, livestock feed), on the basis of their possible grain protein content predicted from the model. Furthermore, this rule-based simulation models could be used for tactical exploration of wheat management aimed at adjustment of farmers' constraints and firms requirement. Further development of the tool is an ongoing activity that should improve the ability to consider the influence of others limiting factors, its user-friendliness, and its performance.

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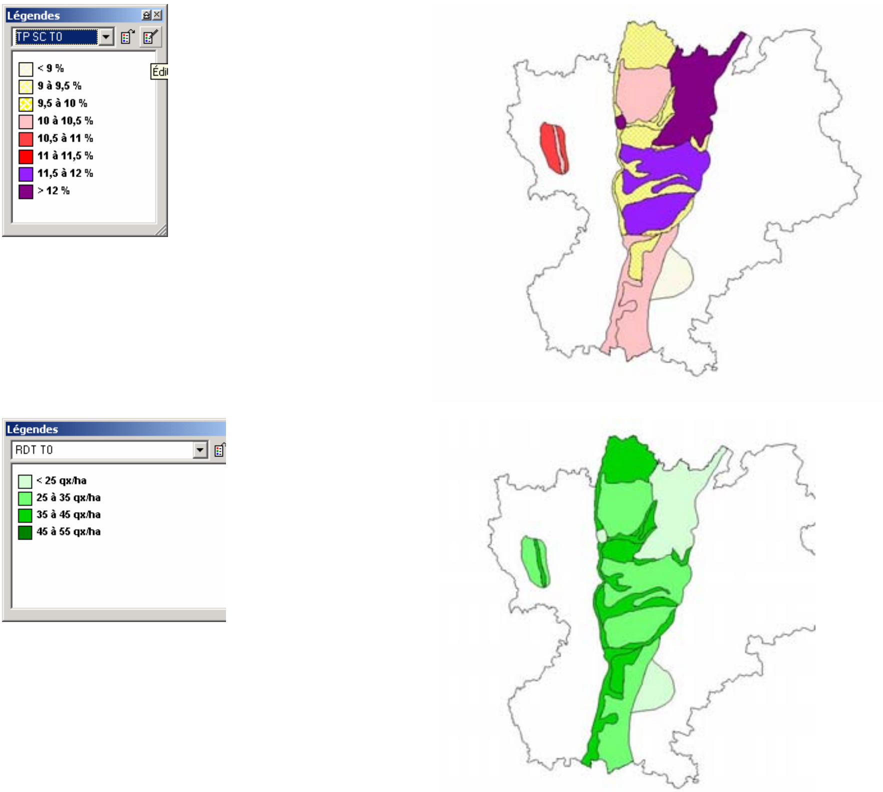
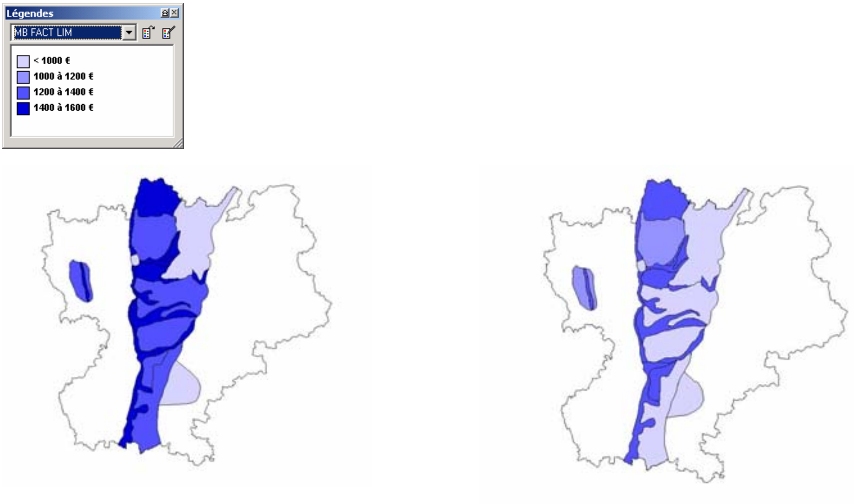


1a. Protein content (g/100g) 1b. Yield (dt.ha-1)

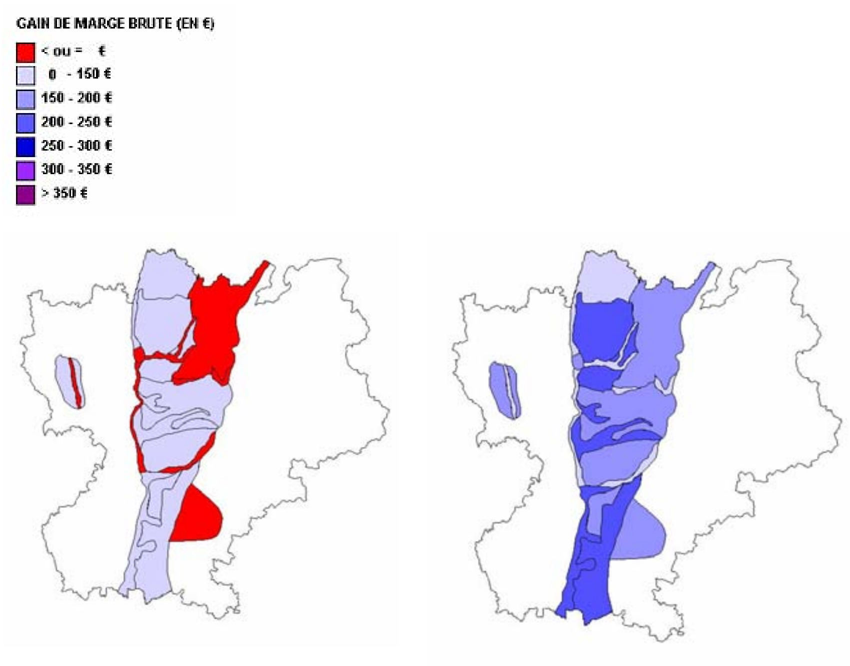
Figure 1. Influence of environmental conditions on protein level - illustration with non-fertilized treatment on wheat crop preceded by wheat



2a. Arable farms

2b. Mixed farms

Figure 2. Influence of the farming systems on gross margin - illustration with non-fertilized treatment



Controlled situations

Uncontrolled situations

Figure 3. Influence of the limiting factors on relative gross margin obtained with optimal N application - illustration on wheat crop preceded by wheat

A COMPARISON OF SOIL PROPERTIES UNDER ORGANIC AND CONVENTIONAL FARMING IN AUSTRALIA

Gunasekhar Nachimuthu, Paul Kristiansen, Peter Lockwood and Chris Guppy

Agronomy and Soil Science, University of New England, NSW 2351, Australia, Tel: +61-2-6773 2003 / 2962 / 2849 / 3567, E-mail: gnachim3@une.edu.au / paul.kristiansen@une.edu.au / plockwoo@une.edu.au / cguppy@une.edu.au, http://www.une.edu.au/agronomy

Key words: Organic and Conventional production, Australia, soil properties, review

Abstract

Organic farming is an alternative to conventional farming for providing sustainable crops with high export demand. This review analyses research findings on organic farming in Australia, with an emphasis on soil health. Several reports have indicated that organic farm management generally improves soil physical properties in Australia and elsewhere. Although low nitrogen (N) availability can constrain yields, organic farmers can improve N supply through legume green manures. Plant available phosphorus (P) is a more serious limiting factor in organic farming, particularly in Australia with naturally low P levels. Phosphorus is less easily replaced in the soil than N, and there is a need for alternate sources of organic-certified P and methods to enhance P availability from existing inputs such as rock phosphate. The role of micro-organisms in improving soil health nutrient availability is discussed, as well as the use of P accumulator crops such as *Acacia* and *Tithonia*, which could be incorporated as border crops or green leaf manure.

Introduction

Organic and low-input farming systems are an alternative to conventional farming systems, with the potential to enhance agricultural sustainability and food quality (OECD 2003, Parr 2003). Organic producers commonly report that weeds, pests and diseases are their greatest challenge; however managing soil fertility also remains a major limitation (Walz 1999). Although organic principles and practices originated in northern Europe, they have been adopted around the world in regions with vastly different soils, climates, environmental issues and production systems. In Australia, growth in organic production is estimated at 15-25% annually and is expected to continue because of strong domestic demand and Australia's ability to supply expanding markets overseas, especially in Asia (Alexandra and May 2004). While the economic prospects are promising for Australian organics, growers face some particular challenges due to infertile soils, high climatic variability and large distances between farms and input sources (Malcolm *et al.* 1996) and the use of stockless systems is also common amongst organic growers (Hudson 1996). Fertility management in Australian organic farming may not be adequately addressed with European methods. Of specific concern are the findings of Penfold (2000) and Kirchmann and Ryan (2004) which indicate that plant available P is a limiting factor in organic farming due to the low natural abundance and slow rate of release from organic-permitted fertilisers, usually rock phosphate (RP).

This review analyses research findings on soil fertility in organic farming in Australia. Due to a limited number of comparative studies in Australia, comparative trials from around the world are also considered. The review is based on scientific papers and reports in which soil characteristics are compared for organic, conventional and other farming systems

Results and brief discussion

Soil physical properties

Research reports have generally indicated that organic farm management improves soil physical properties on Australian farms, partly due to the build up of organic matter (Wells *et al.* 2000, Dumaresq and Greene 2001). An exception was Ashley *et al.* (2003) who reported that organic management increased soil penetration resistance over the short term (3 years), due to compaction from farm machinery. Organic materials are routinely used in large quantities on many organic farms and the literature generally indicates that organic farms have similar or better soil structure than conventional farms (Shepherd *et al.* 2002). Also, Shepherd *et al.* (2002) have highlighted the important role of the volume and quality of soil organic inputs used regardless of the farming systems. Sarkar *et al.*(2003) reported that addition of organic material improves the aggregate stability, moisture retention capacity and infiltration rate. The widely reported increase in organic carbon in soils under organic management underlies many of the commonly observed modifications to the physical and other properties of the soil (Wells *et al.* 2000).

Soil chemical properties

The availability of N can limit yield in some organic production because of low levels of immediately available mineral N from organic sources. On the other hand, the slow mineralisation of N from organic sources in organic systems may reduce N leaching, which causes soil acidification and contaminate ground water supplies (Wells *et al.* 2002). Several strategies are available to supply N and overcome limitation, for example, using crop rotation with legumes, green manuring and applying manure or compost (Watson *et al.* 2002, Ryan *et al.* 2004). In an Australian study of broadacre mixed farming systems, soil available N was found to be maintained in the organic system but increased in conventional system in a 8-year trial with different crop rotations (Penfold 2004). Available potassium (K) and sulphur (S) concentrations under organic farming systems have also been observed to be significantly lower under adjacent conventional systems, for example, in pasture/arable crop rotations (Nguyen *et al.* 1995) in New Zealand.

Penfold (2000) identified low soil P in Australian soils as a major limiting factor in mixed broad acre organic farming systems in South Australia, a result confirmed by Ryan *et al.*(2004) who observed that low P availability resulted in wheat yield reductions of 17 to 84% in an organic mixed farming system in southern NSW. The low P availability seen in some organic systems is a consequence of reduced P inputs due to the low solubility of RP and to the higher input cost of non-acidulated RP sources and processed animal manures relative to conventional alternatives (Penfold 2000). Recent research into soil chemical changes in intensive vegetable production showed that although the available P was lower in the organic system compared to the conventional, the available P increased from the baseline status in the organic plots and the P level was more than adequate for vegetable growing (Wells *et al.* 2000). Further research is necessary given the often slower release of P from acceptable organic RP sources (Evans *et al.* 2003). There may also be scope to increase P cycling and availability in organic systems through the use of P accumulator plants. For example, in a study in south-eastern Australia with mixed plantings of *Acacia mearnsii* and *Eucalyptus globulus*, the Acacia species not only fixed significant quantities of N, but also enhanced P cycling through litter fall (Forrester *et al.* 2005). The value of P accumulating plants such as *Tithonia* has also been reported in other low-input farming systems (Kwabiah *et al.* 2003), highlighting the potential use of perennial crops that can be incorporated in organic cropping as border crops or leafy green manures.

Soil biological properties

Soil organic matter and biological activity are generally higher under organic system than conventional systems (Dumaresq and Greene 2001). However this is not always the case, for example in England total C and microbial biomass C often showed no consistently significant differences in soils under organic and conventional management (Watson *et al.* 2002, Ashley *et al.* 2003). Where organic systems have higher biological activity, this may result from compost application which can substantially increase soil microbial biomass compared to application of chemical fertiliser. Compost application has been found to contribute to chemical and biological health in many regions of the world including Asia (Manna *et al.* 2003), Australia (Wells *et al.* 2000), and the United States (Drinkwater *et al.* 1995). The benefit to plant growth may be derived indirectly by facilitation (e.g. an improved soil biological condition) rather than the direct effect of nutrient. For example, Knudsen *et al.*(1999) found in Denmark that the population of beneficial micro-organisms was higher under organic vegetable production, and that the reverse was true of plant pathogens. Not all studies show increases in beneficial soil organisms in organic systems. For example, Scullion *et al*.(2002) observed no differences in the earth worm population in organic and conventional farms.

Biofertilisers (soil inoculants) have been identified as a means of increasing soil fertility and crop production in sustainable farming (Sivapalan *et al.* 1993). Some fungal organisms present in natural ecosystems, e.g. vesicular-arbuscular mycorrhiza (VAM), are maintained under organic farming but may be severely depressed under conventional farming, suggesting a potential loss of ecosystem function under conventional farming (Penfold 2000). Though VAM can potentially increase P uptake by acting as an extension of the plant root system, it was found to have negligible effect under intensive organic or conventional mixed cropping systems in southern Australia (Ryan and Ash 1999, Ryan *et al.* 2000). Biodynamic and conventional soils have been found not to develop significantly different processes to enhance plant nutrient uptake (Ryan and Ash 1999) and the high colonisation of VAM in an organic system did not overcome the serious P deficiency experienced in that system (Kirchmann and Ryan 2004).

As a result of the complex interactions between different system components, fertility management in organic farming relies on a long-term integrated approach rather than the more short-term very targeted solutions common in conventional agriculture (Ashley *et al.* 2003).

Conclusions

Australian organic farms differ from European farms in a number of important ways, especially variable rainfall, less fertile soils, less use of animals of farming systems, and long distances between input sources and output points. The literature shows that soil physical properties are often improved under organic farming in Australia as well as overseas. When compared to N, S and K, P management is risky particularly in Australian soils with low native P. There is a need for alternate sources of organic-permitted P and methods to enhance P availability from existing inputs such as RP. Crops such as *Acacia* which accumulate high biomass P may have the potential to provide an alternative source of P. Biological soil characteristics are also reported to improve or remain unchanged under organic systems. Organic systems that receive organic amendments such as compost and mulch commonly have an increase in microbial biomass, compared with systems without such amendments. In some Australian organic farming systems, the beneficial effects of soil micro-organisms are inadequate to supply the growing crop and maintain the soil health. In these cases there is a need for some alternative strategies to be developed for organic production to be sustainable

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PLANT UPTAKE OF SOLUBLE ORGANIC MOLECULES AS N-SOURCE

Jennifer Reeve[1], Jeffrey L. Smith[1], Lynne Carpenter-Boggs[1] and John P. Reganold[1]

(1) Department of Crop and Soil Sciences, Washington State University, Pullman, WA, e-mail: jrreeve@wsu.edu

Key Words: Organic Farming, amino acid uptake, wheat

Abstract

Plants take up nitrogen principally in the form of nitrate and ammonium; however, evidence is growing that they can also utilize organic nitrogen in the form of amino acids and soluble proteins. We are conducting research to determine whether wheat grown in soil fertilized with organic N utilizes more organic N directly than wheat grown with inorganic N. We are also testing for differences in uptake of amino acids between pre 1930s varieties and modern varieties of wheat to determine whether this trait has been selected for or against by breeding under high inorganic N input. Preliminary results show both wheat varieties Arco and Madsen take up ^{14}C labelled glycine under sterile conditions. Further experiments to determine the role of microbial competition are underway. Selecting varieties well adapted to competing for organic N could be an important means of maximizing productivity in organic and low input agricultural systems as plants gain more effective access to a wider pool of available nutrients in any given time.

Introduction

Recently, many researchers have demonstrated the important role of organic N uptake in nutrient-limited systems such as the arctic tundra (Lipson and Näsholm 2001). Both mycorrhizal and non-mycorrhizal plants have been shown to compete effectively for organic N sources (Näsholm et al. 2000). The fact the amino acids are taken up intact and not first mineralized has been demonstrated conclusively using GC-MS methods (Persson and Näsholm 2001).

It is increasingly evident that this phenomenon is not limited to arctic systems. In fact, significant organic N use has now been documented in many different natural systems the world over (Lipson and Näsholm 2001). However, whether organic N use is important in agricultural settings is still controversial. It is widely assumed that in systems characterized by high nutrient turnover and additions of inorganic fertilizers, plants would not be effective competitors for less mobile forms of nitrogen.

Research on organic N uptake by agricultural crops is very limited. The ability of several agricultural plants such as barley, castor bean and maize to take up amino acids in pure culture has been demonstrated. Chapin et al. (1993) showed that barley only grew half as well on amino acids as opposed to NO3- or NH4+. However, Schobert and Komer (1987) showed that uptake of amino acids by castor bean was similar to NO3- and NH4+. Using a model based on existing data, Jones and Darrah (1994) predicted maize could capture at least 30% of its nitrogen as amino acids depending on soil concentrations.

Yamagata and Ae (1996) showed that soil inorganic N and estimated mineralization rates did not account for total N uptake in upland rice when fertilized with rice cake. Näsholm et al. (2000) demonstrated that four species of agriculturally important hay meadow species captured up to 19-23% of total glycine supplied in situ as intact amino acid. Highest rates were observed in mycorrhizal species. In a similar experiment Streeter et al. (2000) documented uptake of amino acids by dominant grasses in temperate upland grasslands. Näsholm et al. (2001) showed that field-grown wheat was able to capture 20 % of supplied amino acid in intact form. No evidence of mycorrhizal infection was found, showing that this is not a necessary prerequisite for intact glycine uptake. However, in a laboratory experiment, Owen and Jones (2001) showed that wheat only captured 6% of ^{14}C labelled glycine over a period of 24h in competition with the microbial biomass.

An intriguing study conducted by Matsumoto et al. (2000) showed that carrot and Chinese turnip are able to take up intact proteinacious N material from the soil. Due to the relative abundance of proteins in soil, they suggest proteins may be even more important in plant nutrition than amino acids.

Even a small total capture of amino acids by crops could be highly significant in terms of overall nitrogen acquisition, especially in organic or low input systems. Scheller et al. (1997) showed agricultural soils on organic farms contained significantly higher quantities of amino acids than neighboring conventionally farmed soils. Organic N might account for a greater portion of total N uptake in agricultural systems characterized by low available nitrate but high organic matter, such as organic or low input systems.

Selective breeding under low input conditions is also crucial. Plants selected for their ability to compete effectively for organic N sources would be highly desirable in organic systems relying primarily on the decomposition of cover crops to meet N demand. This ability could give crops a critical advantage, as inorganic N release from organic sources can be slow and difficult to predict.

The role of mycorrhizae in nitrogen capture is also likely to be important. Arbuscular mycorrhizae have been shown to transfer both organic and inorganic nitrogen to their host (Hawkins et al. 2000). In addition pre 1950s wheat cultivars are known to be more heavily dependent on mycorrhizal associations (Hetrick et al. 1992).

In order to determine whether modern breeding efforts under high inorganic N input may have been inadvertently selected against the ability of wheat to take up amino acids from soil, we are testing the following hypotheses: **I.** Wheat varieties grown before the widespread introduction of inorganic fertilizers will have a greater ability to capture amino acids from soil. **II.** Wheat will take up a greater proportion of intact amino acids from soil high in organic matter and low in inorganic N.

Methodology

Seeds of two wheat varieties, Madsen (1988) and Arco (1928) were surface sterilized in 10% bleach, soaked in sterile water overnight and then planted in sterile 5ml pipette tips filled with sterilized sand and transferred to the greenhouse. After 10 d the surface of the tubes were sealed with melted paraffin wax and 2.5ml of ^{14}C labelled glycine injected into the side of the tube at concentrations of 5, 1.5, 0.6, 0.3, 0.15, 0.03 and 0mM with 5 replicates per treatment. After 24h, shoots were removed into individual test tubes and dried at 60°C. Roots were removed from the sand, washed carefully in a 0.02mM $CaCl_2$ solution, and dried as above. Dried samples were weighed before combustion in a Biological Oxidizer and the 14C measured in a Perkin Elmer liquid scintillation analyzer. Background ^{14}C levels present in the controls were subtracted from treatment values and uptake of glycine calculated as ug glycine per g of plant material.

Results and brief discussion

Uptake of glycine from sterile sand, was linear in root material in the range measured for both varieties Madsen ($y = 0.3072x – 0.0289$ $R2 = 0.99$) and Arco ($y = 0.2004x + 0.0033$ $R2 = 1$) (Figure 1). Maximum 14C labelled glycine in roots was 1.59 and 1.10 ug / g root in the two varieties respectively. Uptake of 14C labelled glycine to the shoots was also linear in Madsen ($y = 0.0112x + 0.032$ $R = 0.69$) with a maximum concentration of 14C labelled glycine of 0.09 ug / g shoot (Figure 2). Uptake into shoots was not linear in Arco, however, with maximum concentrations of 0.04 only. The difficulty in obtaining consistent results from leaf tissue has been documented in the literature and is probably due to $14CO_2$ loss through catabolism (Näsholm et al. 2000). These results indicate that the modern variety Madsen took up a larger quantity of glycine than the pre 1930s variety Arco. Visual observation suggested that Madsen had a more extensive root system, although total root mass was not significantly greater (Madsen 9.5 g vs. Arco 7.4 g, $p < 0.2$). This would suggest that enhanced root vigor might incur the added benefit of greater or faster organic N uptake. Many studies have shown significant cultivar variation in a number of root parameters such as weight, length, depth and rate of penetration and overall morphology (O'Toole and Bland 1987), prompting efforts since the 1970s to include root vigor and morphology into breeding programs. In order to determine the significance of these results these data need to be compared to similar experiments in soil so that the magnitude of microbial competition can be determined. It will also be necessary to determine the percentage of glycine to total N uptake under both high and low organic matter conditions. In order to select or develop crop varieties best suited to low input conditions, the role of arbuscular mycorrhizae in organic and inorganic nitrogen capture will need to be determined.

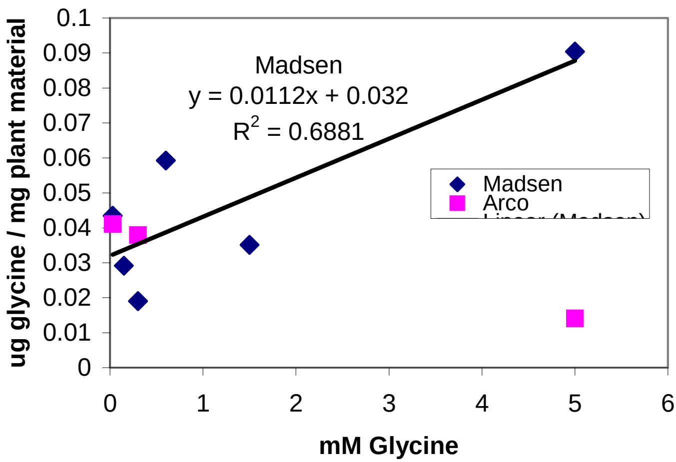

Figure 1. Uptake of [14]C labelled glycine by 10 d old wheat seedlings presented as ug glycine per mg root material at a series of glycine concentrations.

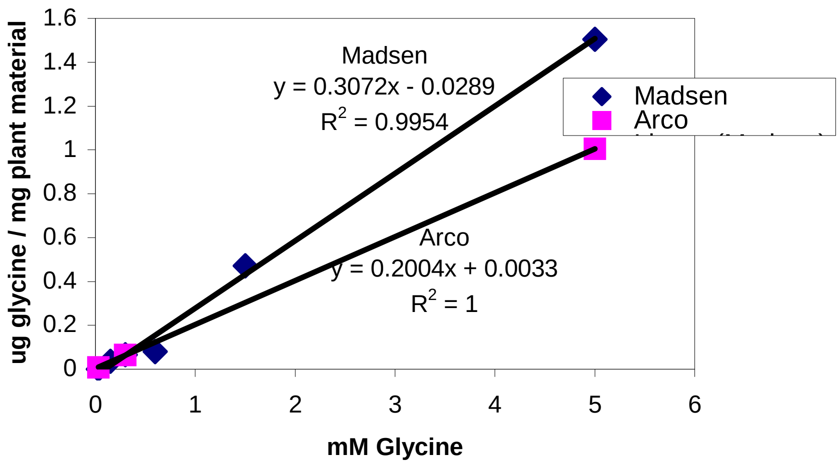

Figure 2. Uptake of 14C labelled glycine by 10 d old wheat seedlings presented as ug glycine per mg shoot material at a series of glycine concentrations.

Conclusions

- Research in organic N uptake in natural systems has already significantly impacted how we model N dynamics in natural soils and this re-evaluation must be extended to agriculture.
- Cropping systems using organic N sources are likely to increase the proportion of N uptake as organic molecules
- Genetic diversity in plant organic N uptake ability would have important implications for selective breeding of varieties suited to organic and low input cropping systems
- Uptake of organic vs. inorganic N sources is likely to affect N metabolism in the plant, with repercussions on crop health, quality and storability.

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EVALUATION OF NITROGEN UTILIZSATION BY MEANS OF THE CONCEPT OF PRIMARY PRODUCTION BALANCE

Pentti Seuri, Helena Kahiluoto

MTT Agrifood Research Finland, Huttulantie 1, FI-51900 Juva, Finland, Tel. +358 15 321230, pentti.seuri@mtt.fi, helena.kahiluoto@mtt.fi, www.mtt.fi

Key Words: nitrogen utilization, nutrient balance, primary nutrient, secondary nutrient, nutrient loading

Abstract

Primary production balance (PPB) indicates the ratio (*) between harvested nutrients and nutrients put into crop production from outside the system (=primary nutrients). The PPB is independent of the final output (crop vs. animal products) and can be used to evaluate different systems (farms). The utilization of nitrogen (N) was evaluated by means of the PPB on nine organic farms, stockless and mixed ones, in eastern Finland. The mixed farms were able to reach a remarkably higher primary production balance (1.0 – 1.2) compared with the stockless ones (0.5). Values higher than 1.0 indicate recirculation of nutrients. Other components of the high PPB were legumes as nitrogen source and optimum livestock density.

Introduction

Nutrient balances (farm-gate balance, surface balance or cattle balance) only indicate an absolute load of nutrients as a difference between input nutrients and output nutrients (kg or kg/ha); basically they do not tell anything about the efficiency of nutrient utilization.

It is also possible to count a ratio between output and input. Sometimes this type of ratio has been used as a measure of efficiency of nutrient utilization. As long as the system is simple enough, i.e. stockless farm without any recycling nutrients, the output/input ratio indicates the efficiency of nutrient utilization. However, as soon as a system involves recycled nutrients, the output/input ratios are difficult to interpret (Myrbeck 1999).

From an ecological point of view there is only one production process in the agricultural system, i.e. crop production or primary production. Primary production can be used either directly as human food or fed to animals. Nutrient load and nutrient utilization, i.e. efficiency to utilize nutrients, are two separate dimensions. If only crop products are produced, the nutrient load is less than an equal amount (kg nitrogen) of animal products, even the efficiency to utilize nutrients is equal. This is because more crop products are needed to produce an equal amount of animal products.

In order to reduce the nutrient load there are two choices: either to produce less or to improve the efficiency of nutrient utilization. Since the amount of primary production is highly dependent on the priorities in the human diet, it can be taken as a given constant. According to this assumption, the harvested yield (Y) to external nutrient input (=primary nutrients, P) ratio alone indicates the nutrient utilization in any system. The concept of primary production balance (PPB) is based on this fact (Seuri 2002).

The aims of this study were:

- To introduce a new method, primary production balance, for the evaluation of nutrient utilization
- To demonstrate and find the key factors to reach a high utilization rate of nutrients

(*) Note: the term "balance" is used to indicate a difference (input – output) or ratio (output/input); the unit of difference is kg or kg/ha, the unit of ratio is either per cent or no unit.

Methodology

A more profound analysis was made on nitrogen utilization on nine organic farms in eastern Finland. Data was collected by personally interviewing farmers in 2004. An overall picture was drawn on how the farms were functioning and, to ensure the validity of data, the results were discussed personally with the farmers. The estimations of harvested yield (dry matter & nitrogen) were adjusted with the number of animals and total animal production. The nitrogen contents of all organic materials within the system (crops, fodder, bedding materials, seeds, animal products, purchased manure) were estimated by means of standard figures, unless measured values were available. Atmospheric deposition, 5 kg nitrogen/ha, was included as input.

All the main nutrient flows were identified. However, because of the steady-state assumption (i.e. balanced systems, no change in reserve nutrients in soil) and estimation of biologically fixed nitrogen the results may include some error.

Biological nitrogen fixation was estimated using harvested legume yield: the assumption was 50 kg nitrogen per 1000 kg harvested dry matter of legume. That means that roughly 70 % of the total nitrogen content in the legume biomass originated from BNF. The assumption was derived from the Swedish STANK model (STANK 1998), the Danish model by Kristensen et al. (1995) and the Finnish model by Väisänen (2000). On all farms the most important legume was red clover. However, some white clover and alsike clover were grown in perennial mixture lays, too. Besides pea, which was the most important annual legume crop, some annual vetch was grown.

Farm-gate balance, surface balance and primary nutrient balance were calculated for each individual farm (Table 1). Primary nutrient balance can be calculated from the following two equations (Seuri 2002):

(I) PPB = Y/P where Y = total harvested yield

P = primary nutrients (=external nutrients)

(II) PPB = U x C where U = utilization rate (=surface balance)

C = circulation factor = (P + S)/P

S = secondary nutrients (=recirculated nutrients)

Equation (I) follows the definition of PPB. Equation (II) illustrates two components of PPB: utilization rate, which is equal to surface balance, and circulation factor, which indicates the importance of recirculated nutrients in the system. There is a major difference between stockless farms and livestock farms. Since there are no recirculated nutrients (S) on stockless farms, the circulation factor is always 1.0. On livestock farms the circulation factor is always higher than 1.0.

To illustrate the difference between primary and secondary nutrients and to point out the role of recirculation in order to improve the nutrient utilization, some simple simulation was made on two stockless farms. The farms produce some fodder and receive some farmyard manure (FYM) from the neighbouring farm. The initial balance (A) indicates utilization in case manure from the neighbouring farm is external nutrient input (primary nutrient). The simulated balance (B) indicates the utilization in case all the harvested fodder yield is used on the farm for dairy cattle. It is assumed that 25 % of the nitrogen in the fodder is sold out from the farm in the form of milk and beef and 25 % is lost in the gaseous form before the manure is spread on the field. The rest of the nitrogen (50%) remains in the manure.

The average utilization rate of the primary nitrogen in the agriculture in Finland was calculated from statistics. Rough estimations and comparisons were made between the farms in this study and national average utilization rates.

Results and brief discussion

The PPB of nitrogen fell in the range 1.0 – 1.2 on all mixed farms except for farm 7, i.e. the farms were able to harvest more nitrogen than they received as an input into the crop production from outside the farm.

Both stockless farms reached a PPB as low as around 0.5; the dairy farm simulation increased the PPB up to 0.8.

The SB of nitrogen fell in the range 0.6 – 0.75 on all mixed farms and by definition PPB and SB are identical in a stockless system (around 0.5), i.e. in any system without re-circulated nutrients. The FGB of nitrogen correlated strongly with production type, being around 0.3 on dairy farms and around 0.2 on beef farms. Analogously to PPB and SB, FGB was identical on stockless farms (around 0.5). The dairy farm simulation decreased the FGP down to 0.19 on farm 8 and down to 0.3 on farm 9.

Table 1. Comparison between primary production balance (PPB), surface balance (SB) and farm-gate balance (FGB) of nitrogen on nine organic farms in eastern Finland. Farms 8B and 9B are simulated from 8A and 9A, respectively.

Farm	Production type	Primary N input (kg/ha)	Total N on field (kg/ha)	Harvested N yield (kg/ha)	PPB	SB	FGB	Circulation factor	N surplus (kg/ha)
1	dairy	60	92	69	1.15	0.75	0.34	1.53	40
2	dairy	68	108	75	1.11	0.69	0.3	1.60	49
3	dairy	53	83	56	1.06	0.68	0.3	1.56	44
4	beef	69	113	84	1.22	0.7	0.18	1.64	60
5	beef	65	113	73	1.13	0.65	0.20	1.74	53
6	beef(+crop)	52	89	50	1.06	0.62	0.17	1.70	48
7	goat(+crop)	56	73	45	0.80	0.62	0.30	1.30	55
8A	crop	87	87	49	0.56	0.56	0.56	1.0	39
8B	” dairy”	63	87	49	0.77	0.56	0.19	1.39	51
9A	crop	66	66	34	0.51	0.51	0.51	1.0	33
9B	”dairy”(+crop)	49	66	41	0.84	0.62	0.3	1.36	34

Simulation on farm 8 shows clearly the role of recirculation and the difference between PPB and SB. On farm 8, the only difference between the real farm and the simulated farm is the method of definition of the origin of input nitrogen, i.e. the initial yield harvested and the initial amount of nitrogen available in the field are exactly the same. On farm 8A, all the nitrogen in FYM from the neighbouring farm is considered as primary nitrogen analogous to the nitrogen in artificial fertilizers or the nitrogen from BNF. This is analogous to any nitrogen input which increases the total amount of nitrogen in the system. On farm 8B, the nitrogen in the FYM from the neighbouring farm is considered as secondary nitrogen analogous to the nitrogen in FYM originating from the farm. This is analogous to any recycled nitrogen which does not increase the total amount of nitrogen in the system. However, the SB method does not identify the origin of the nutrients in the field, i.e. unlike PPB, SB remains constant on farm 8. The higher PPB value on the simulated farm 8B indicates higher efficiency of primary nitrogen utilization, thereby a lower nitrogen load potential.

On farm 9B there are some green manure fields, from which yield is harvested instead of ploughing directly. Therefore the SB is influenced by simulation on farm 9, but otherwise it is analogous to farm 8.

In Finland (1995 – 1999), calculation of nitrogen balance in agriculture shows that the annual total primary nitrogen input (artificial fertilizers, atmospheric deposition and symbiotically fixed nitrogen) is about 100 kg/ha. The total harvested nitrogen yield is about 74 kg/ha, respectively (Lemola & Esala 2004). Thus, the PPB in agriculture averages 74 kg/ha / 100 kg/ha = 0.74, indicating serious lack of nutrient re-cycling. However, there is huge potential to recycle nutrients in agriculture, because 80 % of the total crop yield is used as animal fodder.

In this study, all the livestock farms exceeded the value 0.74, range 0.8 – 1.2, average around 1.0. The high PPB on nitrogen was not only due to recycling but also to biological nitrogen fixation. The main source of primary nitrogen input was symbiotic fixed nitrogen by legumes. The utilization rate of nitrogen by legumes is clearly higher than for any other source of nitrogen into a system. In most cases about the same amount of nitrogen was harvested than was symbiotically fixed, i.e. the utilization rate is approx. 100%.

In addition, the balance between livestock and field area (fodder production) was of major importance in reaching a high PPB. Whenever the livestock density was increased by means of purchased fodder, the utilization of farmyard manure was poor and resulted in lower PPB (farms 3, 6 and 7). Self-sufficient fodder production was the optimum. The farms with high PPB had also a slightly higher yield level than farms with lower PPB.

On the other hand, two stockless organic farms indicated that without recirculation an organic system cannot utilize nitrogen very efficiently. On these farms the primary source of nitrogen consisted of legumes, but because the legume crop was partly used as green manure, there were heavy losses of nitrogen with resultant lower total PPB.

Conclusions

It was fairly easy to calculate the primary production balance for each of the nine farms included in this study. The estimation of biological nitrogen fixation and harvested nitrogen yield are, however, obvious sources of error. The assumption of steady state is not necessarily valid in all cases.

Even though crop production causes only minor nutrient load compared with animal production, it does not necessarily mean that crop farms utilize nutrients effectively. Using the PPB it is easy to compare different farms. The results of this study show clearly that livestock farms are able to reach a remarkably higher PPB compared with crop farms despite the very low farm-gate balance on livestock farms.

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CLOSING NUTRIENT CYCLES IN DUTCH ORGANIC FARMING: AN EXPLORATIVE SCENARIO STUDY OF AGRONOMIC CONSEQUENCES

Gerrie van de Ven (1), Jules Bos (2)

(1) Plant Production Systems, Wageningen University, P.O. Box 430, 6700 AK Wageningen, The Netherlands, +31 317 482140, Gerrie.vandeVen@wur.nl, www.dpw.wau.nl/pp/
(2) Plant Research International, Business Unit Agrosystems Research, P.O. Box 16, 6700 AA Wageningen, The Netherlands, +31 317 475938, Jules.Bos@wur.nl, www.plant.wur.nl

Key words: organic farming, nutrient cycling, linear programming, mixed farming.

Abstract

Given the principles of organic agriculture, nutrient cycling in Dutch organic farming can be characterised as imperfect, mainly because of large imports of nutrients from conventional agriculture and from abroad. Recently, research has been initiated into the perspectives for better closing nutrient cycles by intensifying the exchange of (by-)products between organic farming sectors. The linear programming model was developed to quantify under different scenarios the agronomic consequences of further closing nutrient cycles in terms of changes in land use and exchange of (by-)products.

Better closing of nutrient cycles requires an increase in the proportion of Dutch feed ingredients in animal diets, an increase in the proportion of feed and leguminous crops in rotations, an increase in the export of manure from the organic dairy sector and an increase of the import of 'acceptable' nutrients from society. Depending on the sector and the degree in which 'undesirable' nutrient imports are banned, current sizes of the main farming sectors will have to change to be in equilibrium, i.e. a situation in which total organic manure production determines organic crop areas and crop productivity per ha and *vice versa*. Closing nutrient cycles will result in an extensification of Dutch organic farming and an increase in cost prices.

Introduction / Problem

The principles of organic agriculture *inter alia* include to work compatibly with natural cycles through the soil, plants and animals in the entire production system and to create a harmonious balance between crop production and animal husbandry (IFOAM). Agriculture shaped according to these principles aims at closed nutrient cycles of N, P and K. Current Dutch organic agriculture is far from this goal: nutrient cycles at farm, regional and national scale are open and underlying nutrient balance sheets are unbalanced (Hofstad & Schröder, 2002). The cycles are open due to compensation of nutrient exports to society by imports from conventional agriculture (animal manures, feed ingredients) and from abroad (feed ingredients, mineral ores) (Bos & De Wit, 2005). For example, only 20% of the total manure N use by Dutch organic arable farmers has to be of organic origin. The majority of the organic farmers use organic inputs only according to the minimum legal requirements, as they are scarce and more expensive. Due to the lenient Dutch regulations regarding the origin of feeds and manures, Dutch organic agriculture could adopt one of the main strategies of conventional agriculture, i.e. that of specialisation. This has, amongst others, resulted in unbalanced nutrient balance sheets (Hofstad & Schröder, 2002; Prins, in prep.). Hence, Dutch organic agriculture can be characterised as strongly specialised, with as main sectors dairy and pig farming, arable cropping and vegetable cropping, and with weak links between these sectors in terms of size and exchange of (by-)products. With reference to the principles of organic agriculture and in response to expected future legislation (CEC, 2003), part of the Dutch organic community considers this situation as undesirable and has initiated research into the perspectives for better closing nutrient cycles by means of an intensification of the exchange of (by-)products between the different organic farming sectors.

Better closing nutrient cycles in organic farming requires a better mutual tuning of sectors, such that (1) total organic feed production determines the number of animals that can be kept and their production levels, and, vice versa, (2) total organic manure production determines crop areas and crop productivity per ha. Such a mutual tuning will have drastic consequences for current Dutch organic farming systems.

The aim of this paper is to analyse the effects of further closing nutrient cycles in Dutch organic agriculture. With reference to these effects, numerous 'what if' questions can be posed. Such questions addressed in this paper consider the agronomic configuration of entire Dutch organic production systems (in terms of land areas devoted to the main sectors, land use within each sector, exchange of (by-)products between sectors, productivity per ha and per animal, etc.), varying in the degree to which 'undesirable' nutrient imports from conventional agriculture and/or from abroad are banned, as influenced by contrasting scenarios for future legislation.

Methodology

Modelling enables a transparent and consistent quantification of the design of entire Dutch organic production systems and allows *ex ante* assessment of the impact of changes in the policy environment on these production systems. The linear programming model developed in this study optimises the configuration of Dutch organic farming systems, subject to a set of constraints, for one of a set of objectives by selecting from a large set of organic agricultural activities. Activities comprise sets of coherent operations, each corresponding to a particular way of producing a crop or animal product. Each activity defined is eligible for adoption in organic farming and defined by so-called input-output coefficients. Input-output coefficients are strongly linked to the goals pursued with the production system (e.g. food production, income generation, maintenance of soil fertility) and describe types and amounts of inputs required (e.g. manure, rock phosphate) and outputs produced (e.g. animal products, crop products). In addition to its contribution to the objective, each activity also claims scarce resources, such as land, animal feed or manure. The sum of the claims of all activities is then subject to a constraint, dictated either by an *a priori* set value or by the production of the resource as determined by other activities.

The values of input-output coefficients for organic systems are based on scientific literature, results from research projects with organic farmers, expert knowledge and existing models. They are specific for the Dutch situation on sand and clay soils. The sectors considered are arable and open air vegetable cropping, pig farming and dairy farming.

Definition of organic farming activities and their input-output coefficients

Defined arable activities refer to crop rotations. Nineteen crops were selected, representing root and tuber crops, leguminous crops, grain and grass crops, vegetable crops and feed crops. Crops are combined in 5500 defined 6-year rotations, using the model ROTAT (Dogliotti *et al*., 2004). The rotations are designed in such a way that soil-borne pests and diseases do not influence crop yields. If possible, a green manure crop is cultivated, the type depending on the previous and following crop. Soil structure is taken into account by alternating root and tuber crops with crops that restore soil structure (e.g. grains, grass, legumes). Crop yields, crop responses to nutrient application and effective organic matter inputs are based on experiments (Schröder *et al*., 2003), data derived from a large scale innovation project with organic arable farmers (Wijnands *et al*., 2002) and, if necessary, data on conventional agriculture (Ten Berge *et al*., 2000; Bos, 2002). If sufficient information is available, two N application rates are considered: the recommended rate for organic farming and a rate aiming at a yield of 90% of that at recommended rate. This offers a leeway towards lower nutrient inputs, or extensification, in arable farming. Products are either sold at the market or fed to livestock. For each crop rotation, crop yields, N, P and K requirements and effective organic matter input are calculated.

Input-output coefficients of organic dairy farming systems are quantified per ha grass/clover and refer to feed requirements and feed imports, annual milk production, nutrients in cattle slurry exported to the arable/vegetable cropping sector and nutrient balances. The values of the coefficients have been quantified with a model called FARMMIN (Van Evert *et al*., 2003). Feed requirements of dairy cows depend on annual milk production per cow, of which three rates are defined. Feed requirements can be met with grass/clover consumed during grazing and with conserved grass/clover, maize, grains and/or field beans. Maize and grains can be produced within the dairy farming system itself or be imported from the arable sector. Field beans can only be imported from the arable sector. The amount of cattle slurry available for arable/vegetable cropping activities is determined by the proportion of cattle slurry collected inside the stable and the proportion of this slurry applied within the dairy farming system itself. The amount of cattle slurry collected inside the stable depends on the grazing system. Two grazing systems are considered: day-and-night grazing and day-grazing only, in the latter case with maize supplementation inside the stable. The amount of slurry used within dairy farming systems is set to either 0 or 100 kg total-N per ha grass/clover. Per ha grass/clover, various stocking rates are defined, influencing feed requirements and milk and slurry production per ha.

Organic pig farms in the Netherlands are largely landless and rely on purchased feeds. Defined pig production activities in this study refer to growing pigs only, with feed requirements and productions of meat and slurry as the main input-output coefficients. Quantification is based on Hoste (2004) and Vermeij *et al.* (2005). Growing pigs can be fed three diets. One of these diets is according to current practice, with a considerable proportion of feed ingredients imported from abroad. The other two diets are fully composed of ingredients which can be cultivated in the Netherlands and have to be supplied by feed crop production activities in the arable sector.

Set up of calculations

In a first round of calculations with the linear programming model, the current configuration of Dutch organic farming is simulated. This is achieved by forcing the model to select crop and grass/clover areas and animal numbers according to the current situation, while allowing the import of 'undesirable' inputs such as manures from conventional origin, feed ingredients imported from abroad and mineral ores. In subsequent rounds, the consequences of closing nutrient cycles in terms of changes in land areas devoted to the main sectors, land use within each sector, exchange of (by-)products between sectors and productivity per ha and animal are explored by gradually restricting the use of the 'undesirable' inputs: 1) reduction of the use of externally produced manure and other nutrient sources and 2) reduction of the use of externally produced feeds.

Results and brief discussion

The model proved to be able to simulate the present situation in Dutch organic agriculture rather well. For arable farming the current areas for the main crops can be achieved, for dairy farming the current milk production can achieved on the available area grassland and fodder crops and the current number of pig places can be realised, all at the same time.

The results indicate that to contribute to closing nutrient cycles in Dutch organic agriculture, the organic pig sector should substitute feed ingredients imported from abroad by Dutch feed ingredients. Increasing the proportion of Dutch feed ingredients in diets for pigs may impair the protein supply to pigs and hence the performance of pig production.

Dutch organic crop and vegetable producers will have to increase feed production. They need to increase the area of leguminous crops in their rotations in response to a reduction in the use of conventional manures and the imminent scarcity of organic manures that are already relatively expensive. The increase of the area under feed and leguminous forage or green manure may or may not be at the expense of organic food crop production. Increasing these areas without affecting food crop production obviously implies that the organic cropping sector should increase in size.

Just as the pig sector, the organic dairy sector can contribute by increasing the proportion of Dutch ingredients in feed. Organic dairy farms are more than self-sufficient with respect to N supply due to the availability of manure and use of grass/clover mixtures. The dairy sector can therefore export a larger part of the manure to the plant production sectors, than is the case currently, thus contributing to crop yields. However, increased manure export from the dairy sector also implies a partial shift of imminent P and K shortages from arable/vegetable farms to dairy farms.

The intensification of the exchange of (by-)products between different organic sectors does not resolve the large, structural leakage of nutrients from organic farming systems to human consumers. Compensating this leakage requires first of all the identification of acceptable nutrient sources in society to import into organic farming systems. It should be realised that nutrient cycles cannot be closed completely, as losses will always occur, not least through harvested produce (Hofstad & Schröder, 2002).

Better closing nutrient cycles in Dutch organic farming systems results in a general extensification and an increase in cost prices. Higher cost prices cannot be fully translated into higher consumer prices without jeopardizing sales of organic products. This places the Dutch organic farming community in a dilemma: the choice between accepting the use of undesirable inputs in organic farming but with a reasonable prospect for future sales, or shaping organic farming according to its principles, but with a more limited perspective for sale of produce and hence limited perspectives for growth.

Conclusions

Better closing nutrient cycles requires an increase in the proportion of Dutch feed ingredients in animal diets, an increase in the proportion of feed crops and leguminous forages and crops in rotations, an increase in the export of manure from the organic dairy sector to arable/vegetable farms and the import of acceptable nutrient sources from society back into organic farming systems. Depending on the degree in which ‘undesirable’ nutrient imports are banned and nutrient cycles closed, the different farming sectors will have to be more or less tuned to each other to reach an equilibrium, i.e. a situation in which organic feed and food production is based on organic manure production and nitrogen fixation and *vice versa*. In any case, better closing nutrient cycles will result in an extensification of Dutch organic farming and an increase in cost prices.

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NITROGEN EFFICIENCY IN ORGANIC FARMING USING A GPS PRECISION FARMING TECHNIQUE

Koopmans C.J. and M. Zanen

Louis Bolk Instituut, Hoofdstraat 24, 3972 LA, Driebergen, The Netherlands, 0031-343-523860, c.koopmans@louisbolk.nl www.louisbolk.nl

Key Words: farming systems, GPS-controlled traffic systems, soil structure, low input, nitrogen efficiency

Abstract

A GPS-controlled precision farming technique using the same tracks in the field year after year offers the opportunity to improve soil structure. Organic dairy manure sludge was applied at 40 and 14 ton/ha corresponding to farmers' practice and phosphate equilibrium respectively. Effects on soil structure, nutrient use efficiency and spinach yield were evaluated. Manure inputs could be reduced by 65% with comparable yields in traditional tillage and GPS-controlled precision tillage on permanent tracks.

Introduction

In the coming years, agriculture in the Netherlands will be forced to produce more high quality produce with smaller inputs of fertilisers. 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 tracks in the field year after year offers the opportunity to improve soil structure. The tracks become compacted, improving trafficability (Vermeulen & Klooster, 1992). Our hypothesis is that the soil structure of the remaining beds will improve, providing better aeration and rooting for the crop and access to necessary nutrients. This would mean that nutrient use efficiency would improve in GPS-controlled precision tillage systems. The aim of this study was to assess the effects of a GPS-controlled precision tillage system using permanent tracks on soil structure, nutrient use efficiency and spinach yield. The study was carried out at an organically-managed arable farm in the Netherlands.

Methodology

In a four-year study (2003-2007) the impact of lowering manure input levels in organic farming was studied in combination with GPS-controlled precision tillage. In 2004 spinach was used as a study crop in an on-farm experiment on an 80 ha organic vegetable farm in Langeweg (N. Br), the Netherlands. The soil in the study was characterized as loam (2.6% organic matter, 23% clay, pH-KCL 7.4). The experimental plots (6.3x25 m) were arranged in the open field according to a randomised block design with 4 replications, resulting in 16 experimental plots. Half of the plots were treated using GPS-controlled tillage, half of the plots with traditional organic tillage using no specific tracks in the field. Fertilisation was applied at two levels: 40 and 14 ton/ha dairy manure sludge (NPK= 4:1,5:5,5) corresponding respectively to farmers' practice (100%) and to phosphate equilibrium (35%) in the spinach based on total rotation. The experimental treatments are shown in table 1.

During the growing season, nitrate-N (NO_3-N) levels in the soil, soil structure and resistance were determined. NO_3-N in the soil was measured for each plot 1 month after fertilisation to a depth of 30 cm, as described by Koopmans & Brands (1993).

Soil structure was determined visually with a qualitative soil scan. Soil structure was rated as a percentage of crumbly, round and angular structures, using a modified method according to Shepherd (2000) as described in Koopmans & Brands (1993).

Soil resistance was measured to a depth of 50 cm, using a penetrometer. At harvest time, crop yield and crop quality indicators (N, P) were determined. Nutrient use efficiency was calculated as the N-application rate with fertilisation divided by the total N amount taken up by the plant. Data were analysed with GENSTAT 7.2, ANOVA.

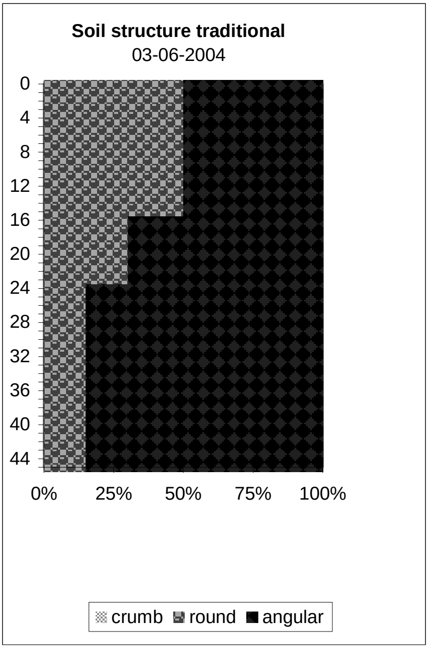
Table 1. Tillage and fertilisation treatments

Treatment	Tillage system	Fertiliser application	Nutrient application (kg/ha)		
			N	P2O5	K2O
1	Traditional	100% (=40 ton/ha)	160	60	220
2	Traditional	35% (=14 ton/ha)	56	21	77
3	GPS precision	100%	160	60	220
4	GPS precision	35%	56	21	77

Results and brief discussion

Nitrate-N levels in the soil, one month after fertilisation were significantly higher ($P<0.05$) with the 100% fertilisation treatment (81 kg NO_3-N/ha) compared to the 35% fertilisation treatment (54 kg NO_3-N/ha).

Using GPS-controlled precision tillage resulted in more crumbling and less angular properties of the topsoil compared with the traditional organic system (figure 1 *left* and *right*).



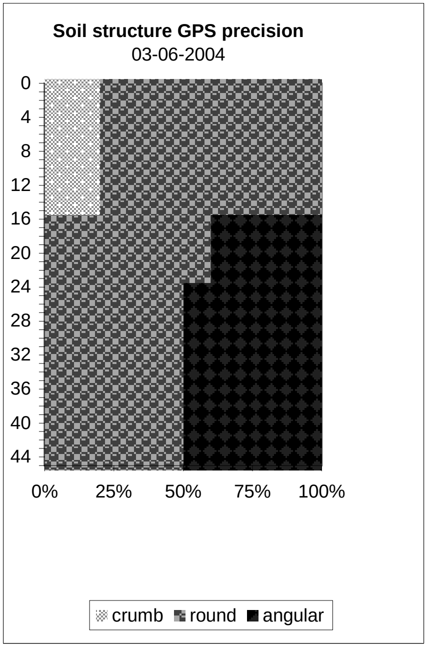


Figure 1. *Left*: soil structure with traditional tillage system. *Right:* soil structure with GPS-controlled tillage system.

Soil resistance was lower when using the GPS-controlled precision tillage technique (figure 2).

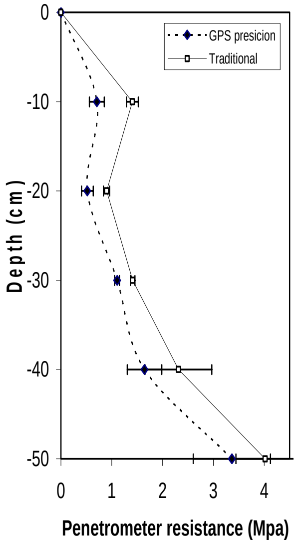


Figure 2. Penetrometer resistance of the soil with GPS-controlled tillage and traditional tillage.

There was a significant difference in the effect of fertilisation on yield between the 100% and 35% fertilisation treatments. The highest yields were obtained from plots with a fertilisation level of 100%. GPS-controlled precision tillage resulted in a significantly higher yield than traditional tillage. Interestingly there was no significant difference between yields in plots with GPS-controlled precision tillage with 35% fertilisation and traditional tillage with 100% fertilisation (figure 3). Nutrient use efficiency was significantly higher with the 35% fertilisation treatment (87%) as compared to the 100% fertilisation treatment (44%). GPS-controlled tillage a showed higher mean nutrient efficiency (71%) compared to traditional tillage (59%).

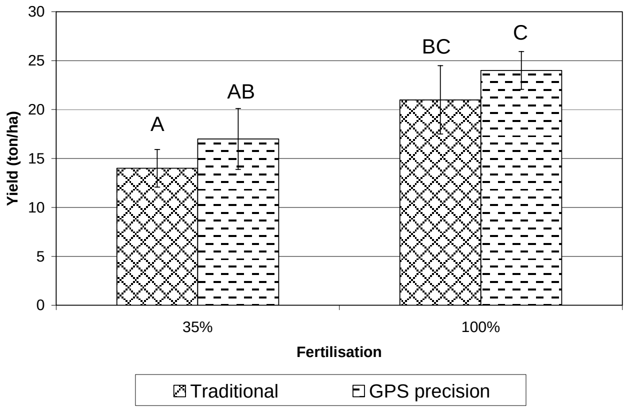


Figure 3. Mean spinach yield in 4 treatments: 35% fertilisation + traditional soil treatment; 35% fertilisation + GPS precision treatment; 100% fertilisation + traditional soil treatment, and 100% fertilisation + GPS precision treatment. Different characters indicate significant differences between the four treatments (Genstat Anova, P<0.05).

Conclusions

The results indicate that, possibly due to improved soil structure, nutrient use efficiencies can be improved using a GPS-controlled precision tillage system. A study of one crop in the rotation showed that lowering the amount of fertiliser has no significant effect on yield reduction when GPS-controlled precision tillage is used. The higher nutrient use efficiency at lower fertilisation levels stretches the possibilities for reducing inputs in organic agriculture. If fertilizer inputs are reduced in the next few years towards phosphate equilibrium at the crop rotation level, the GPS-controlled precision tillage system might become an important tool for organic farmers to maintain high-level yields. For farmers in the field the GPS systems might be a solution to improve their soil structure and increase the sustainability of their practices without substantially lowering yields. The evaluation of the relationship between N availability, soil structure and crop yield is ongoing.

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QUALITY ASPECTS OF COMPOSTS

THE EFFECT OF DIFFERENT COMPOST APPLICATIONS ON ORGANICALLY PRODUCED RED PEPPER (*Capsicum annuum L.*): I. FIRST SEASON RESULTS FOR YIELD, FRUIT QUALITY AND NUTRIENTS

Alev Gürpinar (1) and Nilgün Mordogan (2)

(1) Republic of Turkey, Ministry of Agriculture, Aegean Agricultural Research Institute P.O. Box: 9 35661 Menemen-İzmir/Turkey, Tel. +90 232 8461331, E-Mail: alevpinar@yahoo.com, www.aari.gov.tr
(2) Ege University, Faculty of Agric., Soil Dept. 35100 Bornova-İzmir/Turkey, Tel: +90 232 3884000, E-Mail: mordogan@ziraat.ege.edu.tr, www.ege.edu.tr

Key words: organic fertilization, red pepper, yield, fruit quality, nutrient, leaf chlorophyll

Abstract

The research was carried out at the Aegean Agricultural Research Institute open field experimental area located in the Mediterranean region. The aim of this paper is to evaluate the effects of a green manure crop (common vetch-barley mixture), compost (composted residues of various vegetables), farmyard manure, turkey manure and certified commercial organic manure on yield, some fruit quality parameters, fruit and leaf nutrient levels, and leaf chlorophyll content of red pepper (C*apsicum annuum* L.). In this paper first-year (2002) results are discussed. Most of the observed characteristics (yield, morphological characteristics, titratable acidity, total soluble solids, dry matter, vitamin C, fructose, nitrate, nitrite, N, P, K, Ca) were increased significantly by the applications. However, fruit pH, α-glucose, β-glucose and sucrose contents were not affected by the treatments. The highest yield, 29.7 ton/ha, was obtained with farmyard manure (20 ton/ha) plus the green manure crop. Of the leaf characteristics, chlorophyll-a, chlorophyll-b and total chlorophyll showed significant differences when compared with the controls (untreated and chemical). In addition, N, P, K, Ca, Mg, Zn, and Mn contents of leaf samples were significantly affected by the treatments.

Introduction

Consumers have an increasing concern for fruits and vegetables because of increased awareness of their dietary importance (Wiebel, 1997). Levels of nitrate, nitrite, flavour, vitamins, minerals, etc. in vegetables are important and are probably affected by the use of fertilisers. Pepper fruits are generally used in the diet and eaten raw, but especially nitrogen fertilisation is one of the important and limiting aspects of organic vegetable production. Several models have been developed to optimise N fertilisation in vegetable production (Kristensen, 2002). In organic agriculture, green manuring is important to obtain higher yields (Köpke, 1996). Manure and compost applications generally result in improved soil fertility and crop production (Senesi, 1989). Vegetables account for only 2% of total organic production in Turkey, but there is great potential for growth. Domestic market demands will probably play an important role in this growth (Aksoy, 2001). The present study was conducted to determine the effect of different organic materials on yield and fruit quality of field-grown peppers.

Methodology

The trial was carried out at the experimental fields of Aegean Agricultural Research Institute in Menemen (İzmir/Turkey). Physical and chemical properties of the experimental soil, the applied manures and compost were analysed according to standard methods (Kacar, 1972, Kacar, 1990) (Tables 1, 2). The compost material was obtained by composting vegetable residues from the agricultural production of the Institute. Farmyard and turkey manures were composted for 8 months. The experiment was conducted in randomised block design in 72 parcels with 4 replications, with 68 plants making up each parcel. Distances between the parcels were approximately 2.1 m. Treatments are presented in Table 3. An 80%-20% mixture of common vetch (*Vicia sativa* L.) and barley (*Hordeum vulgare* L.) was grown as a green manure and incorporated into the soil. Pepper (cv. yalova yağlık) seedlings were further transplanted to the field. The experiment was conducted under organic conditions and the research plot was converted to an organic production system two years prior to sowing the green manure crop. Plant materials selected for the trial were all standard varieties that have been commonly used by local farmers. Furrow irrigation was used, with a total of 600 mm of water applied only in summer during the pepper production period. After transplanting the seedlings to the field, only aphid species were observed at the economic threshold level. A plant extract (pyrethrum, 1%) permitted by the Turkish 01.12.2004/5262 regulation (24.12.1994/22145, 11.07.2002/24812 regulations) and the EU 2092/91 regulation was used to treat the peppers. Synthetic pesticides were applied in the parcels under conventional management. However, plant protection measures in this research included a predator (Col.:Coccinellidae) collected from nature and released in the experimental area. Also, at the seedling stage, aphids were cleaned from leaves by rubbing with cotton. Because labour cost is moderate in Turkey, weed control was manual.

Table 1: Properties of soil samples (0-30 cm).

Properties	
pH	7.4
Tot. Salts (%)	0.1
$CaCO_3$ (%)	4.8
OM (%)	0.6
Texture	Sandy Clay
N (%)	0.1
P (mg/kg)	1.4
K (mg/kg)	225
Ca (mg/kg)	5880
Mg (mg/kg)	540
Na (mg/kg)	155
Fe (mg/kg)	6.0
Cu (mg/kg)	0.9
Mn (mg/kg)	4.3
Zn (mg/kg)	0.5
NO_3^- (mg/kg)	3

Table 2: Properties of different composts.

Properties	**C**	**F**	**T**	**CO**
pH	7.7	8.7	7.7	9.2
Tot. Salts (%)	0.9	3.7	3.9	4.3
$CaCO_3$ (%)	4.5	4.9	8.7	3.8
OM (%)	40.6	52	45.7	64.0
C/N	26.6	21.1	15.7	15.0
CEC (meq/100 g)	42.3	55.2	53.0	58.0
N (%)	1.2	1.7	1.3	2
P (%)	1.8	1.3	1.8	1.9
K (%)	2.9	1.7	2.5	1.7
Ca (%)	2.3	1.3	4.2	4.0
Mg (%)	1.3	1.6	3.3	1.2
Na (%)	0.2	0.4	0.4	0.3
Fe (mg/kg)	3075	3850	5430	5880
Cu (mg/kg)	25	45	62	65
Zn (mg/kg)	176	265	478	385
Mn (mg/kg)	269	348	580	440

Table 3: Treatments

1) O (control) (non treated)	7) F1 (farmyard manure) (10 ton/ha)	13) T2 (turkey manure) (10 ton/ha)
2) NPK50 (control) (8,5/5/10-half of recommended chemical fertilisation)	8) F1+G	14) T2+G
3) NPK100 (control) (17/10/20-recommended chemical fertilisation)	9) F2 (farmyard manure) (20 ton/ha)	15) C1 (compost) (20 ton/ha) (composted various vegetable residues)
4) G (green manure crop) (common vetch-barley mixture)	10) F2+G	16) C1+G
5) CO (certified commercial organic manure)	11) T1 (turkey manure) (5 ton/ha)	17) C2 (compost) (40 ton/ha) (composted various vegetable residues)
6) CO+G	12) T1+G	18) C2+G

Leaf samples were collected at two different stages (flowering (1) and harvest (2)), and fruits were sampled only during the second harvest period. Peppers were harvested a total of three times. Yield (*Y*), morphological characteristics (*MC*) [number of days to flowering from planting (*MC1*), number of days to maturing from planting (*MC2*), fruit length (*MC3*), fruit width (*MC4*), fruit pulp thickness (*MC5*), plant height (*MC6*), plant width (*MC7*)], titratable acidity (*TEA*), pH, total soluble solids (*TSS*), dry matter (*DM*), vitamin C (*VitC*), sugar fractions [fructose (*Fru*), α-glucose (*α-Glu*), β-glucose (*β-Glu*), sucrose (*Suc*)], nitrate (NO_3^-), nitrite ($NO_2^=$), macro-micro elements (*N, P. K, Ca, Mg, Fe, Cu, Zn, Mn*) of fruits and also leaf chlorophyll (*Totalch*) [chlorophyll-a (*Ch-a*), chlorophyll-b (*Ch-b*)] and nutrients (*N, P. K, Ca, Mg, Fe, Cu, Zn, Mn*) were analysed following Pearson, 1970; Horthwirth, 1960, Neubeller and Buchlach, 1975; Balks and Reekers, 1960, Kacar, 1972. The collected data was analysed statistically by the TARİST program (Açıkgöz et al., 1993).

Results and brief discussion

Yield and Fruit Quality: Obtained data showed important differences at the 1% significance level for Y, MC, TEA, TSS, DM, VitC, fru, $NO_2^=$, N, P. K, and Ca, and at the 5% level for NO_3^-. However, fruit pH (5.1-5.3), α-glu (0.7-1.3 g/100gFW), β-glu (0.5-1.0 g/100gFW), Suc. (trace-0.1 g/100gFW), Mg (% 0,30-0,34), Fe (88-182 mg/kg), Cu (16-23 mg/kg), Zn (49-58 mg/kg), Mn (11-19 mg/kg) contents were not affected by the tested treatments. The values were similar to those of previous findings (Karaman et al., 1998, Küçük et al., 1995; Luning et al., 1994; McCance and Widdowson, 2002; Sonci et al; 2000) (Table 3). Duncan's test displaying the lowest and the highest applications were obtained as follows (Table 4).

Leaf Parameters: Total, Ch-a and Ch-b were significantly (p<1%) increased by the organic applications. In addition, N (1, 2), P (1, 2), K (1, 2), Ca (1, 2), Mg (2), Zn (2), Mn (2) levels of leaf samples were markedly enhanced (p<1%) by the treatments. The data were in agreement with the values cited in the relevant literature for peppers (Bergmann, 1987; Küçük, 1992). Mg (1) (0.4-0.5 %), Zn (1) (72.5-93.3 mg/kg), Mn (1) (66.8-91.0 mg/kg) contents were not affected by applications. Duncan's test the lowest and the highest applications were obtained and presented in Table 6.

Table 3: Descriptive statistics of yield and fruit quality parameters.

	Y	MC1	MC2	MC3	MC4	MC5	MC6	MC7	NO_3^-	$NO_2^=$	TEA	DM	TSS	Fru	VitC	N	P	K	Ca
	ton/ ha	day	day	cm	cm	mm	cm	cm	mg/ kg	mg/ kg	%	%	%	g/100g FW	mg/ 100ml	%	%	%	%
Minimum	9.0	32	47	7.2	3.0	1.2	44	38	19.5	0.02	0.2	83.7	6.1	0.9	66.7	1.2	0.3	2.8	0.1
Maximum	31.1	59	75	11.3	5.1	5.1	77	80	378.8	0.4	0.5	91.0	8.5	3.9	102.5	4.0	0.4	3.5	0.2
Duncan (%5)	**	**	**	**	**	**	**	**	*	**	**	**	**	*	**	**	**	**	**
CV(%)	32,0	13,1	10,2	9,0	10,1	21,5	10,9	11,6	59,9	53,7	19,4	1,7	8,1	29,1	8,1	15,9	3,7	4,8	29,0

*ns: not significant, *: significant at p<.01; **: significant at p<.05*

Table 4: Duncan's test results for the lowest and the highest applications of yield and fruit quality parameters.

	Y	MC1	MC2	MC3	MC4	MC5	MC6	MC7	NO_3^-	$NO_2^=$	TEA	DM	TSS	Fru	VitC	N	P	K	Ca
Lowest Appl.	O	T2+G	T2+G	NPK50	O	O	O	O	O	O	O	F1+G	O	NPK50	NPK50	O	O	O	T1
Highest Appl.	F2+G	O	O	F2+G	F2+G	F2+G	F2+G, T2+G	T2+G	NPK100	NPK100	NPK100	C2+G	C2+G	C2+G	C2+G	NPK100	C2+G	T2+G	T1+G

Table 5: Descriptive statistics of analysed leaf parameters.

	N 1	N 2	P 1	P 2	K 1	K 2	Ca 1	Ca 2	Mg 2	Zn 2	Mn 2	Ch-a	Ch-b	Totalch
	%	%	%	%	%	%	%	%	%	mg/kg	mg/kg	mg/gFW	mg/gFW	mg/Gfw
Minimum	2.8	2.4	0.3	0.3	3.1	3.0	0.8	1.3	0.3	62	75	0.7	0.4	1.1
Maximum	5.3	4.5	0.4	0.4	4.2	5.0	2.5	2.9	0.6	104	184	2.1	1.8	3.6
Duncan (%5)	**	**	**	**	**	**	**	**	*	**	**	**	**	**
CV (%)	10,6	10,6	4,7	4,6	11,0	9,4	26,4	17,2	13,3	10,6	22,2	20,7	17,7	18,1

*ns: not significant, *: significant at p<.01; **: significant at p<.05*
1: flowering stage samples, 2: second harvest stage samples.

Table 6: Duncan's test results for the lowest and the highest applications of leaf parameters.

	N 1	N 2	P 1	P 2	K 1	K 2	Ca 1	Ca 2	Mg 2	Zn 2	Mn 2	Ch-a	Ch-b	Total ch
Lowest Appl.	O	O	O	O	O	O	O	O	T2	F2	O	NPK50	NPK50	NPK50
Highest Appl.	NPK100	NPK100	NPK100 F2+G T2 T2+G	F2+G T2+G	F2+G	F2+G	C2+G	OC+G	OC+G	O	F1+G	F2+G	F2+G	F2+G

Conclusion

1-The tested organic treatments increased the yield significantly. The highest yield was obtainied in the F2+G parcel at 29.7 ton/ha. **2**-Better properties were noted for the analysed fruit quality parameters (MC, TEA, TSS, DM, VitC, Fru, NO_3^-, $NO_2^=$, N, P, K, Ca) in the organic treatments in comparison with that of the control parcels. **3-** The tested leaf parameters excluding Mg (1), Zn (1), and Mn (1) showed significant differences, with the highest levels generally obtained in the organic parcels. **4-** Although the highest nitrogen in leaves and fruits were measured in the NPK100 treatment, sufficient nitrogen levels were also obtained in the organic parcels.

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SOLID FERMENTED MATERIAL (BOKAHSI) AS A BIOFERTILIZER FOR POTTING MEDIA USING EFFECTIVE MICROORGANISMS (EM)

Tim A. Jenkins, Mike Daly (2)

Biological Husbandry Unit, PO Box 113, Lincoln, New Zealand, Tel. +64 3 3253684, thebhu@quicksilver.net.nz, www.bhu.co.nz
(2) New Zealand Nature Farming Society, 146 Lincoln Road, 8002, Christchurch, New Zealand, Tel. +64 3 9422777, nznfs@paradise.net.nz, www.emnz.com

Key Words: biofertilizer, bokashi, Effective Microorganisms, EM, potting media

Abstract

Adding a solid fermentation product (bokashi) to potting media enhanced the growth of vegetable seedlings when the microbial inoculant Effective Micororganisms (EM) was used. There was a negative response to the inclusion of bokashi made without EM. The benefit to seedling growth from EM bokashi also improved crop performance post-transplanting. Effect on seedlings was further enhanced by the inclusion of fishmeal and, to a lesser extent, by adding trace elements in the bokashi fermentation. Addition of seaweed extract gave no apparent advantage.

Introduction

There is a desire to increase vigour of vegetable seedlings transplants as long as the crop still performs well when planted in the field. A series of experiments was carried out to test the use of bokashi as a biofertilizer to improve the performance of potting media for vegetable seedlings.

Bokashi is a traditional method of fermenting solid organic matter in Japan and can be seen as an alternative to hot composting. The fermentation of solid material can be mediated by microorganisms already present on the organic matter or in added ingredients. A common added ingredient has been molasses which provides readily available energy to aid the fermentation process.

Effective Microorganisms (EM) is a microbial inoculant developed in Japan (described in Higa and Parr 1994; Daly and Stuart 1999). The New Zealand form of EM comprises the same types of organisms as the Japanese form of EM including lactic acid bacteria, propionic acid bacteria, yeasts, actinomycetes and mould fungi. Indicative species and levels are listed in Daly and Stuart (1999).

EM has been used to produce various types of bokashi that are used for crop productions generally by inclusion in cropping soil (e.g. Pei-Sheng and Hui-Lian 2002; Xu, Wang and Mridha 2000). In the series of experiments presented, the benefits of using EM in the fermentation process were assessed.

Methodology

Effect of EM

Bokashi was made by fermenting two parts sawdust and one part fine wheat broll (wheat-milling byproduct including bran, husk, and some flour) at 20% moisture with 0.3% molasses by volume (molasses bokashi). A further bokashi was made by that method but with the addition of Effective Microorganisms (EM) microbial inoculant at 0.3% by volume (EM bokashi). Five 20 L sealed containers were prepared for each treatment to provide material for the five replicates of the bokashi treatments and the fermentation was allowed to proceed for three weeks at 20^{o}C. The effect on the growth of radish (*Raphanus sativus* cultivar 'French Breakfast') and mustard (green mustard *Brassica juncea*) seedlings was tested after adding the bokashi as 5% of potting medium by volume. The basic potting medium (composted bark supplemented with fishmeal and dolomite, and steam sterilised soil at 3:1 ratio) was included in the experiment as nil control and a further control was the same medium with the dry bokashi ingredients moistened and immediately added at 5% by volume. Each replicate included a seedling tray with 60 45 mL cells each sown with a single seed of either mustard or radish. Radish and mustard were grown in separate cell trays. Trays were placed in a randomised block design in glasshouse conditions (17^{o}C mean temperature) and shoot (assessed for every plant) and root growth (assessed for five randomly chosen plants per replicate) was weighed two weeks after sowing and statistically analysed with ANOVA.

Effect of fishmeal, seaweed extract and trace elements

Bokashi was made as above with 0.3% EM and 0.3% molasses by volume. Further additions were made for comparison of effect, these being fishmeal (added at 5% by volume), seaweed extract (proprietary brand, 0.15% by volume) and trace elements (following amounts were added dissolved in 500 mL per 100 L of bokashi being made - Magnesium Sulfate Hepta 1 g, iron sulfate monohydrate 0.2 g, zinc sulfate heptahydrate 0.02 g, copper sulfate 0.01 g, boric acid 0.02 g, manganese sulfate 0.01 g, cobalt sulfate 0.005 g, sodium selenate 0.0005 g, sodium molybdenate 0.002 g). All permutations of these ingredients was tested. One 20 L sealed bucket fermentation was made for each bokashi treatment. Five cell trays were set up per treatment. These contained potting media as above with 5% by volume of a treatment incorporated. The same types of radish and mustard were used as above . Results were analysed between each treatment (ANOVA) and also using pairwise comparisons (paired t-test) for each of the permutations with and without a ingredient (thus allowing true replication of ingredient effect).

Transplanting of treated lettuce seedlings

The objective of this experiment was to assess whether accelerated growth of seedlings due to EM Bokashi use would compromise post-transplanting performance for transplant sensitive crops like lettuce. Lettuce seedlings (cultivar 'Cos Verdi') were grown on 5 replicated cell transplant trays of each of EM bokashi (made as above but with sawdust and broll at a 1:1 ratio – added to potting media as above at 5% by volume) and of nil control (potting media, no bokashi) and subsequently transplanted to plastic tunnelhouse soil. Five pairs of randomised replicate plots were set up with fourteen 28 day old transplants in each plot. Bokashi treated plants were approximately double the shoot size (assessed by leaf length) at transplanting. After 48 days post-transplanting, lettuces were cut and harvest weights assessed and statistically analysed with ANOVA.

Results and brief discussion

Effect of EM

Results for mustard and radish are presented in Table 1.

Table 1. Effect of Bokashi Incorporation on Growth of Mustard and Radish Seedlings

	Mustard				Radish			
Treatment	Seedling Emergence (%)	Shoots FW	Shoots DW	Roots FW	Seedling Emergence (%)	Shoots FW	Shoots DW	Roots FW
Nil Control	84.3a	0.300b	0.033b	0.065ns	93.0a	0.409c	0.047b	0.304ns
Control	10.3b	0.213c	0.022b	0.003ns	82.7b	0.575b	0.049b	0.172ns
Molasses Bokashi	77.9a	0.227c	0.020c	0.020ns	91.7a	0.359c	0.033c	0.163ns
EM Bokashi	79.0a	0.541a	0.049a	0.055ns	88.3ab	0.771a	0.069a	0.263ns

For each column, values sharing a letter are not significantly different from each other at the p<0.05 level.

Mustard: Seedling emergence of mustard was very low in the control treatment (87.7% below nil control) but emergence in the other treatments was not statistically significantly different from nil control. The molasses and EM bokashi treatments both tended to reduce seedling emergence by a small amount (7.6% and 6.3% respectively, not statistically significant) which, given similar results seen in the radish experiment, may represent a true reduction.

Two weeks after sowing, shoot dry weights in the EM bokashi treatment were 46.9% greater than nil control ($p<0.05$). At the same time, shoot dry weights for the molasses bokashi treatment were less than nil control by 29.6% ($p<0.05$). The control shoot dry weights were just 3.4% greater than nil control (not statistically significant). Root fresh weights (dry weights were too heavily affected by potting media residue) in the EM bokashi treatment tended to be 13.3% less than nil control but root dry weights of control and molasses treatments tended to be much less (83.1 and 54.7% respectively) than nil control. None of the roots results was statistically significant given the very high variation present.

Radish: Seedling emergence was significantly lower in the control (11% below nil control, $p<0.01$). As with mustard there was a tendency for the EM bokashi treatment to lower seedling emergence although this was again not statistically significant (-5.0%, $p=0.22$).

Two weeks after sowing, radish shoot dry weights in the EM bokashi treatment were 46.9% greater than nil control ($p<0.05$). Shoot dry weights for the control and molasses treatments were significantly less than nil control by 34.6 and 39.7% respectively ($p<0.05$). Root dry weights in the EM bokashi treatment were 24.5% less than nil control and root dry weights of control and molasses treatments were lower still at 54.5% and 56.9% respectively less than nil control. The somewhat lower root weights for the EM bokashi treatment may reflect a better availability of nutrient in the potting medium and less requirement for root mass. As with the radish results, however, none of the root results was statistically significant.

Discussion: The non fermented control and the molasses bokashi generally had a negative effect on seedling growth. EM bokashi in comparison had a significantly positive effect that may have been due to improved condition and nutrient release from the organic material and/or microbial inoculant value. EM applied directly to crops and EM treated bokashi have been shown to improve yield, which may be in part due to increased mineralisation of nutrients from organic matter (Attanyake et al. 1993; Daly and Stewart 1999).

The tendency for reduced seedling emergence with the bokashi inclusion may indicate continued fermentation activity affecting seeds perhaps similar to non-cured compost. Where such problems are significant it may be advisable to incorporate bokashi into moist potting media a fortnight in advance of planting seed or to allow bokashi fermentation to proceed for a longer time. Further research would be required to determine the time required to cure the bokashi where such an issue was of concern.

Effect of fishmeal, seaweed extract and trace elements

The results are presented in Table 2 for each permutation of the additions and Table 3 for the individual ingredient statistics. The inclusion of fishmeal increased the effect of the EM bokashi on both mustard and radish growth ($p< 0.005$). The seaweed extract gave no clear result while the trace element treatment appeared to increase root growth and possibly mustard shoot fresh weight (only statistically significant for root growth of radish).

Table 2. Effect of incorporating fishmeal, seaweed extract and/or trace element blend to EM Bokashi fermentation on the potting media properties for radish and mustard seedlings.

Treatment	Mustard (g)			Radish (g)		
	Shoots FW	Shoots DW	Roots DW	Shoots FW	Shoots DW	Roots DW
Nil Control	1.107d	0.127c	0.119bc	1.088d	0.139cd	0.330c
EM Bokashi	1.479c	0.162b	0.170abc	1.538c	0.161c	0.457bc
EM Bok incl. Fish	2.328b	0.217a	0.163abc	2.120b	0.212b	0.425bc
EM Bok incl. Kelpac	1.167d	0.114c	0.120bc	1.199cd	0.129d	0.317c
EM Bok incl. Trace	1.113d	0.111c	0.140abc	1.039d	0.115d	0.380c
EM Bok incl. Fish + Kelpac	2.406ab	0.228a	0.188abc	2.375ab	0.245a	0.570ab
EM Bok incl. Fish + Kelpac + Traces	2.302ab	0.232a	0.203ab	2.553a	0.251a	0.665a
EM Bok incl. Kelpac + Traces	1.284d	0.128c	0.144abc	1.316cd	0.136cd	0.443bc
EM Bok incl. Fishmeal + Traces	2.356a	0.246a	0.189abc	2.485ab	0.246a	0.644a

For each column, values sharing a letter are not significantly different from each other at the $p<0.05$ level.

Some of the differences shown in comparison of treatment combinations could be due to factors other than the addition or absence of fishmeal, seaweed extract or trace elements. Although attention was paid to making the fermentation mixtures, there was no replication of recipe ingredients (i.e. only one fermentation container per treatment). The pairwise comparisons for each of the individual ingredients do, however, provide true replication for comparing the effect of each added material. Note that differences between treatments could also be partly due to effect of the ingredients on moisture relations and other factors in the fermenting material.

Table 3. Pairwise comparison of each of the fishmeal, seaweed extract and/or trace element additions to EM Bokashi fermentation. Effect on the potting media properties for radish and mustard seedlings.

	Mustard			Radish		
	Shoots FW	Shoots DW	Roots DW	Shoots FW	Shoots DW	Roots DW
Treatment	% increase	% increase	% increase	% increase	% increase	% increase
Fishmeal	84.9 (p<0.001)	79.4 (p<0.001)	29.5 (p=0.003)	76.4 (p<0.001)	87.2 (p<0.001)	44.3 (p=0.002)
Kelpac	-15.0 (p=0.214)	-7.0 (p=0.143)	-1.5 (p=0.863)	1.0 (p=0.424)	-0.2 (p=0.967)	1.4 (p=0.436)
Trace Elements	7.3 (p=0.306)	-0.51 (p=0.929)	5.5 (p=0.255)	0.0 (p=1.000)	2.2 (p=0.355)	20.5 (p=0.020)

For each column, values sharing a letter are not significantly different from each other at the p<0.05 level.

Transplanting of treated lettuce seedlings

Treated plants weighed 23.4% (fresh weight of harvested lettuce) more on average than control plants at harvest date (highly statistically significant, $p<0.005$). Observations indicated that treated plants were of saleable size more than a week prior to control plants. The improvement in seedling growth from the incorporation of EM bokashi in the potting mix did not appear to impede plant growth in the field and in fact at harvest time there was a significant weight advantage to the treated plants.

Conclusions

Bokashi made with EM can have a positive effect on the growth of vegetable seedlings in potting media and such effects can still be seen in the harvest weights of transplanted seedlings. The ingredients in the bokashi and the rate of use can significantly affect the value of the addition. Experimentation is recommended in the variety of organic material that bokashi can be made.

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Symbols and Abbreviations

Abbreviations used include EM (Effective Microorganisms), FW (fresh weight) and DW (dry weight).

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DEVELOPMENT OF A FARM-BASED EXPERT SYSTEM FOR COMPOSTING AND ORGANIC VEGETABLE PRODUCTION WITH APPLICATION TO DEVELOPING COUNTRIES

Chin-hua Ma, Manuel Palada, Li-hui Chen and Hsien-yang Tien

AVRDC-The World Vegetable Center, P.O Box 42, Shanhua, 741, Tainan, Taiwan, ROC. Tel. (886-6) 5837801, E-mail: mach@avrdc.org, Internet:http://www.avrdc.org

Keywords: Composting expert system, compost formulation, agricultural wastes, organic vegetable production

Abstract

Extensive research has improved composting technology to a more science-based and environment-friendly knowledge. In recent years, types of waste materials generated have become more diversified, and their quantities are huge posing risk to the environment. Developing an expert system based on integrated information on organic waste composting and utilization in a CD (compact disk) format may enhance the composting protocol adoption and efficiency in recycling of organic waste as well as promotion of organic vegetable production. Databases on organic wastes and materials, organic fertilizers, composting technology, compost utilization, organic fertilization for vegetables, and non-chemical disease and pest controls have been established in the expert system. Sub-programs for compost formulation and organic fertilizer recommendation are also developed. Stepwise guidelines and user-friendly menu for searching the composting technological consultancy are designed so as to increase its applicability. For users in the developing countries where personal computer is not available, simple composting leaflet showing formulation based on locally available materials could be easily developed and published from the expert system. Based on the program, 16 compost formulae have been tested for verification. The temperatures of compost piles were raised above 70°C ensuring the production of good quality composts.

Introduction

Composts are major sources of nutrients supplied to crops in organic vegetable production system. In recent years, increasing concerns over the environment and soil sustainability have prompted increasing interest in composting as a way of recycling wastes back to soil. In the past, types of wastes used for composting were relatively limited. Composting was made simply by combining raw materials by trial and error or by blending raw materials that were available on the farm. Today, types of waste materials generated from agricultural production and processing have become more diversified. Also, their quantities are in such huge amounts that they may become pollutants in the environment. Associated risks such as the spread of phytodiseases, human pathogens, weeds, and contamination of heavy metals further complicate the matter.

Extensive research in recent years has improved composting technology into a more science-based and environment-friendly knowledge. However, most results were presented in journals and publications that were difficult for farmers and extentionists to access. Composting is enhanced through the establishment of conditions that encourage the growth of the microorganisms. Many compost practitioners combine raw materials by experience. However, to achieve rapid and good quality composting, it is critical to develop composting formulations based on science-based data. Due to great diversity in compositions of raw materials, the characteristic data are not always available at hand. Several spreadsheets for calculation compost formula are available on the internet. However, they are only applicable to large scale compost producers. Therefore, this project aims to develop a farm-based expert system for compost formulations, composting and compost utilizations in a CD format. The information on organic wastes, compost technologies and organic fertilizations was also established in the databases.

Methodology

The conceptual flow chart of the expert system is shown in Fig. 1. Seven databases have been established in the program, which include databases for organic wastes and materials, organic fertilizers, composting technologies, compost utilization, nutrient requirements for vegetables, and non-chemical diseases and pests control methods. Data sources included information available from national and international journals, on-station research reports, publications, proceedings, books, field guide and analytical reports, etc. Sub-

programs for compost formulation, organic fertilizer recommendation and query system on non-chemical disease and pest control practices are also developed.
The hardware is based on IBM compatible PC and MS Windows is selected as the platform for the expert system. MS ACCESS is the software used for establishment of databases. MS VISUAL BASIC has been chosen as the language to build the interface for connecting the database and query system. The feature of the system will be user-friendly query menus that allow users to easily access information from the databases. It is efficient in sorting ability which can increase its applicability.

Based on the compost formulation system, 16 compost formulae for solid composts were processed for verification. Temperatures were monitored during composting and nutrient compositions of compost were analyzed after compost maturity.

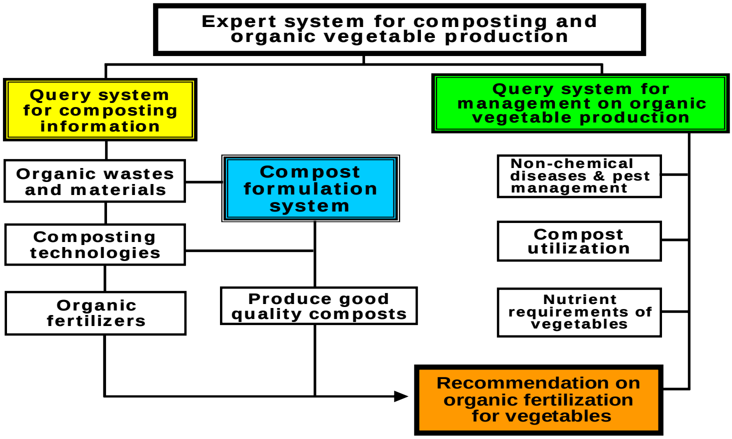

Fig.1. The conceptual flow chart of the expert system

Results and brief discussion

The system is structured with four major components: query system for composting information, query system for management on organic vegetable production, formulation system for composts and the recommendation system for organic fertilizers.

Query system for composting information:

This system provides the user with the composition of waste materials which can assist user later for a better design of the formula. Composting technologies serve as guidelines for management of composting processes and database of listed organic fertilizer nutrient compositions for calculating fertilizer requirements. Three databases are included in this system:

1. Database of organic wastes. More than 300 records of waste material have been collated in the database. Types of waste material include agricultural wastes, livestock production wastes, food processing wastes, fish and meat processing wastes, municipal wastes, kitchen wastes and yard wastes, etc. Main fields selected are the properties (bulk density, C:N ratio, moisture content), nutrient contents (C, N, P, K, Ca, Mg, heavy metals) and sources of information.

2. Database of composting technologies. The composting technologies are divided into six sections: handling of raw materials; mixing and pile formation methods; monitoring of composting processes (watering, aeration, temperature); controlling odor, detection of compost maturity; and storing the composts (curing, and drying). Illustrations for important technologies are included in the database to make the processes easily understandable. More than 70 methods are established in database. Compost recipes are calculated by the compost formulation program.

3. Database of organic fertilizers. Main fields selected are nutrient contents (C, N, P, and K) of the composted product, mixing ratio of raw materials, data source and production country. Types of organic fertilizers include wasted media compost, chicken manure compost, pig manure compost, cow manure compost, bagasse compost, and plant residue compost, etc. More than 200 records are collated in this database.

Compost formulation system

The compost formulation system allows users to select a maximum of six ingredients for making their own compost formulae. They may also refer to standard formulae for making their own composts on farm. Users can either select components of waste materials from the database or key in data from locally available materials. After materials are selected, the program can automatically calculate the amounts of each ingredient required for composting based on pre-set C/N ratio, moisture and dimension of compost pile. The program is calculated on a dry weight basis, but if the bulk density can be estimated, it can also convert dry weight to volume or fresh weight. Amounts of water needed for composting is also calculated. The main display menu is shown in **Fig. 2**. After compost formulation, the user may connect to composting technology program for consultancy. Formulation and monitoring conditions such as temperature, moisture, aeration, and maturity will ensure a high-quality composted product.

For application in the developing countries where computers or information are not available, a simple booklet with compost formulation based on locally available materials can be easily designed and published from this program. This tool can enhance the waste recycling and utilization in the developing countries.

Sixteen compost formulae with different raw materials as C sources have been developed and tested for verification the compost formulation program. Actual C and N contents after maturity were closely correlated with the values predicted. By maintaining good aeration and moisture conditions during compost processing, temperature in all composting piles was easily raised above 70°C within several days and was able to sustain for more than 4 weeks. No offensive odors were detected.

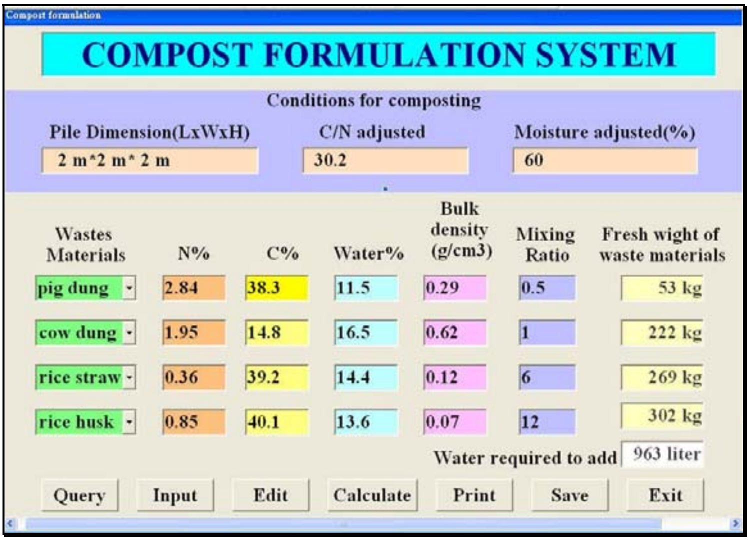

Fig.2. The main display menu of the formulation system

Query system for management on organic vegetable production

The second query system provides the user with the technical practices required for growing vegetables organically. Users may refer to the databases for non-chemical controlling strategies on disease and pest management, to database of compost utilization for reference and consultancy, and to database of nutrient requirements for calculating the organic fertilizer requirements. This system includes another four databases:

1. Databases of non-chemical disease and pest control. Non-chemical management practices for disease and pest are collated in separated database. Query menu is also designed separately. User can select name of vegetable or name of diseases or insects from a pull out menu, the description of symptoms and the control practices will be displayed on the screen. More than 100 records have been keyed-in the databases.

2. Database of compost utilization. This database is a collection of references from national and international publications regarding organic fertilization for major vegetables. The data also include the utilization of compost other than fertilizers, e.g. using composts as potting media, as soil amendment, or as plant disease controller, etc. More than 1000 records of reference have been included in the database.

3. Database of nutrient requirements for vegetables. This database includes surveyed results of major nutrient requirements, dry matter partitions and growth patterns of important vegetables. It is linked to fertilizer recommendation system for calculating the fertilization amounts.

Organic fertilization recommendation system

The organic fertilization program allows user to calculate the amounts of organic fertilizers required for application based on crop and type of organic fertilizer selected. A table with conversion factors is developed to modify the amounts of fertilizers required to apply in different soil textures and soil fertility conditions. Users may either refer to the organic fertilizer database for the composition of fertilizer, or refer to estimated composition for their own formulated composts. Recommendation of organic fertilizer application based on nutrient requirements and yield targets may help farmers in making better estimations of the fertilizer requirements and avoiding over application of organic fertilizers. It can also save production costs and conserve the environment.

Conclusions

The establishment of a composting expert system can help farmers in accessing information for composting and utilization. It will increase efficiency of composting and will result in better quality of composted products. Formulation of compost based on wastes available on-farm can enhance recycling of agricultural wastes as well as promote organic vegetable production. The expert system can provide reference information and serve as teaching tools for researchers and extensionists. For users in the developing countries where personal computers are not available, simple composting guidelines or leaflets with compost formulation based on locally available materials could be easily developed by inputing information into the program. It can also provide useful technologies for composting on-farm and is applicable to organic vegetable cultivation in many locations of the developing countries.

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DIFFERENT COMPOST FERTILIZATIONS ON GROWTH, YIELD AND QUALITY OF ORGANIC MELON IN VENEZUELA

Perez-H., Elimar (1), Pina, Ruben (2), Rodriguez, Josefina (3), Ramirez-Guerrero, Hugo (4)

(1), (2), (3) Universidad Centroccidental Lisandro Alvarado, UCLA-Torres, Avenida Francisco de Miranda, Carora, Venezuela, Tel 00 58 252 4216632, E-mail (1) rubelicar@yahoo.com, (3) chepaucla@yahoo.es
(4) Posgrados de Agronomia, Universidad Centroccidental Lisandro Alvarado, Cabudare, Zip Code 400, Barquisimeto, Venezuela, Tel 00 58 251 2618939 or 00 58 251 2592592, E-mail hramirez@ucla.edu.ve

Key Words: vegetables, sustainable, research, developing country, organic amendments, tropical.

Abstract

An experiment was set up at the agricultural community "Montana Verde" (9º 52' N, 67º 9' W) in Torres county of Lara State, Venezuela to study the effect of five organic fertilization plans on the growth and productivity of a melon crop (*Cucumis melo* L.) in an organic cultivation system. Treatments consisted of five fertilization plans (i) 10 Mg ha^{-1} goat manure compost (GMC), (ii) 25 Mg ha^{-1} cattle manure compost (CMC), (iii) 35 Mg ha^{-1} goat manure vermicompost (GMV), (iv) 21 Mg ha^{-1} sugarcane filtercake compost (FCC) and (v) control without any fertilizer (Control). The growth and melon productivity was higher from plots managed under the fertilization plan using animal wastes (manure), mainly goat manure vermicomposted by the earthworm *Eisenia foetida*.

Introduction

Melon is one of the most economically important vegetable crops in many tropical and subtropical regions of the world. The rapidly growing population in many tropical regions has led to a rising demand for food production in the last decades. However, the unfavourable agroecological conditions are difficult to handle and the results are often degradation of soils and decreasing crop yields (Wezel and Bocker, 1999). In most tropical and developing countries, organic fertilizers have long been replaced by chemical fertilizers. This practice and the other conventional ones have caused a decline in crop productivity, soil productivity (erosion, nutrient runoff, salinity, etc.) and other environmental impacts. One possibility of overcoming this is the use of agricultural wastes, organic fertilizers and crop residues as a compost and mulch. Generation of organic waste is increasing worldwide and strategies for its environmentally-sound use must be developed and optimized. Vegetable crop growth, yield and product quality in relation to application of agrowaste compost has been widely reported (Togun *et al.* 2004), mainly under organic systems. Several experiments have found that organic systems are environmentally sustainable. An understanding of agroecosystems is key to determining effective farming systems. According to Mader *et al.* (2002), enhanced soil fertility and higher biodiversity found in organic plots may render these systems less dependent on external inputs. As there is little information about compost fertilization and vegetable organic cultivation including melon crop under tropical conditions, this research was laid out to study the effect of five organic fertilization plans on the growth, fruit yield and quality of melon crop under tropical conditions.

Methodology

The experiment was carried out under tropical field conditions at the agricultural community "Montana Verde" (9º 52' N, 67º 9' W) in Torres county of Lara State, Venezuela. The climate has a mean annual temperature between 22 to 29 ºC and annual rainfall of 1010 mm. Melon seeds of the hybrid Araucano (Seminis Seed, USA) were sown in August 2002 on a silty clay soil (Table 1). Treatments consisted of five fertilization plans (i) 10 Mg ha^{-1} goat manure compost (GMC), (ii) 25 Mg ha^{-1} cattle manure compost (CMC), (iii) 35 Mg ha^{-1} goat manure vermicompost (GMV), (iv) 21 Mg ha^{-1} sugarcane filtercake compost (FCC) and (v) control without any fertilizer (C). All organic fertilizers were incorporated (only in the sowing row) 5 days before sowing. The experiment was set up using furrow irrigation and under an organic system production (non chemical pest management). Treatments (5) were compared using a randomized complete block design with five replications. Each plot was a rectangular area of 37.5 m^2 (15 m x 2.5 m). The plant density consisted of 14,000 plants per hectare approximately (30 cm between plants in a double row per plot).

Table 1. Selected chemical properties of the experimental soil (0-30 cm depth).

pH (1 : 2)	EC ($dS.m^{-1}$)	Organic matter (%)	P (ppm)	K (ppm)	Ca (ppm)	Mg (ppm)
6.9	0.28	3.2	19	102	+ 3000	171

Chemical analysis in soil solution. Standard methodologies cited by Allen, (1989).

Growth analyses were assessed from a non-destructive sample of three plants per plot, which were measured at 30, 40, 50 and 60 days after sowing (das). Number of green leaves, male and perfect flowers, fruits per plant and the vine long readings were taken. Plants were harvested (3 times) and yields determined from 5 fruits of the row center of each plot. Additionally, five fruits per harvest and plot were taken at maturity for quality postharvest analyses. These analyses consisted of external and internal (cavity) diameters, pulp thickness and total soluble solids (TSS, ºBrix). Growth and productivity parameters were determined following methodologies used by Perez *et al.* (1997) and Bulluck *et al.* (2002).

Results and discussion

Melon growth responded positively to all the organic fertilization plans evaluated, where the GMV treatment produced the greatest results. Table 2 shows the effects of four organic amendments on some of the growth characteristics at some of the sampling dates recorded. At 30 das, leaf numbers from melon plants fertilized with the GMV were greater than those plants given no fertilizers and the other ones. The highest green biomass was reached at 30 das. Flower male number for plants receiving GMC was significantly higher than those plants receiving no fertilizer and the other amendments. The maximum male flower number was recorded at 40 das. Additionally, fruit number per plant (fruits/vine) was significantly higher in plants with CMV, GMV and none fertilizer than all the plants with GMC and FCC. Taha *et al.* (2003), found positive and significant associations between the number of fruits/vine with the number of primary branches. Fruits per vine were also positively correlated with melon yield. Information on the correlation and linkage among different horticultural characteristics is of primary importance in the field of crop improvement. There were no significant differences in vine length and perfect flower number among the fertilization treatments. However, it is important to note that maximum vine length was reached at 50 das, while that the highest perfect flower number was at 40 das. Increased plant biomass recorded by all the animal manure composts was attributed to enhanced soil fertility (better nutrients availability) and improved soil physical condition. We think that vegetal compost as FCC breaks down more slowly in soils than do manures. Manure is composed mainly of faeces and urine, which have already commenced breaking down inside of the animals. These experimental results were related than those of Matsi *et al.* (2003) who found that applications of liquid cattle manure resulted in a significant increase in dry biomass at the two growth stages and in a grain yield and nutrient uptake of winter wheat growing on a calcareous loam soil of Greece. Duenhas (2004) also found that the higher total and commercial yield, vine length and number of commercial melon fruits were obtained with manure addition.

The results showed at Table 2 indicate that melon yields were affected by the organic fertilization plan. Melon yield of plants receiving GMV and FCC was statistically greater than plants receiving no fertilizer and GMC and CMC. These results suggested that as GMV (animal waste) as FCC (vegetal waste) may be a good fertilization practice under organic production system. There are several studies where crop yields have been increased by organic vegetal and animal composts (Maynard and Hill, 2000, Stoffella and Graetz, 2000, Wells *et al*. 2000, Bulluck *et al.* 2002, Matsi *et al.* 2003, Togun *et al.* 2004). Compost has been used as beneficial soil amendments in vegetable crops production systems. Additionally to the use of compost as fertilizers, various studies have demonstrated the beneficial use of compost as alternatives to polyethylene mulch, weed control in alley ways, diseases control (suppression properties) and a soil conditioner (Stoffella and Graetz, 2000).

Table 2. Effects of 5 organic fertilization plans on growth, yields and quality of melon crop.

Das	Organic Fertilizer	Leaves per plant	Male flowers per plant	Fruits per plant	Yields (kg ha^{-1})	Fruit weight (kg)	External perimeter (cm)	Pulp thickness (cm)
	GMC	60.4 **b**	8.8 **a**	-	-	-	-	-
	CMC	49.6 **c**	5.3 **b**	-	-	-	-	-
30	GMV	74.9 **a**	6.7 **b**	-	-	-	-	-
	FCC	51.8 **c**	4.9 **b**	-	-	-	-	-
	None (Control)	53.4 **b**	6.8 **b**	-	-	-	-	-
	GMC	-	-	2.0 **b**	24960 **b**	1.5 **b**	43.0 **b**	4.2 **b**
	CMC	-	-	2.8 **a**	26128 **b**	1.6 **b**	42.2 **b**	4.5 **b**
60	GMV	-	-	2.6 **a**	30899 **a**	2.0 **a**	46.7 **a**	5.4 **a**
	FCC	-	-	1.4 **b**	29302 **a**	1.6 **b**	44.2 **a**	4.6 **b**
	None (Control)	-	-	2.4 **a**	26435 **b**	1.4 **b**	42.8 **b**	4.1 **b**

Means followed by the same letter are not significantly different by Duncan test at the 0.05 level. dat: days after transplant. GMC: 10 Mg ha^{-1} goat manure compost, CMC: 25 Mg ha^{-1} cattle manure compost, GMV: 35 Mg ha^{-1} goat manure vermicompost, FCC: 21 Mg ha^{-1} sugarcane filtercake compost (FCC) and Control: without any fertilizer.

Different organic fertilizers significantly influenced melon fruit quality (Table 2). However, there were no significant differences or effects of different compost applications on the internal fruit diameter (seed cavity) and the TSS. Duenhas (2004) evaluated organic melon crop production at Petrolina, Pernabuco State of Brazil and found there was no effect of manure addition and humic substances application on the consistency, thick flesh and seed cavity of melon fruit. Application of vermicomposted goat manure significantly increased the melon fruit weight and pulp thickness (thick flesh) over the control and the other compost fertilization, whereas GMV and FCC resulted in an increase in the external fruit perimeter. The greatest fruit weight and thick flesh by plants receiving GMV could be attributed to a much higher nutrients availability and balance of this fertilizer than the others organic fertilizers as a consequence for the supplementary break down done by the earthworm *Eisenia foetida*. In an earlier related study, Perez *et al.* (1997), evaluated organic and mineral fertilization on postharvest quality of muskmelon (Laguna hybrid) in another melon commercial area of Lara state, Venezuela. The results showed that the organic manure treatments obtain the best quality values for most of the parameters evaluated. Thick flesh and a small seed cavity are correlated with increased fruits per vine or a high fruit density, while fruit weight and fruit shape index are positively correlated with yield per plant (Taha *et al*. 2003).

Conclusions

Melon growth and productivity in tropical conditions could be differentiated by the organic fertilization plan applied. This investigation has demonstrated consistently that vermicomposted goat manure can have beneficial effects on melon growth, yield and fruit quality growing in tropical environments. In general any animal or vegetal organic waste that has been well-composted may be a partial substitute for fertilizer in commercial organic melon production. These results and many others suggest that organic fertilization in organic production system has great potential under tropical conditions in developing countries. However, the practices implemented by vegetables growers differ among the developing countries. For example, other Latino American vegetable growers are being encouraged to organic farming because of the inability of the farming communities to afford the use of modern inputs likes fertilizers and pesticides due to their prohibitive costs. However, Venezuelan vegetable growers are encouraged to organic farming because the mineral richness (important oil world producer) of the country and government and because of the inappropriate agricultural and environmental policies taken by the national governments over the time.

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EFFECT OF INCORPORATING RICE STRAW OR LEAVES OF GLIRIDCIDIA (*G. sepium*) ON THE PRODUCTIVITY OF MUNGBEAN (*Vigna radiata*) AND ON SOIL PROPERTIES

U R Sangakkara[1], G Pietsch[2], M Gollner[2], B Freyer[2]

1. Faculty of Agriculture, University of Peradeniya, 20400 Sri Lanka (sanga@ids.lk)
2. Institute of Ecological Agriculture, University of Natural Resources and Applied Life Sciences, Vienna, Austria.

Key words: *Organic farming, organic matter, application methods, soil, crop growth*

Abstract

A field study evaluated the impact of mulching or incorporating two organic materials with differing C:N ratios on selected soil properties and the productivity of organically grown mungbean in a dry season, under rainfed conditions. While the organic matter improved the soil parameters and hence yields, incorporation had a greater beneficial impact on measured parameters, except weed numbers, which were reduced significantly by mulching with straw. Gliricidia leaves, with a lower C:N ratio than rice straw, had the better effect on soil properties and crop growth. The potential for using commonly available organic materials in smallholder tropical cropping systems to enhance productivity in dry seasons is discussed.

Introduction.

Organic farming is a rapidly growing system of agricultural production all over the world, and the developing nations of the tropics are no exception. Either through choice or necessity, farmers produce crops organically for consumption, or more importantly for sale locally or as an export item (Joergensen, 2002). However, tropical soils generally have low organic carbon contents (Hartemink, 2003), and inclusion of organic matter is of primary importance in maintaining soil fertility, productivity and sustainability, especially in organic farming systems (Dick and Gregorich, 2004). Organic matter used for crop production in the tropics is generally the residue of crops, or *in situ* or *ex situ* green manures. The method of application could affect the efficacy of biomass as shown in India (Venugopalan and Tarhalkar, 2003). Furthermore, the season of cultivation could also affect the efficacy of organic matter in promoting crop yields (Dick and Gregorich, 2004). Due to the lack of information on the impact of organic matter addition in organic systems, especially in the tropical minor season when crop growth is difficult due to moisture stress, field studies were carried out to ascertain the effect of two common organic materials (rice straw, C: N ratio 45; and leaves of *Gliricidia sepium*, C: N ratio 18) when applied as a mulch or incorporated before planting a crop, on selected soil properties at the onset of the season and yields of mungbean (*Vigna radiata* L).

Methodology

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 of the island, over the period May, 2003 to August, 2004, to encompass the minor (DRY) season, that corresponds to the South West monsoons. The soil of the site was an Ultisol (Rhodoult) with a sandy clay loam texture. The site receives some 1600 mm of rainfall per annum, with a mean temperature of 31°C. Rainfall during the crop growth period was 244 mm, and the mean humidity was 72.5%

The land was tilled manually to develop a good seedbed after an organically managed maize (*Zea mays* L) crop, grown in the previous major (Wet) season from December 2003 – March 2004. With the onset of rains in early May, plots of dimensions 3 x 2 m were demarcated, and either rice straw or Gliricidia leaves added to randomly selected plots (located in 4 replicates) as a surface mulch or incorporated into the top 30 cm manually, at a rate equivalent to 6 t per ha (i.e. 600 gm^{-2}). One plot was left bare as per standard practice of farmers. At 14 days after the addition of the organic matter, the soil was sampled to a depth of 40 cm and analyzed for bulk density, water holding capacity, pH (1:2.5 H_2O) and N using standard methods as described by Anderson and Ingram (1996). At flowering of the mungbean crop (30 – 32 days after planting), similar soil samples were obtained for determining water holding capacity) and N. The organic matter in the surface mulched plots was carefully removed prior to both samplings. The sampled soil was air dried and stored at 4.0 °C for analysis. Thereafter, uniform seeds of mungbean were sown at a spacing of 20 x 30 cm, as recommended for Sri Lankan conditions. No fertilizers or pesticides were applied and weeding was carried out manually on two occasions. At each weeding the weed populations were determined within a 1-m^2 quadrate. At flowering, shoot water potential ('pressure bomb'), soil N and soil water holding capacity were determined. At crop maturity, seed, shoot and root yields were determined after drying samples at 80°C for 48 hours. The data was subjected to analysis of variance using a general linear model (GLM).

Results and Discussion

Soil parameters

Incorporation of organic matter reduced the pH of the soil, which could be attributed to the more rapid breakdown of the added material when compared to surface mulching (Table 1). The impact was greater with Gliricidia, which could break down more easily due to its lower C: N ratio. Bulk density, an important parameter related to root development (Kuchenbuch and Ingram, 2004), was also less, especially when the two organic materials were incorporated. The water holding capacity of the soil was increased by incorporation of organic matter, especially the slower decomposing rice straw. However, the beneficial impact of organic matter in moisture retention declined with time, possibly due to the decomposition of the material in the warm climate of the dry season (Mean temperature 32.5°C). A longer-term program with continued application of organic matter would show greater and improved benefits to soil parameters (Hartemink, 2003).

Table 1. Impact of method of incorporating rice straw or Gliricidia leaves on selected soil parameters at the onset of the planting season and at flowering of mungbean

Soil parameter	Rice Straw		Gliricidia leaves		Control	LSD
	Sur	Inc	Sur	Inc*		(p=0.05)
pH (1.2.5 H_2O)	6.21	6.19	6.20	6.14	6.24	0.03
Bulk Density ($Mg.m^{-3}$)	1.25	1.16	1.27	1.19	1.31	0.05
WHC$^+$ (%) (Seeding)	18.6	19.4	18.5	19.3	17.9	1.21
(Flowering)	14.5	14.4	13.3	13.3	12.8	0.95
Soil N mg.100g $soil^{-1}$						
(Seeding)	1.10	1.06	1.16	1.13	1.04	0.02
(Flowering)	1.08	1.03	1.11	1.08	1.02	0.009

*Sur and Inc refer to surface addition and incorporation respectively + WHC refers to water holding capacity of the soil (%)

Plant growth and yields

Germination increased with the addition of organic matter, especially when incorporated (Table 2). This suggests the lack of allelopathic affects of the two organic materials on the mungbean crop. However, mulching reduced the germination marginally, which could be due to a barrier effect. This could obstruct the emergence of tender seedlings. Application of mulch soon after emergence could overcome this phenomenon.

While the addition of organic matter increased the shoot water potential at flowering (ie less negative potentials), a lower pressure was required to extract the water in plants grown in plots where straw or Gliricidia were incorporated. This again could be related to the increased water holding capacity of the soil in these plots (Table 1) when compared to the untreated or surface mulched plots.

Table 2. Germination, shoot water potential, biomass and seed yields and weed populations of mungbean as affected by the method of adding rice straw and gliricidia leaves

Parameter	Rice Straw		Gliricidia leaves		Control	LSD
	Sur	Inc	Sur	Inc*		(p=0.05)
Germination (%)	84	81	80	83	75	4.38
SWP (MPa)$^+$	-5.56	-4.71	-5.28	-4.18	-6.01	1.04
Shoot yield ($kg.ha^{-1}$)$^@$	1488	1789	1655	1781	1907	56.14
Root yield ($kg.ha^{-1}$)$^@$	564	661	614	685	445	29.07
Seed yield ($kg.ha^{-1}$)$^@$	766	821	793	864	668	40.92
Weeds (m^{-2})	85	154	128	181	149	29.80

*Sur and Inc refer to surface addition and incorporation respectively. + SWP refers to Shoot water potential - @ Refers to the parameters measured at crop maturity.

Root and shoot yields at harvest increased most with Gliricidia, the organic matter with the lower C: N ratio, and which had the potential to provide a suitable rhizosphere as well as plant nutrients, especially N. The beneficial impact of rice straw was lower, but greater than a control plot that did not receive any organic matter. Decomposition of the straw with its higher C: N ratio could utilize some soil N, which could have an adverse impact on the growth and yield of the crop. Application of the organic matter increased seed yields significantly. Furthermore, incorporation increased seed and residue yields, suggesting the benefits of mixing organic matter into the soil for better soil quality and crop growth, resulting in higher yields.

Weed populations

Mulching also has its benefits in terms of weed suppression. Weeds are a major problem in most organic systems (Bond and Grundy, 2000), and the application of the organic matter, especially the slow decomposing rice straw, reduced weed populations significantly when compared to all other treatments. The impact of Gliricidia mulch was lower due to the more rapid decomposition, although surface application reduced the weeds to a greater extent than when incorporated.

Conclusions

Application of biological material is vital in organic farming systems. This becomes imperative in the tropics, where soil organic matter is low and where the organic matter decomposes rapidly due to the warm and dry climatic conditions. The organic matter available in the smallholder tropical farming systems is generally of a low quality (e.g. cereal crop residues). This short-term study highlights that fresh leguminous material that could be gathered from the surroundings provides more benefits to soils and crops than a cereal (rice) straw. Although not studied, a mixture of the two may provide greater benefits than the straw alone. While the benefits of mulching the organic material lie in weed control, better rhizospheric conditions are developed with incorporation, resulting in better growth and yields of the food crop, irrespective of the type of organic matter.

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SOIL COMMUNITIES

IMPROVEMENT IN SOIL NUTRIENT STATUS AND BENEFICIAL MICROBIAL POPULATIONS USING COMPOST, PLANT JUICE AND HOME-MADE FERTILISER PREPARATIONS

Aini Z.[1], Zulkefli M.[2], and G.Krishnen[3]

[1] Malaysian Agricultural Research and Development Institute, P.O. Box 12301, General Post Office, 50774 KUALA LUMPUR, Malaysia, ainizak@mardi.my

[2] Malaysian Agricultural Research and Development Institute, P.O. Box 12301, General Post Office, 50774 KUALA LUMPUR, Malaysia, zulmalik@mardi.my

[3] Malaysian Agricultural Research and Development Institute, P.O. Box 12301, General Post Office, 50774 KUALA LUMPUR, Malaysia, ganisan@mardi.my

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Abstract

Natural farming (NF) techniques use farm inputs such as indigenous microbes (IMO), composts, fermented fruit and plant juices, fish amino acids and other home made fertiliser preparations in managing the soil fertility. Experiments were carried out on farmers' plots at two different sites, Air Kuning and Serdang to quantify the effectiveness of the technique using long beans (*Vigna sesquipedalis)* as the test crop. Soil qualities such as the carbon content, total nitrogen and cation exchange capacity especially that of calcium, increased significantly after planting in the NF plots compared to the conventional farming (CF) plots. A higher number of beneficial microbes such as *Azotobacter, Azospirillum, Actinomycete, Lactobacillus,* was obtained during harvest on the NF treated plots in Air Kuning, a site that has been cultivated under natural farming for 2 years. There was a slight drop in soil pathogens such as *Erwinia* and *Fusarium* in the soil in the NF treated plots. However, no significant changes in both NF and CF plots were obtained in Serdang, a plot that was prior to the experiment cultivated under conventional farming. Higher yields, however, were obtained in the NF plots at Air Kuning.

Introduction

Land use and farming practices may change the soil quality. Amongst farming practices that can maintain soil quality are addition of organic material, crop rotation, growing of legumes and minimal tillage (Watson et al., 2002, Parr et al. 1992). However, there are varying practices adopted by organic farmers of which one of it is termed natural farming (NF). Natural farming practices by and large utilize indigenous micro-organisms (IMO) that are complimented with plant and animal-based fertilizers to enhance crop growth. Farmers employing the NF farming production techniques claimed significant increases in yield and low production costs compared to conventional farming (CF) (Cho, 1997; Ramli and Williams, 2003).

In view of these claims, a study was done on two sites that were managed by the farmer's themselves according to the Natural Farming techniques and schedules. The objectives of the study were to i) quantify the effectiveness of homemade fertilisers and derived enzymes (as routinely practised by the farmers using the NF technique), and ii) observe nutrient and microbial changes in both plots.

Methodology

Two sites managed by farmers chosen for the experiment were at : a) Air Kuning (sandy loam), which had been managed under natural farming (NF) for 2 years and b) Serdang (clay loam), which was previously under conventional management. A randomized complete block design was laid out with 16 replicates. Treatments consisted of long beans (*Vigna sinensis*) grown under NF and CF. Each treatment consisted of 3 beds measuring 1 x 4 meter and were surrounded by a 1 meter wide dense crop of corn to contain contamination. IMO4 at the rate of 1 ton/ha and compost 10 t/ha were added on the NF plots 4 days before planting.

Several natural farming preparations were made by the farmers prior to the experiment. They included:

<u>i) IMO4</u>. Indigenous microorganisms naturally inoculated by placing cooked rice under a tree in an undisturbed area for a few days. Brown sugar (1:1 ratio) was added to the rice and then further fermented for

3 days. The fermented mixture (1gm/L) was then added to 10 kg rice bran and further fermented for a few days. The final fermented mixture of rice bran was mixed with the farm soil in the ratio of 1:1.

ii) Compost. The IMO4 was added at the rate of 1:10 to oil palm empty bunches and composted for about 3 months.

iii) Fermented plant juice extract (FPJ). Water spinach *(Ipomoea aquatica)* and brown sugar were added at a volume ratio of 1:1 and left in a jar for 5-7 days.

iv) Fermented Fruit Juice FFJ. Papaya (*Carica papaya*) fruits were chopped into small pieces and mixed with brown sugar (1:1 ratio) and kept in a jar for a week.

v) Oriental Herb Nutrient (OHN). Cinnamon was added with rice vinegar at a ratio of 1:3 by volume. Brown sugar was topped up at a volume of 1:1 of the mixture of the latter. The mixture was left to degrade for 7-10 days in a jar before use.

vi) Fish Amino Acid (FAA). Fish head, bones and entrails were mixed with brown sugar at a ratio of 1:1 volume and kept in a jar for 1 month.

vii) Egg calcium phosphate (CaP). Egg shells were initially burnt and then mixed with rice vinegar at a volume ratio of 1:10. It was left to degrade for 30 days.

viii) Bone calcium phosphate PCa. The procedure is similar to (vii) and cattle bones were used instead.

For the NF plots, FFJ, FPJ, FAA, CaP and PCa were sprayed onto the long beans at different combinations and at specific days after planting according to the natural farming practice (Table 1). The various spray formulations followed the generic names (Type II, Type III and morning sickness) given by Cho (1997). Type II formulation for instance, consisted of FPJ, rice vinegar, FAA and PCa at dilutions as stated in Table 1. Only 2% concentration of the stock of Type II, Type III, and morning sickness were used for the foliar sprays. In the CF plots, no composts were applied. Chemical fertiliser (NPK Blue) was applied 3 times instead, namely, one day before planting, 14 and 28 days after planting, at the rate of 800 kg/ha. No chemical herbicides and pesticides were used for either CF or NF plots.

Soil samples from both sites were taken at 0-15 cm depth (before and after planting) and analysed for chemical and physical properties. Soil pH (in water) and electrical conductivity (EC) were measured using glass electrode-pH meter and conductivity meter, respectively. Soil organic carbon was determined by the Walkey-Black dichromate titration method (Walkey and Black, 1934), while total nitrogen content was determined by macro-Kjedhal digestion (Bremner and Mullraney, 1982). For the CEC determination, the leaching methods with 1M ammonium acetate buffered at pH 7 was used. The exchangeable K, Ca, Mg and Na were determined by Atomic Absorption Spectrometry. Phosphorus was determined by Bray-Kurtz methods (Bray and Kurtz, 1945). The Phosphorus in the extract is measured colorimetrically by the molybdenum methods on double beam spectrophotometer (Hitachi U-2000). The homemade fertilisers were also analysed for N, P, K, Ca and Mg using the same methods as above.

Only selected microorganisms, namely four common beneficial microbes (*Lactobacillus*, *Azotobacter*, *Azospirillum*, *Actinomycetes*) and two pathogenic microbes (*Fusarium, Erwinia corotovora)* were studied. Soil samples from 0-15cm depths were taken from both NF and CF plots. Serial soil dilutions were made and 1 ml of each dilutions was dropped and spread on specific agar medias. Spread plates containing Tomato Juice Agar (TJA), Azotobacter Agar (Azob), Azospirillum Agar (Azos), Actinomycete Isolating Agar (AIA), PCNB Agar (PCNB) and Crystal Violet Pectate Agar (CVP) were used for enumerating the microbial populations of *Lactobacillus*, *Azotobacter*, *Azospirillum*, *Actinomycete*, *Fusarium* and *Erwinia corotovora* respectively.

Data were analysed using SAS package (SAS Institute 1985). The Least Significant Different (LSD) analysis was carried out to determine the level of significance among the treatment means.

Results and brief discussion

The chemical and physical properties of the soil in both sites (Table 3) showed contrasting changes. At Air Kuning, the soil properties improved in the NF plots. Total nitrogen content, organic carbon and CEC increased significantly. The nitrogen % increased from 0.15 to 1.95 %, the organic carbon increased by 64% and the CEC increased by 37%. In the CF plots, no significant changes were observed in all the soil parameters. At Serdang, there were only significant changes in the CEC, especially the exchangeable Ca and Na of about 30% in the NF plots. Very subtle soil changes were seen in the CF plots.

Due to different soil types and management, both sites show different trends in changes. In Air Kuning where NF had been practised on the plot for two years before the experiment, overall soil improvements were observed even though some were not significant. This is perhaps due to the continuous application of the home-made fertilisers and composts which contained some amount of nutrients, particularly nitrogen (Table 2). Though the amount of nitrogen is small in most cases, but the repeated applications over the two years of practice as in Air Kuning, could have caused the improvement in the soil. The soil in Serdang prior to the experiment was not exposed to any microbial amendments and changes in the soil nutrients would not have a significant effect over one season. Studies comparing changes between the conventional and organic farming systems which have been farmed for 70 years have shown increased changes especially in the nitrogen mineralisation and soil organic matter (Pulleman et al. 2002).

Beneficial microbial activity was generally higher in the NF than the CF treatments in the Air Kuning site (Fig. 1)**.** The numbers of *Lactobacillus*, *Azotobacter* and *Azospirillum*, were significantly higher in the NF than the CF treatments. In the Serdang site however, no significant changes in the number of Lactobacillus, *Azotobacter*, *Actinomycetes,* were obtained (Fig. 2) between the CF and NF treatments. This is probably due to the site being newly practised with natural farming compared to Air Kuning, which had been on natural farming management the past 2 years. The presence of high organic content in Air Kuning may have provided greater microorganism growth. Greater amounts of newly formed and readily decomposed nutrient fractions may have been the contributing factor of growth of more microorganisms (Elmholt & Kjoller, 1987). The pathogen, *Erwinia*, showed a decreasing number at the end of the experiment, for both the CF and NF treatments in Air Kuning. In the CF and NF treatments, a very slight increase in the *Fusarium* number was observed, from 20 - 32 x 10^4 cfu/ml in the NF treatment especially.

In the Serdang plots however, no significant increase of beneficial microorganisms was observed in both the CF and NF plots. No significant decrease in pathogens was also observed in both CF and NF plots even though use of compost had shown that it suppresses a wide range of soil-borne plant pathogen (Cook & Baker, 1983, Hoitink, et al. 1997). The conflicting evidence in relation to the number of beneficial microbes in the Serdang site may be attributed to management practices (Shannon et al., 2002).

The total harvested yield in NF plots in Air Kuning was 6.7 % higher than the CF plot. Conversely, the CF plot in Serdang had higher yields compared to NF. This may be attributed to the Serdang plot being exposed to chemical inputs for a long time compared to the soil in Air Kuning which had been under NF practice over 2 years.

Conclusions

Results showed that NF practices had a potential ability to improve the soil nutrient status compared to CF. However, significant levels of soil physical properties, especially in the Serdang site, previously under CF, was not evident because a longer period of study is required to observe the significant changes under both farming systems. In the Air Kuning site, this had been cultivated under NF for 2 years, the beneficial microbial population increased and the number of pathogen showed a downward trend. This preliminary observation also showed that the crops yields too, increased though not significantly, under continuous natural farming practices.

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Table 1. Type, rate and fertilization schedule

NF	Days after planting	Type of spray	
Fertilizer		Type of preparation	No of ml/amount of water
FPJ + OHN	-1	Type II	
Type II	5	FPJ	1:500
Type II	12	Rice vinegar	1:500
	14	FAA	1:1000
Morning sickness	19	PCa	1:1000
Type III	26		
	28	Type III	
Type II	30	FFJ	1 :500
Morning sickness	40	Rice vinegar	1:800
Type III	47	CaP	1:800
Morning sickness	54	FAA	1:1000
Type III	61	Sea water	1:30
Type II	68		
Morning sickness	75	Morning sickness	
Type III	82	FFJ	1 :500
Type II	89	Rice vinegar	1:300
Morning sickness	96	FAA	1:1000
		PCa	1:800

DAP = Days after planting

Table 2. Nutrient content of compost and the home made fertilizers

Material	Nutrient content (%)				
	N	P	K	Ca	Mg
IMO compost	1.48	0.26	0.17	1.64	0.18
Fermented fruit juice (FFJ)	1.2	0.1	0.5	0.2	0.2
Fermented plant juice (FPJ)	1.3	0.1	0.5	0.2	0.1
Fish amino acid (FAA)	14.2	1.0	0.7	0.8	0.1
Egg calcium phosphate (CaP)	0.2	0.04	0.02	2.3	0.03
Bone calcium phosphate (PCa)	0.6	0.2	0.02	0.3	0.01
Oriental herb nutrient (OHN)	-	-	-	-	-

Table 3. Soil chemical and physical properties at Air Kuning (3.1) and Serdang (3.2)

Air Kuning (3.1)	Air Kuning			
	Natural Farming (NF)		Conventional Farming (CF)	
	Before	After	Before	After
pH	4.48a	4.95a	4.07a	4.35a
Conductivity	37.1a	40.8a	24.2a	30.5a
Organic Carbon	1.95b	3.20a	1.82b	2.05a
Nitrogen (%)	0.15b	1.95a	0.21b	0.45b
Phosphorus (ppm)	38.2a	45.9a	37.4a	35.9a
Cation Exchange Capacity (meq / 100g soil)	4.55b	6.25a	3.78bc	4.21b
Exchangable Cation (meq / 100g soil)				
K	0.10b	1.25a	0.35b	0.45b
Ca	1.04a	1.45a	0.77ab	1.23a
Mg	0.18a	0.26a	0.15a	0.10a
Na	0.15b	0.41b	0.10b	1.25a
Bulk density (g / cm^3)	1.30a	1.01a	1.35a	1.25a

Means followed by the same letter in rows is insignificant at P≤0.05 by DMRT

Serdang (3.2)	Serdang			
	NF		CF	
	Before	After	Before	After
pH	4.85a	5.04a	4.98a	4.75a
Conductivity	39.11a	45.20a	40.05a	43.12a
Organic carbon	2.42a	1.95ab	2.57a	2.19a
Nitrogen%)	0.16a	0.25a	0.15a	0.09a
Phosphorus (ppm)	13.68a	15.30a	12.80a	10.32a
Cation Exchange Capacity (meq / 100g soil)	11.03b	14.04a	12.25b	11.55b
Exchangable Cation (meq / 100g soil)				
K	0.10a	0.25a	0.14a	0.16a
Ca	1.15b	3.30a	1.35b	1.09b
Mg	0.48a	0.65a	0.55a	0.63a
Na	0.10b	0.86a	0.13b	0.15b
Bulk density (g/cm^3)	1.28a	1.25a	1.30a	1.27a

Means followed by the same letter in rows is insignificant at P≤0.05 by DMRT

Table 4. Total yield of long beans at Air Kuning and Serdang

	Total harvest (kg)			
	Air Kuning		**Serdang**	
	NF	**CF**	**NF**	**CF**
Total Yields (Mean ± Standard Error)	515 (10.20±5.33)	483 (8.60±4.47)	123 (2.86±1.52)	152 (3.55±1.98)

Figure 1. Soil microbial population changes in Air Kuning soil before and after planting
(The vertical bar represent standard error)

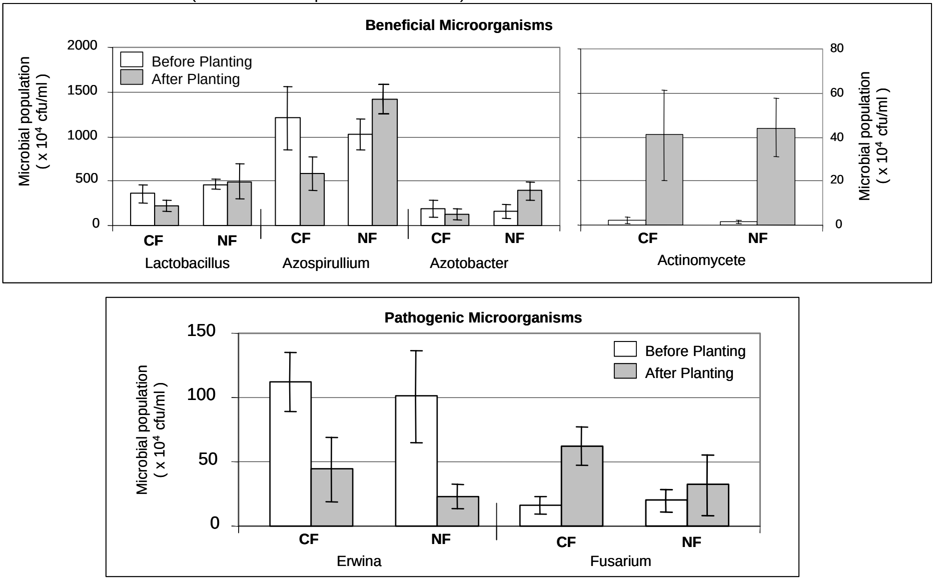
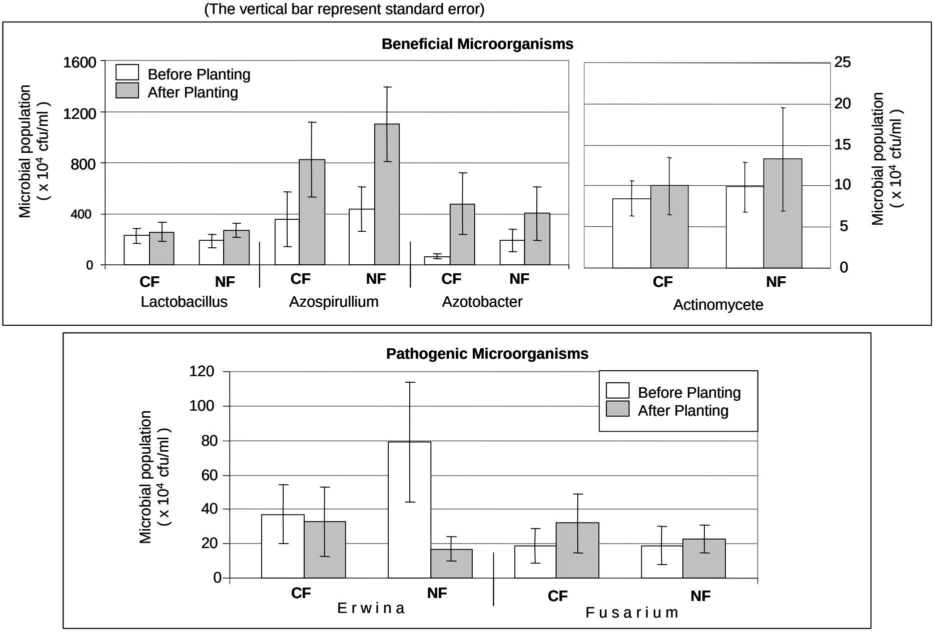


Figure 2. Soil microbial population changes in Serdang soil before and after planting
(The vertical bar represent standard error)



SOIL MICROBIAL COMMUNITY STRUCTURE AND ORGANIC MATTER TRANSFORMATION PROCESSES IN ORGANIC AND INTEGRATED FARMING SYSTEMS

Andreas Fliessbach[1], David Dubois[4], Jürgen Esperschütz[3], Lucie Gunst[4], Paul Mäder[1], Hansruedi Oberholzer[4], Michael Schloter[3], Andreas Gattinger[2]

(1) Research Institute of Organic Agriculture (FiBL), Ackerstrasse, 5070 Frick, Switzerland, +41 62 8657225, andreas.fliessbach@fibl.ch, www.fibl.org
(2) Technical University Munich, Chair of Soil Ecology, Ingolstädter Landstr. 1, D-85764 Neuherberg, +49 89 31873531, gattinger@gsf.de, www.wzw-tum.de
(3) GSF-National Research Center for Environment and Health, Institute of Soil Ecology, Ingolstädter Landstr. 1, D-85764 Neuherberg, +49 89 31872304, schloter@gsf.de, www.gsf.de
(4) Agroscope FAL Reckenholz, Reckenholzstrasse 191, 8046 Zürich, Switzerland, +41 1 3777220, david.dubois@fal.admin.ch, www.reckenholz.ch

Key Words: farming systems, soil quality, organic matter, soil microbial communities, phospholipid fatty acids

Abstract

The DOK long-term field trial in Switzerland started in 1978 (Mäder et al., 2002). Biodynamic (BIODYN), bioorganic (BIOORG) and integrated (CONFYM) farming systems with manure fertilization, an integrated system based on mineral fertilizer only (CONMIN) and an unfertilized control (NOFERT) were investigated for changes in soil organic matter and on the structure of the soil microbial communities. Soil organic matter (SOM) in the A_p-horizon (0-20 cm) was analysed from the beginning of the DOK field trial in 1978. Roughly 20% of the initial SOM was lost when no manure was applied for 21 years as in the CONMIN and the NOFERT system, whereas SOM increased slightly by 4% in the BIODYN system that makes use of composted farmyard manure, corresponding to 1.4 livestock units per hectare (LSU). The BIOORG and the CONFYM system lost about 7%.

Soil microbial biomass analysed from 2000 and 2003 samplings revealed higher values in organically fertilised plots. Bacterial and eukaryotic biomasses followed the order: CONMIN < CONFYM ≤ BIOORG ≤ BIODYN. Phospholipid etherlipids, indicative for micro-organisms of the domain *Archaea* occurred in abundance compared to other organically fertilised soils and followed the order: CONMIN < BIODYN = BIOORG = CONFYM. Clear differences in PLFA based microbial community structure among the four farming systems were observed. Organic fertilization compared to no manure had the strongest effect, followed by organic farming compared to integrated, and finally the kind of organic farming management (BIODYN with composted manure *vs*. BIOORG with rotted manure). The incorporation of maize-derived carbon – with higher ^{13}C content – to some of the PLFA was detected and highlights the functional role of the corresponding microbial groups in carbon transformation processes. Contrasting ^{13}C values in the PLFA-biomarkers for *Archaea* in organic and conventional soils support the assumption that carbon transformation processes are affected by the farming systems.

Our results suggest that changes in SOM are indicated by changes in soil microbial biomass. The functional role of microbial groups will be further investigated. The enhanced chemical and biological soil quality found in the field plots fertilized with manure and manure compost maintains key soil functions, on which low input farming systems rely.

Introduction/Problem

Investigations of the impact of agricultural practices on soil carbon sequestration emphasize the return of carbon especially by animal manure (Freibauer et al., 2004; Smith et al., 2000). Having passed the digestive tract, manure is enriched in more refractory compounds that may persist as stable soil organic matter associated with clay and silt particles (Paustian et al., 1997). While the return of farmyard manure to soils has a positive impact on soil carbon, the application of composted manure may have further benefits that are carried along with the aerobic decomposition, where less methane – an important greenhouse gas – develops than in stacked manure (Davis, 2002).

Soil microbial communities are responsible for productivity and stability of agricultural land use systems and have, moreover, important functions in global nutrient cycling. Mäder et al. (2002) found a higher nutrient efficiency in organically managed soils of the DOK long-term field trial, which might be due to higher biodiversity found in these systems. Changes in soil organic carbon over 21 years of organic and conventional farming are presented and discussed within the frame of carbon sequestration and effects on soil quality. In the view of higher nutrient efficiency in organic compared to conventional farming systems, structure and *in situ* functions of microbial communities were investigated in this study.

Methodology

In 1978 the DOK field experiment, comparing two organic and two conventional farming systems, was set up at Therwil in the vicinity of Basle, Switzerland. The biodynamic (BIODYN) and the bioorganic (BIOORG) systems received organic fertilizers, whereas organic and mineral fertilizers were applied in one conventional (CONFYM) system, managed according to integrated production since 1985. Another treatment was left unfertilized during the first crop rotation, but was converted to a conventional treatment with mineral fertilizer only (CONMIN) in 1985. A control treatment remained unfertilized (NOFERT). The biological systems (BIODYN and BIOORG) received 45-69% of the nutrients (NPK) that were applied to the conventional systems (CONFYM and CONMIN) (Mäder et al., 2002). Soil organic matter in the top soil (0-20 cm) was analysed by wet potassium dichromate digestion.

In spring 2003, soil samples from winter wheat plots of the DOK long-term field trial (0-20 cm soil depth) with potatoes and maize as preceding crops were taken. Maize shows a higher content of the ^{13}C isotope than all other (C3) plants cultivated on the DOK soils so far and has not been grown on the DOK soils for at least 30 years. It serves as a natural tracer for carbon transformation in this study. Soil samples were subjected to analyses of phospholipid fatty acids (PLFA) and phospholipid etherlipids (PLEL) to determine bacterial, eucaryotic and archaeal microorganisms (Gattinger et al., 2003; Zelles, 1999). PLFA and PLEL biomarker were determined by gaschromatography/mass spectrometry-combustion-isotope ratio mass spectrometry (GC/MS-C-IRMS). This instrumentation allows the analysis of the community structure and the simultaneous determination of $^{13}C/^{12}C$ ratios in PLFA and PLEL biomarkers for functional analyses of the soil microbiota.

Results and brief discussion

Soil organic carbon values in the A_p-horizon (0–20 cm) decreased in all farming systems in the first years after the initial setup of the DOK field experiment in 1978. Over the three crop rotation periods studied, soil organic carbon in the BIODYN system increased by 4% with respect to the starting value, whereas in the other farming systems values decreased slightly. The total loss in soil organic carbon was highest in the NOFERT system, where 20% of the initially present carbon had disappeared from the A_p-horizon. The CONMIN system lost 13 % of the initial carbon content. The BIOORG and the CONFYM systems showed a loss of 5% compared to the starting values. Compared to the conventional mineral fertilizer system (CONMIN) the amount of carbon sequestered in the BIODYN system was 6.9 Mg C ha^{-1} and compared to the CONFYM system 3.4 Mg C ha^{-1} over 21 years. The difference between BIODYN and CONFYM accumulated to 16 Mg C ha^{-1} when the soil profile was analyzed down to 80 cm in a one-year study (Fliessbach et al., 1999), where significant differences were found until 60 cm depth.

Soil microbial biomass carbon (C_{mic}) in the top soil varied between 526 kg ha^{-1} soil in the CONMIN system and 864 kg ha^{-1} soil in the BIODYN system. These criteria of soil quality were generally enhanced in organic farming systems as compared to integrated emphasizing the important role of element cycling processes that are supported by an abundant and active soil biological community (Mäder et al, 2002).

Analyses of soil samples for phospholipids biomarkers from 2000 and 2003 revealed higher microbial biomass in the organically fertilised plots. Bacterial and eukaryotic biomass in these samples followed the order: CONMIN < CONFYM ≤ BIOORG ≤ BIODYN. Archaeal communities as indicated by phopholipid etherlipids occurred at moderate abundances compared to other organically fertilised soils (Gattinger et al., 2005) and followed the order: CONMIN < BIODYN = BIOORG = CONFYM. The preceding crop (winter wheat or maize) for the 2003 samples did not have an effect on total microbial biomass.

Using the phospholipid fatty acid (PLFA) biomarker approach, clear differences in microbial community structure among the DOK farming systems were observed. The effect of organic as compared to mineral fertilization had the strongest effect on changes in microbial community structure, followed by the type of management either organic or integrated, and the kind of organic farming (BIODYN or BIOORG) and finally the preceding crop showing the weakest effect. Diversity indices (Shannon-Weaver) were calculated for the microbial communities based on the number of PLFA and their abundance. The CONFYM system showed the significantly highest number of PLFA (≈ richness) and highest diversity (H), followed by BIODYN and BIOORG which had similar values for both. No difference in equitability or evenness (E_H) among farming systems were found. However, apart from the suitability and meaningfulness of diversity indices in soil ecology, they don't provide information on the functional aspects of the respective microbial communities. Therefore, we combined a specific ^{13}C-isotope analysis of the phospholipid biomarkers, which links microbial community structure to carbon transformation processes (Boschker et al., 1998). This analysis shows the eventual uptake of maize derived carbon sources that are enriched in ^{13}C, due to the C4 photosynthesis pathway, by the microbial decomposer community in soil discernible by phospholipid analysis. First results showed that 6 months after maize harvest in all investigated farming systems, several Gram-positive and Gram-negative bacteria, fungi and protozoa incorporated maize-derived C in their membrane lipids. Representatives of the domain *Archaea* did not show maize incorporation, however archaeal lipids showed significantly higher ^{13}C values in BIODYN and BIOORG plots. This clearly indicates that archaeal communities in BIODYN and BIOORG perform different C transformation processes than in CONFYM and CONMIN plots. Ongoing analyses of lipids from further microbial groups will contribute to the knowledge of *in situ* functions of microbial communities and may reveal different C transformation processes among farming systems.

Conclusions

Soil organic matter in farming systems of the DOK trial was positively affected by manure amendment. After 21 years of plot management only the biodynamic farming system at 1.4 livestock units per hectare showed higher soil organic matter levels as compared to the start. Farming systems without manure showed the severest loss in soil organic matter over time. Mixed farming and manure amendment of soils, therefore, is proven again to exert positive effects on soil carbon content, which may have important implications for the current discussion on carbon sequestration. Even though other factors cannot be excluded, the outstanding role of the biodynamic system is probably due to the composting of farmyard manure.

The analysis of microbial biomarkers (PLFA, PLEL) shows that long-term organic farming may lead to the formation and adaptation of a "system-specific" soil microbial community. This could be demonstrated at least for the community structure. First results of the functional analyses of soil microbial communities support the assumption that carbon transformation processes differ between the investigated farming systems.

Differences in microbial biomass and microbial soil processes between the organic and integrated farming systems of the DOK trial may differ under real conditions, since the DOK trial systems were different only with respect to plant protection, manure quality and mineral fertilizer supplement. Crop rotation and soil tillage were identical. The inclusion of a more diverse crop rotation, as often found in organic farming practice is likely to favour organic farming systems in the real world. Comparison of farming systems under real on site conditions, however, are much more complex, due to the higher diversity and variability of crops and management measures. More work has to be done to evaluate in depth the single effects of management factors and their integrative effects on soil organic matter and the total soil microbial community in order to interpret the effects of farming systems.

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ARBUSCULAR MYCORRHIZA OF WINTER WHEAT UNDER DIFFERENT DURATION OF ORGANIC FARMING

Manfred Gollner, Jürgen Friedel, Bernhard Freyer

Division of Organic Farming, Department of Sustainable Agricultural Systems, University of Natural Resources and Applied Life Sciences, Gregor-Mendel-Strasse 33, A-1180, Vienna, Austria, Tel. +43 1 47654 3750, E-mail manfred.gollner@boku.ac.at, http://www.boku.ac.at/oekoland/English.htm

Key words: organic farming, field research, arbuscular mycorrhiza (AM), AM fungi, long-term management

Abstract

The effect of continuous organic farming (OF) on the arbuscular mycorrhizal fungi (AMF) of winter wheat (*Triticum aestivum*) was investigated in a greenhouse pot trial. Representative soil samples were taken from 5 farms in the “Weinviertel” region, northeast of Vienna, Austria. On each farm three sites with a different duration of OF were selected for soil sampling; wheat was used as test plant. The mycorrhizal colonization (MC), root length density (RD) and the mycorrhizal colonized root length density (MD) were evaluated for the wheat roots. The majority of the wheat plants indicated an increasing MC and MD with increasing duration of OF. Based on our results we assume that a conversion period from conventional to OF of approximately 15 years is needed to establish a stable population of AMF, with all their considerable potential benefits for the host plants, and their contribution to maintaining soil fertility and structure.

Introduction/Problem

Arbuscular mycorrhizal fungi (AMF) are a main component of the soil edaphon in most agroecosystems. These obligate mutualistic symbionts colonize the roots of the majority of crop plants (Smith et al. 1997). AMF can efficiently absorb mineral nutrients (George et al. 1995) by their extended hyphal network, especially from nutrient-poor soils, and deliver them to their host plants in exchange for carbohydrates. AMF can also enhance the host plant’s resistance to root pathogens (Azcon-Aguilar et al. 1996) and its tolerance of abiotic stresses, such as drought (Subramanian et al. 1995). Furthermore, AMF play an important role in the formation of stable soil aggregates that allow water and air infiltration and prevent soil erosion (Miller et al. 2000). Because of these beneficial effects it is a challenge to develop AMF management strategies applicable for sustainable low-input but productive agricultural systems such as OF (Hamel 1996, Klironomos et al. 2000). Industrial farming practices are apparently detrimental for AMF, as recent studies indicate that AMF performance is declining with agricultural intensification (Ryan et al. 1994; 2002). However, little is known about how the duration of OF affects AMF. Therefore, we performed a study about the effect of the duration of OF on the root colonization of wheat by AMF.

Methodology

On five farms (A-E), three field sites with a different duration of OF on each were selected for this study. They are all located in the so-called "Weinviertel", an area northeast of Vienna extending to the border with the Czech Republic. The climate of the region is temperate, with an annual precipitation of about 650 mm and an annual average temperature of about 9.0°C. The soils on the five farms (A: Haplic Phaeozem; B and C: Eutric Cambisol; D: Haplic Chernozem; E: Luvic Chernozem) developed from loess, a wind-blown sediment of silty texture deposited during the last ice age. The agricultural use of the soils is arable land with OF in accordance with the Austrian guidelines corresponding to EU regulation 2092/91, from 7 to 19 years on average without applying mineral fertilizers or synthetic pesticides. Fertilization was based on green manuring by various legumes, the application of composted plant residues produced on the farm, and horse manure. The previous crops and soil management by tillage was the same for every plot.

Soil samples (four replicate plots per field site) were taken after the harvest of the crop plants and tillage in September 2000. At each plot, two soil blocks (30 x 30 cm) were taken with a spade to a depth of 30 cm. The soil samples from each plot were mixed and sub-samples were used in a greenhouse pot trial with 4 replicates. Because of its importance as cash crop in arable OF, wheat (seed density 200 kg ha^{-1}) was used as trap plant for colonization with autochthonous AMF. The soil parameters (pH, available P) were measured in the laboratory of the Austrian Agency for health and food safety (AGES), Vienna, according to standard methods. The trap cultures were kept in a greenhouse under natural light from October 2000 till May 2001.

For vernalisation, a cold temperature treatment before flowering (Thomas 1993) was necessary, therefore the trap cultures were placed outside the greenhouse for some days in January. Four soil cores (30 cm^3, sampling depth 20 cm) were taken at the shooting of the wheat plants from each pot for the extraction of roots in May 2001.

Cereals show the highest uptake rates of P until shooting (Römer *et al.* 1986) and the rate of root growth is in accordance with the hyphal growth rate of the AMF hyphae. The wheat roots were separated from the adhering soil by a hydropneumatic elutriation system (Gillison´s Variety Fabrication Inc., USA) through a sieve with a mesh of 560 µm (Smucker *et al.* 1982). The root length density (m_{root} m^{-3}_{soil} RD) was determined according to the method of Giovanetti *et al.* (1980). Roots were stained according to the method of Vierheilig *et al.* (1998) and the mycorrhizal colonization (% MC) was determined under a light microscope according to the method of McGonigle *et al.* (1990). Considering that plants can compensate for a low MC due to a low colonization potential in the soil by a higher density of their root system, RD was multiplied by MC to obtain the mycorrhizal colonized root length density ($m_{colonized\ roots}$ m^{-3}_{soil} MD), a more reliable parameter for the determination of a significant MC of a plant root system (Amijee *et al.* 1989). The data obtained for RD, MC and MD were divided into 3 groups of different duration of OF (long-term, mid-term, short-term) and subjected to a one way ANOVA. The mean values of four replicate pots were compared using Tukey's multiple range test (P<0.05).

Results and brief discussion

In a first step, the determined parameters were compared for the three sites investigated on each of the five farms. The MD of wheat grown in the soil of the farm Alt Prerau was significantly increased after 16 and 13 years of OF compared to 9 years. Wheat grown in the soil of the farm Herrnleis showed a significantly increased MD after 17 and 11 years of OF compared to 6 years. No dependence of the MD of wheat on the year of conversion from conventional to OF could be found in the soil of the farm Neubau. The MC of the wheat roots of all treatments was approximately 35%, a relatively high value compared to the other treatments. The duration of organic farming on this farm ranged from 13 to 22 years. This long duration of OF even on the most recently converted site presumably was beyond the time needed for the establishment of a stable AM population, and can be regarded as the reason for the lack of effect of the conversion date on this farm. The MD of wheat grown in the soil of the farm Obersiebenbrunn was not significantly different between the longest (25 years) and the shortest (9 years) duration of OF. Interestingly, the MD of wheat was lowest in the soil with a medium-term duration (18 years) of OF, which was due to the relatively high RD. The MD of wheat grown in the soil of the farm Spillern was significantly increased after 11 years of OF.

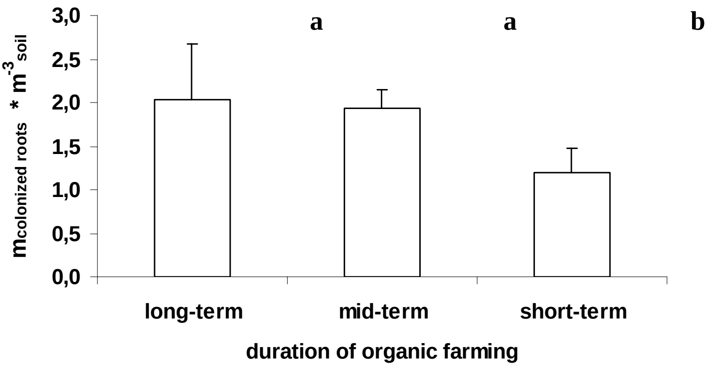
In a second step, the determined parameters were compared over all the five farms. Therefore, the field sites of each of the farms were pooled in three groups of different duration of organic farming: (long-term, medium-term and short-term OF, with an average duration of 19 years, 13 years, and 7 years of OF, respectively) (Tab. 1).

Tab. 1: Overview concerning the MC, RD and the MD of winter wheat (*Triticum aestivum*) within the groups as affected by the duration of organic farming.

Duration of Organic Farming	MC (%)	RD (m m^{-3})	MD (m m^{-3})
long-term (∅ 19 yr)	31 ± 7 a	6,4 ± 0,9 a	2,0 ± 0,6 a
medium-term(∅ 13yr)	30 ± 2 a	6,3 ± 0,6 a	1,9 ± 0,2 a
short-term (∅ 7yr)	17 ± 2 b	7,2 ± 1,3 a	1,2 ± 0,3 b

Values for determined parameters are shown with standard deviation (±), Treatments within one column with the same letter are not significantly different according to Tukey's multiple range test (P < 0.05).

Wheat plants grown in the pots with the soil from the plots with a medium- and long-term duration of OF maintained a significantly higher level of MC (Tablel 1) and MD (Figure 1) than in the short-term group. No differences were found in the RD of the wheat plants across the different treatments. No differences were found in the yield of wheat in the trial (data not shown).



Bars are shown with standard deviation error of means, treatments with the same letter are not significantly different according to Tukey's multiple range test ($P < 0.05$). Short-term.∅ 7 years, medium-term.∅ 13 years, long-term ∅ 19 years of organic farming

Fig. 1: Mycorrhizal colonized root length density (MD) of winter wheat (*Triticum aestivum*) within the groups as affected by the duration of organic farming.

Already more than 60 years ago, Sir Albert Howard (1943), one of the most important figures in the development of the organic movement, suggested that "the presence of an effective mycorrhizal symbiosis is essential to plant health". The potential benefits of OF to soil fertility and soil microorganisms such as AMF has been shown in numerous investigations (e.g. Foissner *et al.* 1986, Lee *et al.* 1992, Liebhart *et al.* 1989, Limonard *et al.* 1989, Hole *et al.* 2005). Of high significance, therefore, is the enriched humus content due to organic fertilization, especially with composted farmyard manure and soil management with reduced (conservation) tillage. Several observational studies have assessed differences between colonization levels and spore populations in differently managed agricultural systems (Sattelmacher *et al.* 1991, Douds *et al.* 1995 & 1999, Mäder *et al.* 2000, Oehl *et al.* 2003, 2004 & 2005).

To our knowledge, the MC, RD and MD of cereal crop plants have not been investigated over a broad range of OF duration. In two (Alt Prerau and Spillern) of the five investigated organic farms we found an increase of the MC after at least 11 and 13 years of continuous OF, respectively. Werner (1997) already found a significantly higher MC in an apple orchard (*Malus domestica*) after 2 years of continuous OF, probably due to the higher occurrence of highly mycorrhizal accompanying weeds and complementary herbs. In the pot cultures with soil samples from the farm Obersiebenbrunn we found an increase of the MC after 20 years of continuous OF, whereas no differences concerning the MC of wheat in the pot cultures from the farm Neubau were found. That could be due to the relatively high duration of continuous OF (at least 13 years) and the relatively high MC (>30%) in all treatments. In this case, the reestablishment of the soil organisms probably already had taken place within 13 years. In the comparison over all the farms, we found a significantly higher MC of wheat plants after at least 13 years continuous OF. The divergence to the shorter duration of OF causing a significantly higher MC in the comparison within the farms in relation to the comparison over all five farms is probably due to the relatively high MC of wheat in the pots with the soil trials of the farm Neubau, which increased the standard deviation.

Conclusions

For the majority of the wheat plants in our investigation we found an increasing MC and MD with longer duration of OF. Highly probable reasons responsible for our results are the rejection of easily soluble mineral fertilizers and artificial agro-chemicals such as pesticides and fungicides, as well as the establishment of a stable autochthonous soil organism community. Based on our results we assume that approximately 15 years is needed after conversion from conventional to OF to establish a stable population of AMF, with all their potential benefits for the host plants and their contribution to maintaining soil fertility and soil structure.

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EFFECTS OF PAST AND CURRENT CROP MANAGEMENT ON LEACHING LOSSES, SOIL MICROBIAL COMMUNITY COMPOSITION AND ACTIVITY

Stark, Christine H.[(1)], Condron, Leo M.[(1)], Stewart, Alison[(2)], Di, Hong J.[(1)], O'Callaghan, Maureen[(3)]

(1) Agriculture & Life Sciences Division, PO Box 84, Lincoln University, Canterbury 8150, New Zealand, ++64 3 325 2811, starkc@lincoln.ac.nz, condronl@lincoln.ac.nz, dih@lincoln.ac.nz.
(2) National Centre for Advanced Bio-Protection Technologies, PO Box 84, Lincoln University, Canterbury 8150, New Zealand. ++64 3 3253697, stewarta@lincoln.ac.nz
(3) AgResearch, PO Box 60, Lincoln, Canterbury 8150, New Zealand. ++64 3 3259986, maureen.ocallaghan@agresearch.co.nz

Key Words: soil; mineral N losses; microbial community composition; microbial activity; past and current management

Abstract

A lysimeter experiment was conducted to investigate differences in soil biological properties and leaching losses caused by past and present management practices. Intact monolith lysimeters were taken from sites of the same soil type that had either been under long-term organic or conventional crop management and were then managed according to organic and conventional practices and subjected to the same crop rotation for a period of 30 months. Soil samples were taken at the start and the end of the experiment and analysed for biological soil properties, including microbial diversity. Leachate was analysed for mineral N losses. Results indicated that over the trial period, leaching losses were similar for all treatments and that current management practices, e.g. crop rotation and green manuring, were the main influences on microbial biomass composition and size resulting in microbial communities of similar size and structure for all treatments. Enzyme activities showed significant differences that were equally caused by past and present management practices.

Introduction

Soil biota play a vital role in the maintenance of soil fertility and productivity; however, we know little about the role of microbial community structure and function in sustaining soil ecosystems (Ritz *et al.* 1994; Insam & Rangger 1997). Microbial diversity in soils is influenced by many factors, including soil properties, environmental conditions, and anthropogenic activities, including land management techniques like organic production systems. Therefore, changing management practices could have significant effects on the soil microbial community and associated soil processes (Shepherd *et al.* 2000; Waldrop *et al.* 2000; O'Donnell *et al.* 2001; Girvan *et al.* 2003). Intact monolith lysimeters (0.2 m^2 surface area) are a suitable way to investigate microbial diversity (community composition, activity and function) and its relationship to nutrient cycling and the associated environmental impacts (e.g. Di *et al.* 1998). They provide the benefits of a pot trial with the ability to subject soils to various management practices and measure leaching losses. The objectives of this study were to evaluate the influence of organic and conventional farm management practices on the soil microbial community and mineral N leaching losses, and to compare impacts of soil history and current management on selected soil properties, including microbial diversity and activity.

Methodology

Eight intact monolith lysimeters (50 cm diameter; 70 cm deep) were taken from each of two sites within the Lincoln University cropping farm (Canterbury, New Zealand) (43°38'S; 172°27'E). Both areas had the same soil type (Udic Ustochrept, USDA; free draining to 70 cm) and comparable chemical and physical soil properties. At the time of collection, the sites had been under either organic or conventional management for at least 25 years. For the following 30 months, four lysimeters from each site were managed under the original production system, while the other four were managed under the alternative management system, resulting in four treatments distinguished by farming history and current management practice (Table 1).

Hand weeding was used for all treatments and pesticide application was unnecessary during the trial period; the fertilisation regime was, therefore, the main distinguishing factor between the organic and conventional managed lysimeters. The lysimeters were cultivated under identical cropping regimes (three main crops plus a lupin green manure) and managed according to best organic and conventional practices, receiving the same amounts but different forms of fertiliser (mineral vs. BioGro approved; no additional N in ORG treatments) (BioGro New Zealand 2001).

Table 1: Details of treatments included in the lysimeter study.

Treatment ID	*Soil origin (past management)*	*Current management*
B ORG	BHU (organic)	organic
B CON	BHU (organic)	conventional
L ORG	LCF (conventional)	organic
L CON	LCF (conventional)	conventional

Leachate was collected from the lysimeters after irrigation or significant rainfall events and analysed for total mineral nitrogen. Soil samples (0-15 cm) were taken at the beginning and the end of the experiment and analysed for total carbon (C_{tot}) and nitrogen (N_{tot}) (Leco® CNS-2000 elemental analyser), microbial biomass carbon (C_{mic}) and nitrogen (N_{mic}) by fumigation extraction (Sparling & West 1988), arginine deaminase activity (ADA) (Alef & Nannipieri 1995), and fluorescein diacetate hydrolysis (FDA) (Adam & Duncan 2001). Genetic diversity of the bacterial communities was determined by DNA extraction, followed by PCR amplification of 16S rRNA genes and denaturing gradient gel electrophoresis (DGGE) (e.g. Heuer *et al.* 2001).

Data was analysed by general linear model analysis of variance and least significant differences ($LSD_{0.05}$) were calculated using GenStat (Release 7.1). DGGE patterns were analysed by cluster analysis according to Ward (1963) using Quantity One 1-D Analysis Software (Bio-Rad, USA).

Results and brief discussion

All treatments showed comparable leaching patterns over the course of the experiment with cumulative mineral N losses ranging from 20.8 to 29.1 kg ha^{-1} ($LSD_{0.05}$=10.9), although both ORG treatments showed lower losses than the CON treatments (Figure 1). This suggests that the lack of N inputs in the organically managed lysimeters reduced the leaching of mineral N; however, the duration of the experiment was too short to allow for definite conclusions regarding trends. Most researchers' findings suggest that differences in soil properties can only be observed after 5 years or more following conversion to an organic farming system (e.g. Mäder *et al.* 1996; Stolze *et al.* 2000).

At the initial sampling, LCF had significantly higher levels of C_{mic}, C_{tot} and higher C_{mic}:C_{tot}, while ADA was significantly higher in BHU, suggesting a relatively smaller but more active microbial community. N_{mic} and FDA were higher in LCF (not significant) (Table 2). Consistent with the differences in activity and biomass size, DGGE banding patterns showed differences in community composition indicating that differences in management practices are reflected in the microbial community which is consistent with other researchers' findings (e.g. Marschner *et al.* 2003).

At the end of the experiment, no significant differences between treatments were measured in microbial biomass size (C_{mic} and N_{mic}), i.e. previously measured differences were lost over time mainly in response to management practices that were the same for all treatments (i.e. addition of a legume green manure and crop rotation) by increasing C_{mic} and N_{mic} in BHU soils and counteracting possible negative effects of mineral fertilisers in CON treatments (cf. Robertson & Morgan 1996; Johnson *et al.* 2003). As expected, C_{mic}:C_{tot}, C_{tot} and N_{tot} were less variable and more strongly affected by past (BHU vs. LCF) compared to current (ORG vs. CON) management (Table 2). However, measured differences were negligible. Microbial activity was affected by past as well as current management. While FDA was significantly higher in LCF and CON soils, ADA was higher in BHU and CON; however, for ADA, differences between ORG and CON were not significant (Table 2 and Table 3). Similar to the microbial biomass measurements, DGGE banding patterns showed no differences between the treatments, indicating comparable community structures. This implies that similarly sized and structured microbial communities can express varying activities.

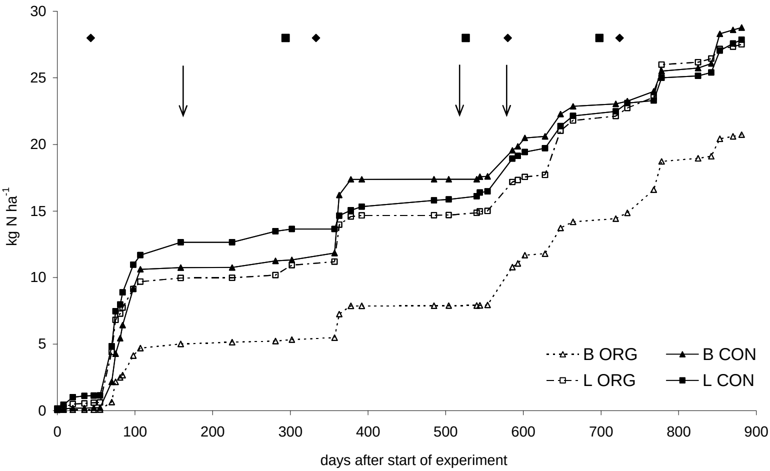

Figure 1: Mean cumulative mineral N leaching losses (kg ha^{-1}) over the course of the lysimeter study. Diamonds, time of sowing; Squares, time of harvest; arrows, fertilisation (days 127 and 600) and lupin incorporation (day 526), respectively. N=4.

Table 2: Effect of past organic (BHU) and conventional (LCF) management on mean concentrations of soil properties at the beginning and the end of the lysimeter study.

Soil property	Beginning of experiment			End of experiment		
	BHU	LCF		BHU	LCF	
C_{mic} (µg C g^{-1})	494 (25.0)	596 (26.4)	***	551.8 (10.4)	553.7 (11.0)	NS
N_{mic} (µg N g^{-1})	50.1 (3.42)	47.6 (2.49)	NS	45.9 (1.85)	42.8 (1.88)	NS
ADA (µg NH_4-N g^{-1} h^{-1})	2.86 (0.10)	1.91 (0.08)	***	2.95 (0.28)	1.81 (0.10)	***
FDA (µg fluorescein g^{-1} h^{-1})	115 (9.3)	123 (12.1)	NS	228.3 (8.96)	283.2 (6.95)	***
C_{mic}:C_{tot} (%)	1.93 (0.05)	2.25 (0.04)	**	2.03 (0.04)	1.87 (0.03)	**
C_{tot} (%)	2.77 (0.01)	2.93 (0.04)	**	2.72 (0.02)	2.96 (0.04)	***
N_{tot} (%)	0.24 (0.001)	0.24 (0.003)	NS	0.22 (0.002)	0.23 (0.002)	*

***, p<0.001; **, p<0.01; *, p<0.05; NS, not significant. Standard error of means in parentheses. N=3 at initial sampling. N=8 at the end of the experiment.

Table 3: Effect of current organic (ORG) and conventional (CON) management on mean concentrations of soil properties at the end of the lysimeter study.

	ORG	CON	
C_{mic} (µg C g^{-1})	557 (9.6)	549 (11.5)	NS
N_{mic} (µg N g^{-1})	43.4 (1.98)	45.2 (1.87)	NS
ADA (µg NH_4-N g^{-1} h^{-1})	2.16 (0.30)	2.60 (0.27)	NS
FDA (µg fluorescein g^{-1} h^{-1})	237 (11.6)	274 (10.6)	***
C_{mic}:C_{tot} (%)	1.97 (0.05)	1.93 (0.04)	NS
C_{tot} (%)	2.83 (0.05)	2.85 (0.06)	NS
N_{tot} (%)	0.23 (0.002)	0.23 (0.003)	NS

***, p<0.001; NS, not significant. Standard error of means in parentheses. N=8.

While microbial biomass and community composition were strongly and permanently affected by the addition of organic matter, enzyme activity seemed to be a more inherent, resilient soil property. Only FDA was significantly affected by past as well as current management, but for both enzyme activities the differences detected between the two soils at the beginning of the experiment could be measured after 30 months. These differences were observable even after addition of mineral fertilisers (as in B CON). For FDA, this result agrees with findings that enzyme activities are rapidly affected by changes in management practices and can, hence, serve as soil quality indicators (Bandick & Dick 1999; Bending *et al.* 2004). However, it also indicates that microbial activity continues to be influenced by soil history for several years after management has changed. This observation of "residual activity" questions the suitability of enzyme activities as an early indicator for changes in soil quality.

Conclusion

After 30 months under the same crop rotation and cultivation regime, no major differences between treatments were detected in mineral N losses and soil microbial biomass size and community composition. However, past management was reflected in measurable differences in chemical soil properties, which are expected to change slowly, and microbial activity. This indicates that in the short term, microbial community size and composition are mainly influenced by management practices such as crop rotation and green manuring that were the same for all treatments. Management history, on the other hand, has a lasting effect on enzyme activities with initial differences remaining visible after conversion to organic and re-conversion to conventional, respectively.

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SOIL HEATH: A COMPARISON BETWEEN ORGANICALLY AND CONVENTIONALLY MANAGED ARABLE SOILS IN THE NETHERLANDS

Anne D. van Diepeningen (1), Wim J. Blok (1), Gerard W. Korthals (2), Ariena H.C. van Bruggen (1)

(1) Biological Farming Systems Group, Wageningen University, Marijkeweg 22, 6709 PG Wageningen, Netherlands, Tel. 31-317-487201, E-mail wim.blok@wur.nl, Internet http://www.dpw.wau.nl/biob/
(2) Applied Plant Research PPO, Wageningen UR, Edelhertweg 1, 8219 PH Lelystad, Netherlands, Tel. 31-320-291111 , E-mail Gerard.korthals@wur.nl, Internet http://www.ppo.wur.nl/ppo

Key Words: Organic Soil, conventional soil, nitrate, bacteria, nematodes, DGGE, diversity

Abstract

A comparative study of 13 organic and 13 neighboring conventional arable farming systems was conducted in the Netherlands to determine the effect of management practices on chemical and biological soil properties and soil health. Soils were analyzed using a polyphasic approach combining traditional soil analysis, culture-dependent and independent microbiological analyses, a nematode community analysis and an enquiry about different management practices among the farmers. Organic management resulted in significantly lower levels of both nitrate and total soluble nitrogen in the soil, higher numbers of bacteria of different trophic groups, as well as larger species richness in both bacteria and nematode communities and more resilience to a drying-rewetting disturbance in the soil. All factors together indicating a higher level of soil health under organic management.

Introduction/Problem

A healthy soil is defined as a stable system with (1) resilience to stress, (2) high biological diversity, and (3) high levels of internal nutrient cycling (van Bruggen and Semenov, 2000). In this study we searched for the effects long-term organic management under the Dutch conditions has on soil health determined by biological, physical, and chemical parameters of the soil.

The recent emphasis in policy of the European Union towards more environmentally-sensitive farming practices and the importance of surplus reduction has led to an increased focus on organic farming. Under organic management, traditional conservation-minded farming methods are combined with modern farming techniques but conventional inputs as synthetic pesticides and fertilizers are excluded. Instead of synthetic inputs, compost and animal and green manures are used to build up soil fertility; pests are controlled naturally, crops are rotated, and both crops and livestock diversified (Reganold et al., 2001). Varying results with respect to both chemical and biological soil parameters were obtained in recent years with studies comparing conventional farms – often only one or a few - with organic or reduced-input farming systems.

We chose a polyphasic approach to study soil health parameters in 13 pairs of arable soils. We combined chemical and physical analysis, culture-dependent and independent microbiological analyses, nematode community analysis and enquiries among the farmers concerning the management practices used.

Methodology

Sampling: 13 SKAL*-accredited organic farms and neighboring conventional farms on different soil types throughout the Netherlands were sampled. Pairs had the same cover crop. *SKAL is the inspection body for organic production in the Netherlands.

Management data: All farmers filled in a questionnaire about the farm practices in the last three years regarding (cover)crops, amount and types of animal and green manure and/or fertilizer used, pesticides, disinfectants, mechanical weeding, soil improvements and plowing depth. Amounts of added organic C, N and P per hectare were calculated based on average (organic) fertilizer contents.

Chemical and physical analyses: Soil samples were analyzed for their NO_3, NH_4, total soluble N, organic N, total N, organic C, PO_4, and total P contents. For physical characterization the pH in water, fractions of soil particle sizes, and moisture content were determined.

Biological analyses: Basal CO_2 respiration and response amplitude (resilience) after drying and rewetting of the soil were determined with an infrared CO_2-analyzer. Total amount of copiotrophic and oligotrophic groups of bacteria were determined by plating on selective media. Bacterial Species Richness and Shannon

Index as indices for the microbial biodiversity were determined by denaturing gradient gel electrophoresis (DGGE) with eubacterial primer sets and were based on band presence and abundance respectively. Nematodes were extracted in a sub-sample of 100 grams and than counted and identified. Also, nematode species richness and Shannon indices were determined.

Statistical analyses: One-sided paired t-tests were used for the comparisons between organic and conventional soils for all measured and calculated chemical, physical and biological variables, both for sandy and clayey soils separately as for the combined soil types.

Results and brief discussion

The management enquiry data showed that farmers did not significantly differ in their opinions about the quality of their soil, a value based on answers given in the questionnaire about soil quality, structure and moisture (not shown). The organic farmers tend to add more organic carbon to their soils via organic fertilizers (Table 1). The total amounts of N and P applied as synthetic or organic fertilizer did not differ between the two groups of farmers. Fifty percent of the conventional farmers also used fertilizers of animal origin and about 40% also applied mechanical weeding. Similar numbers of organic and conventional farmers used green manure crops, but they were used more often on clayey soils than on sandy soils. Organic farmers generally plowed their field less deep.

Clayey and sandy soils differ in soil particle sizes and pH, but these were not influenced by management of the soil. The nitrate and total soluble nitrogen levels of the organic soils were significantly lower than those in the conventional soils (Table 1). But, neither ammonium, organic nitrogen, phosphate, total phosphorus, total nitrogen, nor organic carbon levels in the soils differed significantly between management types (not shown). In contrast to the study of Mäder et al (2002), our set of soils showed relatively few differences in chemical and physical parameters, except for the nitrate and soluble nitrogen levels.

Biologically, the organic soils often showed a higher level of basic respiration as measured by the amount of CO_2 produced per gram of dry soil per time interval. Furthermore, the organic soils showed a better resilience after a drying-rewetting disturbance of the soil, expressed as a greater response amplitude in microbial respiration (Table 1). The organically managed soils contained higher numbers of copiotrophic and oligotrophic bacteria, and had a higher diversity (both in species richness and Shannon index taking in account species abundance) in both eubacteria and nematodes. These results are in accordance with the findings of higher biological activity (Mäder et al., 2002), biodiversity (Mäder et al., 2002, Mulder et al., 2003, Oehl et al., 2003) and biomass (Mulder et al., 2003) in organic soils in previous studies. The number of Dauerlarvae increased with organic management. This corresponds to the observation that the number of nematode resting forms tends to increase after application of organic manure in a field (Bongers et al., 1997).

Soil type in our study was often a much stronger determinant of the soil characteristics and soil communities than management type. These findings were in accordance with those of Girvan et al., (2003).

Table 1. Chemical, biological and management characteristics of 13 pairs of organic and conventional clayey and sandy soils; averages are given of (almost) significant characteristics only as determined by paired one-tailed t-tests or chi-square tests between organic and conventional treatments in all samples combined (13 pairs) and per soil type (7 pairs).

		Clay soils			Sandy soil			Combined
	variable	Organic	conventional	significance level t-test	organic	Conventional	significance level t-test	significance level t-test
A.	estimated added Corg (mg/kg)	1222	360	0.179	4093	1272	0.355	0.259
Management data	estimated added N (mg/kg)	76.9	159.2	0.158	229.2	234.7	0.152	0.074
	estimated added P (mg/kg)	44.2	83.7	0.295	129.6	64.0	0.107	0.098
	Manure as fertilizer	100%	28.6%	0.000	100%	71.4%	0.009	0.001
	N/C ratio applied fertilizer	0.05	92.4	0.016	0.06	46.5	0.097	0.005
	Mechanical weeding	100%	42.9%	0.002	100%	28.6%	0.000	0.000
	Plow depth (cm)	23.2	26.0	0.074	20.9	21.3	0.242	0.046
B.	pH	7.32	7.39	0.051	5.38	5.46	0.217	0.098
Chemical data	NO_3 (mg/kg)	21.4	29.3	0.005	5.4	16.7	0.082	0.005
	Nts (mg/kg)	27.2	35.3	0.003	15.4	25.7	0.068	0.003
	Norg (mg/kg)[a]	3.29	3.35	0.379	6.50	5.04	0.1181	0.162
	Corg (mg/kg)[b]	20345	20227	0.458	28323	25402	0.132	0.133
C. Biological data	Basal resp. (µg/g dry soil/hr)	7.69	4.54	0.011	4.99	4.99	0.500	0.047
	Response amplitude[c] (µg/g dry soil/hr)	6.25	7.67	0.107	7.12	8.39	0.084	0.026
	Copiotrophic bacteria (CFUs/g)	2.44 E7	2.21 E7	0134	2.36 E7	1.77 E7	0.008	0.006
	Oligotrophic bacteria (CFUs/g)	6.16 E5	3.75 E5	0.064	8.64 E6	5.36 E6	0.020	0.015
	Bacterial Diversity S[d]	47.50	41.00	0.004	52.00	45.86	0.002	0.000
	Dauerlarvae bacterivore nematodes	26.5	10.1	0.027	147.4	79.7	0.120	0.075
	Nematode Diversity S	23.83	22.43	0.055	25.86	22.43	0.24	0.042
	Nematode Diversity H[e]	1.01	0.94	0.086	1.02	0.93	0.27	0.076

Norganic= Ntotal soluble – (NO_3 + NH_4); [b]) % C in dry matter; [c]) Amplitude of the initial response in respiration to rewetting of dried soil; [d]) "Species" Richness as determined by DGGE; [e]) Shannon Index as determined by nematode frequency data.

Conclusions

We conducted a comparative study of 13 organic and 13 neighbouring conventional arable farming systems in the Netherlands to determine the effect of management practices on chemical and biological soil properties and soil health. Often management practices were shared among both management types and many of the measured or calculated soil characteristics were not significantly different between the two management types, emphasizing that the differences between organic and conventional are more gradual than black-and-white. Successful practices in organic farming are readily adopted in conventional farming and, of course, where possible also the conventional farmer will reduce his input of energy and pesticides.

The soil type, clayey or sandy, has a more pronounced effect on most of the determined soil characteristics than its management types. The main reasons for the higher biodiversity in the organic soil - and thus a higher soil health - seem to be the lower plow depth and especially the use of the organic amendments and the absence of artificial fertilizer, which results in lower nitrate levels and a higher biodiversity in nematodes and bacteria.

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MANAGING WEEDS

ADVANCES IN WEED MANAGEMENT FOR ORGANIC CEREAL PRODUCTION IN SOUTHEAST AUSTRALIA

Viv Burnett[1], Tim Enshaw [1] and Steve Sutherland [2]

[1.]Primary Industries Research Victoria, Department of Primary Industries, Rutherglen Centre, RMB 1145 Chiltern Valley Road, Rutherglen Victoria 3685, viv.burnett@dpi.vic.gov.au

[2.] NSW Department of Primary Industries, Yanco Agricultural Institute, Private Mail Bag, Yanco New South Wales 2703

Key Words: Organic farming, weed management, cereal production

Abstract

Organic cereal production in southeast Australia is challenging for producers due to a range of influences such as weeds and low soil available phosphorus. Two experiments were conducted on a certified organic property at Berrigan NSW during 2001-2003 to investigate ‘within crop’ weed management and forage crop management for weed control. Sowing later using a short season wheat cultivar did not affect yield and reduced ($P<0.05$) levels of annual ryegrass (*Lolium rigidum* Gaud.). Incorporating a forage crop into the rotation prior to sowing a cereal resulted in improved ($P<0.05$) weed management for the cereal crop, in comparison to retaining annual pasture. There were no differences between forage treatments in weed management in the following wheat crop. Where forage was cut for silage and then grazed, grain yield was higher ($P<0.05$) than where forage was only grazed or cut for silage, or where annual pasture was retained.

Introduction

Organic crop and pasture production in southeast Australia is constrained by the presence of many exotic plant species, a result of pastoral occupation, over-grazing by sheep, and extensive soil cultivation (Moore 1957). Cereal crops are further constrained by low levels of available phosphorus (P) (Penfold 2000), making profitable organic production challenging for the majority of producers. Recent research into the non-chemical management of annual ryegrass (*Lolium rigidum* Gaud.) in certified organic farming systems has provided options to manage this weed in these farming systems (Burnett *et al*. 2004). Sowing cereal crops later using a short season cultivar can provide an opportunity to manage ryegrass before the crop is sown. Managing ryegrass in the year prior to growing cereals, by growing and managing a forage crop, has also demonstrated significant weed reduction. This paper reports results from two experiments that investigated the management of annual ryegrass in cereal crops and forage phases.

Methodology

Two experiments were conducted at a certified organic property at Berrigan in NSW (35º 40' S, 145º 9' E) from 2001 to 2003. In experiment A the effect of establishment system and sowing rate on the density of annual ryegrass in wheat was investigated over three years. Establishment systems consisted of sowing wheat (*Triticum aestivum* cv. Chara) at a standard sowing time compared with a late-sown system using a short season cultivar (H45). Different cultivars were selected. as the focus of the experiment was the production system; consequently, cultivars were chosen on their suitability for that system. Standard sowing times were 5 June 2001, 22 May 2002 and 6 May 2003, and late sowing times were 27 June 2001, 25 June 2002 and 6 June 2003. Three sowing rates (60, 100 and 150 kg/ha) were used and treatments were replicated three times. The seed was sown into prepared soil and P (20 kg/ha) was applied as Guano™ with the seed. Annual ryegrass density and wheat yield were measured.

In experiment B the effect of forage (field pea and oats) management on the subsequent weed burden and grain yield in wheat crops was measured. A control treatment of annual pasture was grazed with sheep as per current producer practice. Forage was sown in 0.22 ha plots in 2002. Forage was managed by grazing with sheep, cutting for silage, green manuring, or a combination of silage and grazing. Wheat (cv. Chara) was established in the year after forage production (2003), with weed burden and wheat yield assessed. The soil was classified as a eutrophic red chromosol (silty clay loam) (Isbell 1996). Site soil characteristics (0-10 cm) and available nutrients for both experiments based on autumn tests are presented in Table 1 with growing season rainfall data in Table 2.

Table 1. Soil characteristics (0-10 cm) for experiments A and B.

Experiment and year Experiment A	pH ($CaCl_2$)	Available N (kg/ha)	Olsen P (mg/kg)	Total C (%)
2001	5.1	56	3	1.2
2002	5.1	31	8	1.1
2003	5.0	20	7	1.3
Experiment B				
Forage, 2002	5.4	41	4	1.2
Wheat, 2003	5.3	65	3	1.2

Table 2. Growing season rainfall (mm) (GSR) (April-November), total GSR and long term average (LTA, 120 years) rainfall.

	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	GSR total	LTA
Berrigan 2001	26.5	3.5	19.0	37.0	29.0	24.5	69.5	6.0	215.0	322
Berrigan 2002	38.0	13.5	22.5	11.0	22.5	26.5	8.5	4.0	146.5	321
Berrigan 2003	42.5	86.5	47.5	70.5	96.5	29.5	67.0	48.5	484.0	322

Results and brief discussion

Experiment A

In 2002 and 2003, there was less ryegrass ($P<0.05$) at crop emergence and at crop tillering with the late-sown system (Table 3). Similarly, at crop anthesis, there was less ($P<0.05$) weed DM yield with the late-sown system in 2001 and 2003 (Table 4) whilst only in 2002 was there a yield penalty ($P<0.05$) with the late-sown system (Table 5).

At crop anthesis, weed DM yield was reduced ($P<0.05$) by sowing rate increases in 2002 and 2003 (Table 4) but sowing rate had no effect on grain yield in any year (Table 5).

Table 3. Effect of establishment system on annual ryegrass density (plants/m^2) at crop emergence and crop tillering.

Year/ Establishment system	Ryegrass density at crop emergence			Ryegrass density at crop tillering		
	Standard	Late	l.s.d.	Standard	Late	l.s.d.
2001	60	238	51.8	228	168	69.6
2002	67	38	21.9	85	45	34.0
2003	331	80	42.5	187	97	28.1

Table 4. Effect of establishment system and sowing rate on weed DM yield (t/ha) at crop anthesis.

Year/ Establishment system	Establishment system			Sowing rate (kg/ha)			
	Standard	Late	l.s.d.	60	100	150	l.s.d.
2001	1.3	0.8	0.21	1.1	1.1	1.0	0.25
2002	0.6	0.5	0.12	0.7	0.5	0.4	0.14
2003	2.4	1.3	0.60	2.4	1.5	1.6	0.74

Table 5. Effect of establishment system and sowing rate on wheat grain yield (t/ha).

Year/ Establishment system	Establishment system			Sowing rate (kg/ha)			
	Standard	Late	l.s.d.	60	100	150	l.s.d.
2001	0.4	0.4	0.12	0.4	0.4	0.4	0.10
2002	1.0	0.8	0.12	0.8	0.9	0.9	0.15
2003	1.5	1.4	0.30	1.4	1.4	1.5	0.37

Sowing later using a short-season cultivar provides an opportunity for producers to better manage a competitive species such as annual ryegrass. However, sowing later does carry the risk of reduced grain yield, particularly if the spring period is drier than usual, as yield is highly dependent on available moisture during this period. In northeast Victoria, Coventry *et al.* (1993) found losses up to 250 kg/ha of grain for each week's delay in sowing after the beginning of May. Gomez-Macpherson and Richards (1995) also showed a 1.3% decline in grain yield if sowing was delayed after late May at Wagga Wagga in southern New South Wales. Increased sowing rates are used widely by organic producers to increase competition against weeds and to allow for losses with post-sowing cultivation (Patriquin 1988). However, there was no effect of increased sowing rate on wheat grain yield. It is likely that this was due to insufficient soil moisture in the critical spring period and low available soil nitrogen.

Experiment B

Where forage was cut for silage and then grazed, grain yield was higher ($P<0.05$) than where forage was only grazed or cut for silage, or where annual pasture was retained (Table 6). Green manuring resulted in the second highest wheat grain yield (Table 6). There was more weed DM ($P<0.05$) in the wheat following annual pasture (Table 6). There was more wheat DM yield ($P<0.05$) after forage had been green manured compared to grazed annual pasture and grazed forage (Table 6).

Table 6. Forage composition and DM yield, weed biomass, and grain yield of wheat during the 2002-2003 phase.

Treatment in 2002	2003 Wheat		
	Wheat DM yield (t/ha)	Weed biomass (t/ha)	Grain yield (t/ha)
Forage green manured	**14.5**	**0.5**	**4.5**
Forage grazed	**11.9**	**0.4**	**4.0**
Forage cut for silage	**12.2**	**0.5**	**3.7**
Forage cut for silage and grazed	**12.1**	**0.5**	**4.8**
Annual pasture grazed	**8.9**	**2.0**	**3.1**
l.s.d.	2.31	0.50	0.68

Gross margin returns were calculated on the 2002-2003 phase. The silage and grazing treatment provided the highest returns per hectare, followed by green manuring (Table 7). Whole farm analysis based on the particular system used is required to more accurately gauge the relative profitability of forage treatments.

Table 7. Gross margins ($/ha) for the forage/wheat cropping sequence at Berrigan in 2002/2003.

Forage treatment /Gross margin	**Green Manure**	**Grazing**	**Silage**	**Silage & Grazing**	**Annual Pasture**
2002-2003					
Cost of forage treatment in 2002	298	283	384	384	133
Income from forage in 2002	0	59	124	133	88
Cost of wheat crop in 2003	313	313	313	313	328
Income from wheat in 2003	1125	1000	925	1200	785
Total for 2002 - 2003	**515**	**464**	**353**	**637**	**412**

Conclusions

Sowing later using a short-season wheat cultivar can provide organic producers with an option to manage annual ryegrass prior to crop sowing. However, producers should be aware that sowing later in the southeast Australian grain production zone does carry increased risk of reduced grain yield, especially if the spring is dry. Using a forage crop to manage weeds prior to sowing a cereal crop provides producers with an economical way of reducing the influence of weeds in the cereal crop. Given the limitations to managing many weed species within the pasture phase, incorporating a forage crop that can be utilised by either cutting silage or grazing or a combination of both to reduce weed seed banks prior to the cropping phase is a valuable tool for organic cereal producers.

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ROLE OF GOLDEN APPLE SNAIL IN ORGANIC RICE CULTIVATION AND WEED MANAGEMENT

R. C. Joshi[1], E. C. Martin[1], T. Wada[2], and L. S. Sebastian[1]

[1]Department of Agriculture-Philippine Rice Research Institute (DA-PhilRice), Maligaya, Science City of Muñoz, Nueva Ecija, 3119, Philippines, +63-44-4560112, rcjoshi@philrice.gov.ph, joshiraviph@yahoo.com, joshiravi0@lycos.com

[2]National Agriculture Research Center for Kyushu Okinawa Region (KONARC), 2421 Suya, Nishigoshi, Kikuchi, Kumamoto 861-1192, Japan, +81-96-242-7732, twada@affrc.go.jp

Key Words: Organic rice farming, invasive alien species, golden apple snail, Pomacea canaliculata, weed management, utilization

Abstract

The Golden Apple Snail (GAS), *Pomacea canaliculata* (Lamarck), is a major pest of rice and other aquatic crops in many Asian farms. Farmers' first line of defense is to use non-specific chemicals for "instant" kill of GAS, without considering its effect on their health, the environment, and non-target organisms. However, some organic rice farmers in Japan, Korea, and the Philippines do not kill GAS but manage them as bio-weeders in rice fields. We evaluated organic farmers' innovation at the PhilRice Central Experimental Station (CES) using large fields. Then we demonstrated GAS paddy-weeding effects in several farmers' fields in the Philippines, during the 2003 and 2004 dry (DS) and wet seasons (WS). Our own experiences and that of the farmers' in the Philippines and Japan on the role of GAS in weed management, promotion of organic rice farming, and lessons learned are discussed.

Introduction

Golden Apple Snail (GAS), *Pomacea canaliculata* (Lamarck) is a dreaded pest of the rice plant because of its rapid and new invasions in Asia and North America. It is listed in the "100 World's Worst Invasive Alien Species" of the Global Invasive Species Group Database (ISSG, www.issg.org/database). In an attempt to control GAS, pesticide misuse and abuse by farmers have caused serious economic, social, and environmental impacts, biodiversity loss, and health hazards to rice farming communities (Rejesus *et al.*, 1988). Ten years after its introduction, the cumulative costs of GAS invasion were between US$425 million and US$1.2 billion. However, some organic farmers in Japan, Korea, and the Philippines do not kill GAS but employ them to feed on aquatic weeds in rice fields, thus saving expenses on herbicides (Okuma *et al.*, 1994; Wada e*t al*., 2002). The benefit from using GAS as a biological weeding agent far exceeds that of ducks or carps for paddy weeding (Yusa *et al.*, 2003).

Methodology

We evaluated GAS as a bio-weeder at the PhilRice Central Experimental Station (CES) using two large fields (each 0.25 ha). Then we demonstrated GAS's paddy weeding effects on several farmers' fields in the Philippines provinces of Nueva Ecija, Aurora, and Negros Occidental during the 2003 and 2004 dry (DS) and wet seasons (WS). We also provided insights on how to use resident (field) GAS populations for weed control.

Rice variety IR64 was used at PhilRice CES in 2003 WS and DS, and rice hybrids Mestizo 1 and Mestizo 3 were used during the 2004 DS and WS, respectively. To produce healthy seedlings for paddy weeding by GAS, a 400-m^2 area was used as a seedbed. Each seedbed was 2 m wide and 10 m long and was raised for easy draining of water. Carbonized rice hull (CRH) was incorporated into the seedbed two days before seeding. With saturated water level and no inorganic fertilizer, the seedlings' leaves were erect and pale with a hard culm, making it difficult for GAS to damage them.

In the 2003 and 2004 crops, a 0.5-ha field was divided into two plots. One plot was treated with Niclosamide 250 EC (synthetic commercial molluscicide) to ensure that no GAS existed prior to transplanting. In another plot, all GAS were spared. Both fields were prepared thoroughly and leveled well to maintain shallow depth of water so that GAS could not damage the newly transplanted seedlings. However, no herbicide was applied in either field. Seedlings 21 days old were transplanted at 20 x 20 cm between hills and rows with 2 seedlings per hill. The area was kept saturated until it dried up slowly. Water was introduced to 2-cm depth at 6-8 days after transplanting or when weeds just emerged with 1-2 leaf stage. By this time, rice plants would not be damaged because they already have hard culms, and GAS would prefer to feed on young weeds.

Results and Discussion

The weed species in all demonstration plots were grasses (*Echinochloa* spp. and *Leptochloa chinensis*), sedges (*Cyperus* spp. and *Fimbrystylis milliacea*), and broadleaves (*Ludwigia octovalvis,* and *Sphenoclea zeylanica*). At the first demonstration of paddy weeding by GAS at PhilRice CES in DS 2003, higher weed density was observed at 10 DAT in plot with GAS (Figure 1A). This was because re-entry of water after transplanting was not done. Interestingly, after the introduction of water, weed densities at 30 and 45 DAT from plots with GAS were lower than in plots without GAS. This implies that the release of water is an important factor in paddy weeding. No water was added to the rice field for several days after transplanting. Once the weeds had sprouted and grown to 1 cm, we released water into the field. Then GAS started to come out from underground to look for food. Learning from the first demonstration, water release was timed with the presence of sprouting weeds, so in WS 2003, higher weed density was recorded in plots without GAS from 15 to 45 DAT (Figure 1B).

Similar patterns in weeding efficiency by GAS were observed during DS and WS 2004 (Figures 1C & 1D) at PhilRice CES. Moreover, higher rice grain yield for 2003 and 2004 cropping seasons was recorded in plots with GAS (Table 1).

Table 1. Rice grain yield at PhilRice-CES, Maligaya, Science City of Muñoz, Nueva Ecija, Philippines, 2003-2004 cropping seasons.

Year / Season	Variety	Grain yield (t/ha) ‡	
		With GAS	Without GAS
2003 DS	IR 64	7.30	5.00
2003 WS	IR 64	5.00	4.60
2004 DS	Mestizo 1	7.65	6.26
2004 WS	Mestizo 3	5.52	3.12

‡Average of 5 crop cut samples per field. Each crop cut sampling unit measured (2 x 5 m) 10 m2.

This technology was introduced to farmers in Nueva Ecija (Bantug), Aurora (Caraksacan), and Negros Occidental (Lacaron) during the 2003-2004 DS and WS. Higher weed density was noted in plot without GAS compared with plot with GAS in both cropping seasons, at Bantug and at Caraksacan during the 2004 WS. However, during the 2004 WS at Lacaron, weed density was very low due to flooding (Table 2).

With this technology, we are converting a pest to an ally by changing its behavior into a useful organism in lowland irrigated transplanted rice systems. It is necessary to level the field well to control the movement of GAS. Shallow water depth should be maintained to regulate the feeding damage of the GAS. The seedlings should be sturdy and at 3-leaf stage (21 days). This technology strictly discourages farmers from collecting GAS and putting them into their rice fields. In all demonstrations before transplanting, the average resident GAS size was between 15 and 20 mm, with a GAS density of 2 m^{-2}. We recorded a maximum of 5.6% missing hills in our first demonstration at PhilRice CES, but in all subsequent trials we recorded less than 1% missing hills.

This practice is not appropriate with direct-seeded rice where weeds sprout at the same time. It cannot be done on upland environment where GAS are inside the soil, and in flood-prone areas where water depth is difficult to control. This is the first report to demonstrate that paddy weeding by GAS is possible even in tropical paddy fields.

Table 2. Weed Density at Farmer's Fields in Bantug, Science City of Muñoz, Nueva Ecija; Caraksacan, Dingalan, Aurora; and Lacaron, Villadolid, Negros Occidental, Philippines, 2003-2004 Cropping Seasons.

Year /	Village	Variety	Weed density / 1.5 m^2								Rice grain yield ($t\ ha^{-1}$)		Weed seed weight ($t\ ha^{-1}$)	
			With GAS				Without GAS							
Season			DAT				DAT				With	Without	With	Without
			15	30	45	60	15	30	45	60	GAS	GAS	GAS	GAS
2003 DS	Bantug	Mestizo 1	-	14	167	-	-	167	146	-	9.3	7.7	-	-
2003 DS	Bantug	Mestizo 1	-	11	180	-	-	180	106	-	8.75	7.18	-	-
2004 WS	Bantug	PSB Rc 82	0	0	0	0	0	73	37	39	5.95	5.9	0	0.53
2004 WS	Bantug	PSB Rc82	0	0	0	0	0	0	2	3	5.12	4.9	0	0.5
2004 WS	Bantug	PSB Rc14	0	0	0	0	132	170	108	65	7.21	4.67	0	2.95
2004 WS	Bantug	PSB Rc82	2	0	0	0	58	100	59	36	4.38	4.08	0	0.83
2004 WS	Bantug	PSB Rc82	0	0	0	0	0	27	26	37	5.89	4.87	0	2.08
2004 WS	Caraksacan	IR 64	0	0	0	0	0	16	22	10	8.3	6.6	-	-
2004 WS	Lacaron	PSB Rc-10	0	0	0	0	†	†	†	†	3.5‡	2.9‡	-	-

(-) No available data. (†) Weeds not counted because of low density due to flooding, (‡) Affected by rice tungro virus disease.

Conclusions

GAS are a serious pest of rice and other aquatic crops if they are not properly managed. We found that GAS as a bio-weeder is an ecologically sustainable and cost-saving technology and thus we documented it at http://www.applesnail.net .

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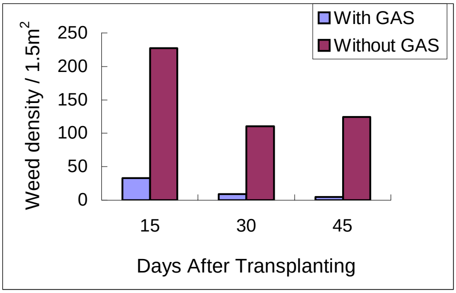

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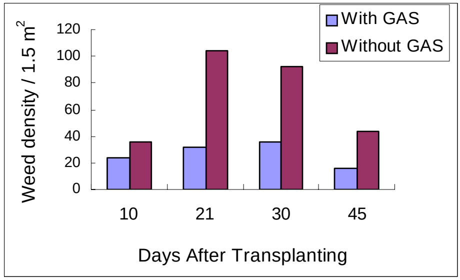

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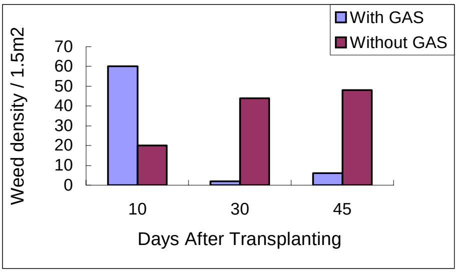

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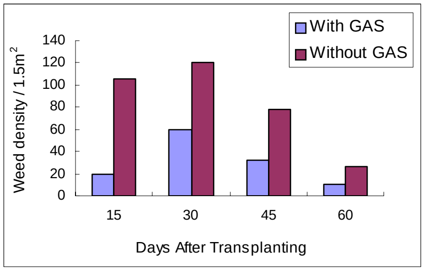

D

Figure 1. Weed density from 10 to 60 days after transplanting, PhilRice-CES, 2003 (A-B)-2004 (C-D) dry and wet seasons, respectively. (Weed density recorded thrice in 0.5 m2 quadrant per field on each sampling date, and expressed as cumulative density in 1.5m2).

ODOR AND IRRIGATION WATER CONTAMINATION BY DUCK-RICE SYSTEM AND ITS EFFECT IN WEED CONTROL, RICE GROWTH AND YIELD

Yong Hwan Lee, Sang Min Lee, Doo Hoi Choi, Sang Kae Lee, Sang Mok Sohn (1)

National Institute of Agricultural Science and Technology, RDA, Suwon, Republic of Korea
Tel: +82-31-290-0257, yonghlee@rda.go.kr
Research Institute of Organic Agriculture, Dankook University, 330-714, Cheonan, Republic of Korea, Tel: +82-41-550-3633, smsohn@dku.edu, http://www.rioa.or.kr

Key Words: Organic farming, Duck-Rice Farming, Green manure, Irrigation water pollution, Hairy vetch, Natural enemy, Rice growth, Bio-mass, Nitrate nitrogen, Ammonium nitrogen, Yield

Abstract

This study aimed to find out the odor and irrigation contamination by duck-rice farming systems and its weed control, rice growth and yield under the system with hairy vetch cultivation. Rice yield was reached at 4.1t/ha in the plot of duck-rice + hairy vetch cultivation while the plot of duck-rice achieved only 3.9t/ha. The nitrate nitrogen concentration in irrigated water ranged between 0.17 and 0.37ppm and did not show much difference among the treatments until the end of June, but the maximum difference detected was in the duck-rice plot in July, 0.11ppm, compared to the hairy plot and duck-rice + hairy vetch plot, 0.08ppm and 0.09ppm respectively. But the concentration of ammonium nitrogen at the end of July reached 4.07ppm in the plot of duck-rice, but it was 2.83ppm in the plot of duck-rice + hairy vetch and 2.12ppm in the hairy vetch plot respectively. The bio-mass of weed showed the lowest in the plot of duck rice + hairy vetch and highest in hairy vetch plot among the treatments. The plot of duck-rice shows the water contamination in terms of nitrate and ammonium nitrogen in the irrigation outlet and strong odor of duck dung even in the neighbouring or surrounding field were detected due to high number of ducks introduced in the duck-rice system, 300 ducklings/ha. Therefore, it is strongly recommended to reduce the number of ducks introduced to the rice field. It was concluded that cultivation of hairy vetch in the duck-rice system is necessary because it shows not only the positive environmental impact such as irrigation water and insect habitats, but also the rice growth and yield.

Introduction/Problem

Duck-rice farming is the most popular farming system in Korea in terms of organic rice cultivation. But hairy vetch cultivation is not yet widely implemented in duck-rice farming systems, although it is recommended in organic farming. The aim of this study was to gather some basic data on the effect of green manure cultivation on the natural enemy, weed bio-mass, mineral nitrogen contents of irrigation water, rice growth and yield. And it was also focused on delivering the basic information about soil fertility of hairy vetch cultivation in duck-rice system.

Methodology

The experimental design for the fertilization experiment (5 replicates) was;

- Control: No fertilization during the experiment
- Duck-rice plot: 300 ducking per ha were imported to rice paddy field
- Duck-rice + Hairy vetch: Hairy vetch cultivation as green manure prior to rice transplanting, and

rice was cultivated by same system as duck-rice plot

- Hairy vetch: Hairy vetch cultivation as green manure prior to rice transplanting, and rice was cultivated by same system as control

Bio-mass of 5 weeds were measured and quality of irrigation water such as pH, EC, nitrate nitrogen, ammonium nitrogen were also analyzed from June to August 2004. 5 natural enemies, 5 agricultural pests and 5 insects were detected and rice yield and yield components were also analyzed after harvest.

The experiment was conducted in Hongdong, Hongseong, Chungnam / Korea which had a nation wide reputation for duck-rice organic farming in the year 2004. Soil of experimental site was a clay acid soil, Deokpyung-tong, which has pH value of 5.5 and were characterized with plant available P_2O_5 62mg/kg by

Lancaster method, organic matter content of 1.4g/kg, SiO2 content of 114.8mg/kg and cations such as K, Ca, Mg were 0.30, 2.28 and 1.05 Ex.cmol+/kg respectively. Cultivar of rice, Yonggeum #1, was transplanted with rice transplanter on 30th May 2004 in paddy field with 40 days old seedlings. Hairy vetch, Early Pod, was sowed on the 27th of September, 2003 and incorporated into the soil 2 weeks before rice transplanting. Weed biomass, rice growth and yield were checked. Samples of water, soil and plants from paddy fields were collected regularly and analyzed to determine the content of nitrate and ammonium by Gas chromatography (HP 5890 II Plus, ECD, DB-5, 0.25mm×30m, film thickness 0.25㎛). And the intensity of odor was also checked in the experimental site and neighbouring or surrounding field.

Results and brief discussion

Weed bio-mass in the plots of duck-rice and duck-rice + hairy vetch were similar, but most effective among the treatments while green manure plot with hairy vetch cultivation in the previous year was 3 times higher weed bio-mass than those of duck-rice plot. The bio-mass of weed was the lowest in the plot of duck rice + hairy vetch and the highest in hairy vetch plot among the treatments. Hairy vetch which has the C/N ratio of 12.4 and contains 40.0% of T-C, 3.2% of T-N, furthermore duck dung contains 40.2% of T-C, 2.5% of T-N. Therefore duck-rice + hairy vetch treatment produce the highest numbers not only in plant height and stem number, but also chlorophyll content throughout the vegetation period.

The number of pests, insects and natural enemies by cultivation of hairy vetch did not change; however, an introduction of duck to the rice-paddy dramatically decreased the pests, insects and natural enemies. Rice yield was reached at 4.1t/ha in the plot of duck-rice + hairy vetch cultivation while the plot of duck-rice achieved only 3.9t/ha.

The nitrate nitrogen concentration in irrigated water ranged between 0.17 and 0.37ppm and did not show much difference among the treatments until end of June, but the maximum difference detected was in the duck-rice plot in July, 0.11ppm, compared to the hairy plot and duck-rice + hairy vetch plot, 0.08ppm and 0.09ppm respectively. The concentration of ammonium nitrogen at the end of July reached 4.07ppm in the plot of duck-rice, but it was 2.83ppm in the plot of duck-rice + hairy vetch and 2.12ppm in the hairy vetch plot respectively.

The plot of duck-rice displayed water contamination in terms of nitrate and ammonium nitrogen in the irrigation outlet and a strong odor of duck dung even in the neighboring or surrounding field was detected due to a high number of ducks introduced in the duck-rice system, 300 ducklings/ha.

Tab 1. Biomass of weed as affected by duck-rice and hairy vetch cultivation

Treatments	Biomass of weed (g/m^2)				
	Monochoria varginalis (Burm. F.)	*Cyperus amuricus* Maxim.	*Echinochloa crus-gall* L.	*Bidens tripartite* L.	*Persicaria hydropiper* L.
Duck-rice plot	0	0	15.6	0	0.5
Duck-rice + Hairy vetch	0	0	10.3	0	0
Hairy vetch	10.3	2.2	11.2	3.0	1.0

Tab 2. Yield and yield component of rice as affected by duck-rice and hairy vetch cultivation

Treatments	Grains / stem	1000 weight (g)	Maturity (%)	Yield (kg/ha)
Duck-rice plot	60,8	21.0	66.3	3905 (100.0)
Duck-rice + Hairy vetch	65.4	21.5	71.6	4030 (103.2)
Hairy vetch	67.6	21.6	69.1	4106 (105.1)
Control	59.8	21.1	52.3	3708 (94.8)

Tab 3.Chemical characteristics of paddy field water as affected by duck-rice and hairy vetch cultivation

Treatments	5th June 2004				15th June 2004				25th June 2004			
	pH	EC ds m^{-1}	NO_3-N mgℓ$^{-1}$	NH_4-N mgℓ$^{-1}$	pH	EC ds m^{-1}	NO_3-N Mgℓ$^{-1}$	NH_4-N mgℓ$^{-1}$	pH	EC ds m^{-1}	NO_3-N mgℓ$^{-1}$	NH4-N Mgℓ-1
Duck-rice plot	7.3	0.67	0.34	1.39	7.6	1.19	0.39	3.07	6.7	0.67	0.29	3.38
Duck-rice + Hairy vetch	7.3	0.67	0.35	1.11	7.5	1.09	0.42	2.64	6.5	0.65	0.19	3.06
Hairy vetch	7.3	0.66	0.32	1.08	7.5	0.75	0.23	1.14	6.5	0.65	0.17	1.20
Control	7.2	0.51	0.30	0.78	7.5	0.72	0.37	1.27	6.5	0.65	0.32	1.09

Tab 4. Growth and chlorophyll content of rice as affected by duck-rice and hairy vetch cultivation

	15th June		6th July			1st August		
	Plant height (cm)	Stem number	Plant height (cm)	Stem number	Chlorophyll (spad-502)	Plant height (cm)	Stem number	Chlorophyll (spad-502)
Duck-rice plot	25.0	13.3	61.7	28.0	36.8	85.0	25.0	30.6
Duck-rice + Hairy vetch	27.8	13.6	67.6	30.1	36.9	89.7	27.5	35.0
Hairy vetch	28.1	13.3	62.0	30.0	36.2	83.8	24.5	32.3
Control	22.9	9.0	58.3	20.3	32.2	79.0	18.0	35.3

Conclusions

It was concluded that hairy vetch cultivation was effective not only in maintaining soil fertility in duck-rice farming systems, but also in obtaining a high number of natural enemies, plant growth and chlorophyll content, in increasing rice yield and in improving yield components. But the ammonium concentrations were increased in duck-rice and duck-rice + hairy vetch plots due to high numbers of ducklings introduction into paddy fields. It was recommended to reduce the number of ducks in paddy fields to minimize the contamination of irrigation water in terms of NO3-N and NH4-N and to minimize the strong odor in neighboring or surrounding field.

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COMBINATION OF DIFFERENT METHODS FOR DIRECT CONTROL OF *VICIA HIRSUTA* IN WINTER WHEAT

Pavel Lukashyk, Ulrich Köpke

Institute of Organic Agriculture, University of Bonn, Katzenburgweg 3, D-53115 Bonn, Germany, E-mail: iol@uni-bonn.de, Internet: www.iol.uni-bonn.de

Key Words: Organic farming, hairy tare, kainite, flame weeding, harrowing

Abstract

Combinations of three different direct methods for controlling *Vicia hirsuta* (kainite application, flame weeding and harrowing) were investigated in field experiments. They were based on different strategies at early growth stages of *V. hirsuta* and standardised harrowing at late growth stages. The highest efficacy of kainite application and flame weeding was achieved at the one leaf stage of *V. hirsuta*. Winter wheat regeneration from damage caused by both kainite and thermal control was satisfactory when treatments were applied at early growth stages (GS 23). *Vicia hirsuta* plants that survived kainite application or flame weeding were successfully controlled by repeated harrowing at later crop growth stages; crop growth was not affected. Seed production of *V. hirsuta* declined with increasing harrowing in all treatments; however the strongest and most reliable reduction was achieved when flame weeding had been previously applied. All combinations of direct measures reduced winter wheat grain-yield losses and enhanced thousand-grain weight more efficiently than the use of a single method only. The highest wheat-grain yield was gained after repeated harrowing (3 times) both with and without kainite application.

Introduction/Problem

Under organic farming conditions in Germany, hairy tare (*Vicia hirsuta* (L.) S. F. Gray) is a very common weed, especially in low-competitive winter cereals. Heavy infestation with this climbing legume can cause serious problems at harvest, resulting in reduced crop yield and product quality. Indirect control measures are often not sufficient to suppress it efficiently (Eisele 1996). Results of former investigations (Lukashyk *et al.* 2004) show that a single direct weed control using either kainite or flame weeding at early growth stages was not sufficient to reduce seed production of *V. hirsuta* when the infestation level was high. Moreover, *V. hirsuta* plants surviving the treatment were able to produce a higher amount of biomass and a larger number of seeds. Consequently, there is also an urgent need to control *V. hirsuta* at later growth stages. During 2001 and 2003, the efficacy of single applications of the three measures kainite application, flame weeding and harrowing were compared in field trials. The main aim of the investigations presented here was to test combinations of the different direct methods to reduce *V. hirsuta* density in early crop growth stages (kainite, flame weeding) and to control residual surviving *V. hirsuta* plants by harrowing in later growth stages.

Methodology

A one-factorial field experiment combining kainite application, flame weeding and harrowing as control measures was conducted in winter wheat with four replications and plot sizes of 1.5 x 9 m. The trial site was located at the Organic Research Farm 'Wiesengut' in North-Rhine Westphalia, Germany (50°48’N, 7°17’O). Kainite application and flame weeding were performed on the basis of former experiments in the years 2002 and 2003. The treatments with flame weeding (Reinert Company, A 311 HB, 3 burners SB 500/i) and kainite (59 % NaCl, 17 % KCl and 16 % $MgSO_4$, Kali & Salz GmbH 2002) were applied once at growth stage (GS) 23 of winter wheat under dry weather conditions. The concentration of the kainite solution was 350 g L^{-1} (230 kg kainite ha^{-1} = 21 kg K ha^{-1}, 660 L ha^{-1}). Flame weeding was conducted at low speed (1.5 km h^{-1}, gas consumption 41 kg ha^{-1}) in order to ensure sufficient damage to the weeds. The crop ground cover at GS 23 was relatively high at about 50-55 %. The spring-tine harrow (Einböck) was applied at GS 32, 47 and 61 of the crop once, repeatedly and in combination with kainite or flame weeding, respectively. Winter wheat was harrowed with soil contact at GS 32 and combed (10-15 cm above soil surface) at GS 47 and 61. Harrowing speed was 5 km h^{-1} (speed limit of equipment). Hand-weeded control plots were used to estimate the influence of *V. hirsuta* on grain yield. The parameters assessed were plant density and seed production of *V. hirsuta*, crop ground cover, crop damage, and regeneration and yield of winter wheat.

Results and brief discussion

The efficacy of the kainite application was substantially lower than that of the thermal weed control (42 and 88 %, respectively). This was probably due to the poor adhesion of the kainite solution. The optimal application of kainite solution still requires further investigation. Growth stage of *V. hirsuta* at treatment time strongly influenced the efficacy. The highest reduction of *V. hirsuta* plants was achieved at the one-leaf stage of the weed, with an efficacy of 76 and 96 % after kainite application and flame weeding, respectively (Figure 1). The higher kainite and thermal sensitivity of younger plants was also found in investigations of Vasters & Remy (1914), Ascard (1994) and Leroux *et al*. (2001), which are in agreement with our results. The younger plants are more susceptible, mainly due to thinner leaves, thinner layers of hairs and wax, lower biomass and less well protected meristems compared with older plants (Lien *et al.* 1967, Parish 1990, Vester 1990).

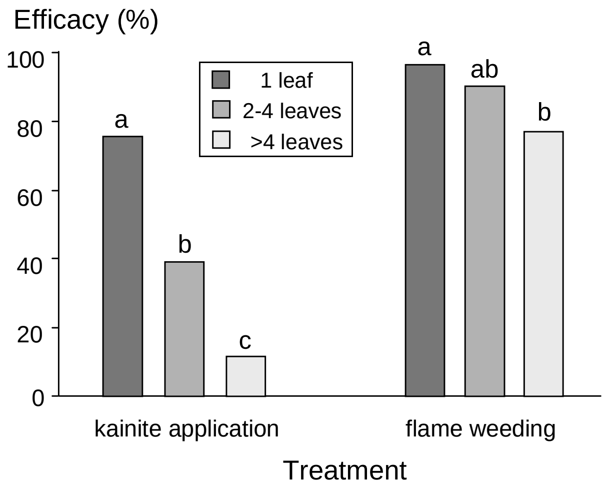

Figure 1: Efficacy of kainite application and flame weeding on density of *V. hirsuta* in winter wheat (GS 23), 8 days after treatment. Weed density of control (no weed control) = 47 plants per m^2. Different letters within treatments indicate significant differences (Tukey test, α = 0.05).

Treated *V. hirsuta* plants with more than 4 leaves were able to regenerate even after complete desiccation of the shoots. The ability of these damaged plants to regrow was likely due to a larger amount of assimilates in the roots, higher water availability, and low competition by neighbouring plants.

Leaf area of winter wheat was reduced by 20 % and 60 % after kainite application and thermal weeding, respectively. Wheat stands recovered rapidly from theses injuries. Three and 6 weeks after the application of kainite and flame weeding, crop ground cover in the treated plots was not significantly different compared to that of the untreated plots. These findings confirm the results of Ascard (1995). Monocots like winter wheat with protected growing points that are located near the soil surface were able to reproduce shoots rapidly after damage.

Two weeks after kainite application and flame weeding, a considerable number of *V. hirsuta* plants germinated (average 16 plants per m^2). Surviving and newly germinated *V. hirsuta* plants were successfully controlled by single or repeated harrowing, which damaged the plants especially by breaking off branches or pulling out the stems. The winter wheat was not affected by repeated harrowing.

Single harrowing at both GS 32 and GS 47 was also able to control *V. hirsuta* sufficiently. However, the efficacy was lower than that of a combination of different direct control methods, because a high number of entwining *V. hirsuta* plants were not reached by the tines. The winter wheat was sometimes injured by the harrow, which frequently pressed down the crop stand.

Both kainite application and flame weeding significantly reduced *V. hirsuta* biomass and seed production (Figure 2). Weed seed production in plots treated with kainite was higher than in the plots treated with flame weeding. This can be explained by the lower efficacy of the kainite application with respect to *V. hirsuta* density compared with that of flame weeding (Figure 1). Seed production of *V. hirsuta* generally declined with increasing harrowing intensity due to higher efficacy in reducing biomass, e.g., broken off branches of *V. hirsuta* resulted in a decline in photosynthesis (Kemball *et al*. 1992). The severest decline of seed production (95 %) compared to the untreated control was achieved by the highest intensity of combined weed control (3 times harrowing + flame weeding) (Figure 2).

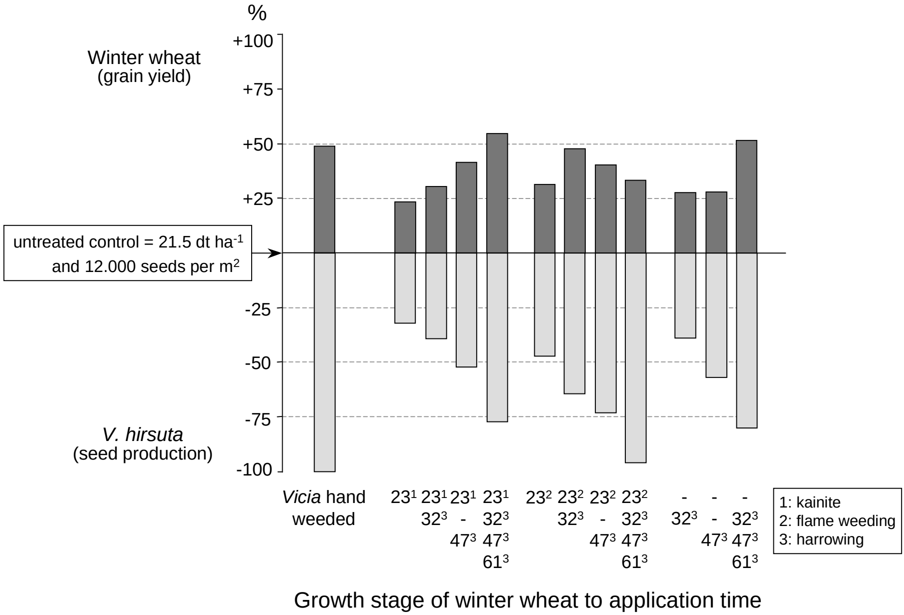

Figure 2: Relative increase of grain yield (winter wheat) and decrease of seed production (*V. hirsuta*) after weed treatments at different crop growth stages in relation to untreated control.

In the present study, a high infestation of *V. hirsuta* in a low competitive winter wheat stand caused a high reduction of grain yield in the absence of any direct control. Hand weeding of *V. hirsuta* reduced crop grain yield losses by 49 % compared with the untreated control (Figure 2). All direct control methods resulted in reduced yield loss and enhanced thousand-grain weight (data not shown). Grain yield losses declined with increasing harrowing intensity.

The highest grain yield (33.3 dt ha^{-1}) in our experiment was achieved after kainite application combined with repeated harrowing (3 times). This effect was caused by the successive reduction of weed biomass due to harrowing. On the other hand, in plots previously treated by kainite this high grain yield could be the result of the fertilising effect of kainite (21 kg K ha^{-1}) on the crop. The yield of the kainite + three times harrowing treatment was significantly higher (55 %) than that of the untreated control and even 10 % higher than in the hand-weeded control (not significant).

According to Wehsarg (1931), kainite can be used for both weed control and overhead potash fertilisation of the crop. However, kainite broadcast for fertilisation purposes only (53.5 kg K ha-1) resulted in a reduction of the crop yield due to enhanced growth of *V. hirsuta* (Lukashyk *et al*. 2004).

Conclusions

Results show that a combination of different direct weed control methods (kainite application, flame weeding and harrowing) can significantly increase the efficacy of controlling the density and seed production of *V. hirsuta* when compared to the single or repeated use of single methods only. In early crop growth stages, the effect of kainite application or flame weeding on *V. hirsuta* density is higher than that of harrowing. However, in later crop growth stages, harrowing (combing) is much more effective in reducing the number of surviving and newly emerged *V. hirsuta* plants than kainite application or flame weeding. Nevertheless, three times harrowing/combing resulted in nearly the same grain yields and the same efficacy in reducing weed seeds as when this treatment was combined with flaming or kainite application. Kainite application as well as flame weeding is recommended for patches with high infestation of *V. hirsuta* in early spring, whereas harrowing/combing can be used efficiently in later growth stages and on larger areas.

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POTENTIAL OF DECISION SUPPORT SYSTEMS FOR ORGANIC CROP PRODUCTION: WECOF-DSS, A TOOL FOR WEED CONTROL IN WINTER WHEAT

Neuhoff, Daniel, Schulz, Dirk & Köpke, Ulrich

Institute of Organic Agriculture (IOL), University of Bonn, Katzenburgweg 3, D-53115 Germany, d.neuhoff@uni-bonn.de, http://www.iol.uni-bonn.de/

Key Words: Decision Support System, Weed Control, Organic Winter Wheat

Abstract

Based on a comprehensive description of a recently published Decision Support System (WECOF-DSS) for weed management in organic winter wheat (http://www.wecof.uni-bonn.de), the potential of these tools for application in organic crop production is discussed. WECOF-DSS offers site-specific recommendations on cultivar choice, mechanical control, crop rotation and crop management for efficient weed control. Although Decision Support Systems are neither able to replace the decision maker nor to reflect all possible site conditions, the educational character of these tools is expected to result in an increasing use for specific objectives, e.g. high quality cereal production, also in Organic Agriculture.

Introduction/Problem

Computer based Decision Support Systems (DSS) have gained increasing importance in the eighties of the last century. Decision Support Systems are not targeted on replacing the decision maker but to help in making choices by providing additional information, while the user is responsible for the choice and implementation action (Harsh et al. 1989). Main requirements a DSS needs to fulfil include biological accuracy, high quality of recommendation and ease of use (Wilkerson et al. 2002). Reducing herbicide use by optimal timing of selected agents is one major application area of DSS's in conventional agriculture (e.g. Wiles et al. 1996, Renner et al. 1996). This curative approach, often based on sophisticated models on interactions between weeds and crops as well as on the definition of thresholds, is neither wanted nor feasible in Organic Agriculture (OA). Flexible short term responses to agronomic problems play a minor role in organic cropping systems resulting in a restricted usability of classical decision tools. Knowledge based Decision Support Systems however may help to improve weed management in organic crop production by tailoring site specific control strategies. Concepts for a DSS for weed management in organic cereals therefore need an approach that is targeted on preventive rather than on curative control methods (Davies & Welsh 2002) taking spatial rather than temporary dynamics of weed populations into account. The specific growing conditions in OA, in particular the rejection of herbicides and mineral nitrogen fertilisers, have a direct impact on crop development and weed species composition resulting in a wide range of possible growing conditions. Consequently weed management in organic cereal production requires expertise not only in weed science but also in classical agronomy. This paper describes the development and application of a DSS for weed management in organic winter wheat production and critically discusses the potential of these tools for the future development of OA.

Methodology

User friendliness is a key element for a widespread adoption of any DSS. This requirement includes easy technical management on the computer screen but also the exclusion of any primary deterrent such as labour intensive investigations, e.g. weed scouting. In a first step the user has to fill in a questionnaire on site-specific agronomic conditions including soil conditions, management factors and the expected weed species abundance and composition. WECOF-DSS is not based on bioeconomic weed management models for crops as described e.g. by Forcella et al. (1996) but on observations derived from our experiments and expert knowledge. The scientific background is mainly based on classical agronomy combined with weed science. The limited availability of direct control methods in OA entails the consequent use of all indirect methods available, in particular the establishment of competitive crop stands by variety choice and seed spacing. Verschwele & Niemann (1996) confirmed the potential use of wheat cultivar variation in weed suppression and noted that shading capacity through crop cover and canopy height were highly correlated. Our experiments have shown significant varietal differences in weed suppression of winter wheat and have identified key crop features involved (Drews et al. 2002).

Crop rotation design is another key element of any strategy for weed management (Stopes & Millington 1991) requiring specific attention in organic crop production. Further specifications on the fertility status of the field are necessary in order to estimate the expected crop growth vigour.

Recommendations given by WECOF-DSS are mainly based on ‘if / then’ or ‘yes / no’ decisions. ‘If / then’ decisions define a set of conditions that will result in a specific recommendation. A key focal point is the evaluation of the expected weed abundance based on the farmer's own experiences. Weed data input is hierarchically categorised and compared with a decision matrix according to an if / then scenario. Expected high infestation with defined problem weeds such as Wild Oat (*Avena fatua*) will result in the recommendation to apply hoeing, whenever technical conditions allow. Corresponding conditions for harrowing are defined as well. Further if / then decisions include the application of some optional weed control measures. For example, the recommendation to delay sowing time is linked to some preconditions including an expected heavy pressure of specific autumn emerging weeds and the possibility to delay sowing without higher risks (Rasmussen 2004). Depending on the specific growing conditions a stale seed bed preparation may alternatively be recommended as well.

Recommendations such as the improved application of slurry to avoid nitrophilous weed growth (Juroszek et al. 2004) or the compulsory use of healthy seeds are based on yes / no decisions. Key elements of strategies derived from WECOF-DSS including variety choice and mechanical control were compared with individual farmer approaches in pilot trials on practical farms using a simple experimental design with 4 replications. Crop and weed development were regularly assessed and submitted to analysis of variance. Based on the results of these experiments a partial validation of WECOF-DSS was possible.

Results and brief discussion

The technical structure of WECOF-DSS is designed in a way that allows interactive online operations of the decision maker without any specific knowledge. By this procedure the user has permanent easy access to updated versions via internet without downloading any specific software.

The DSS output includes recommendations on variety choice, crop establishment, mechanical control, crop rotation, soil tillage and some additional site specific advices. Depending on the expected weed flora and the soil fertility status, the selection of different leaf inclination types, i.e. either planophile or erectophile, is recommended. Site specific variety choice combined with optimal seed spacing is expected to result in high crop competition against weeds. A high soil fertility status may allow the use of a narrow sown erectophile leaf inclination type known to be more productive compared to planophile growth types under conditions of high nitrogen supply. In contrast a low fertility status of the soil will result in the recommendation to use a planophile growth type known to intercept more light with a given leaf area index (Topp et al. 2004).

Facilitating hoeing as a presowing decision requires a minimum inter row spacing of 15-17cm in order to avoid serious crop damages. The decision on whether to hoe or not depends on the expected weed species composition and abundance. Hoeing has been shown to be essential for a range of weed species including aggressive grasses such as blackgrass (*Alopecurus myosuroides*).

Weed harrowing is the classical method for mechanical weed control in organic cereals. WECOF-DSS defines a list of conditions including the expected weed species abundance at specific growth stages and the overall necessity to reduce weed pressure, e.g. for carrot growing, that will result in the recommendation to harrow.

Rotation analysis is based on the ratio between different crop types (row crops, cereal crops, grass-clover leys) and the sequence of the individual crops within the rotation with respect to weed management. Warning functions inform the user of potential risks of a specific crop rotation.

Additional advices given by WECOF-DSS include recommendations with an option for farmers interested in testing innovations, e.g. the use of allelopathically active crops such as buckwheat for couch grass control (Golisz et al. 2004). In addition to various recommendations the DSS user has access to a wide range of current knowledge on organic winter wheat production offering encyclopedic information on more than 70 weed species occurring in organic cereals. Information on biology include competitive ability, main germination time, seed viability, seed production, vulnerable growth stages to mechanical control as well as practical recommendations for efficient control. Further background information is given on seed quality and field hygiene. Additionally online use of WECOF-DSS offers various links to interesting websites on weed control.

Weed control strategies derived from WECOF-DSS were compared with individual farmer approaches in a series of pilot trials carried out in Poland, Spain, United Kingdom and Germany. As shown in Table 1 for the German trials, the DSS derived strategy, consisting of the use of a competitive cultivar, resulted in 4 out of 5 trials in a comparable level of weed infestation, although harrowing was omitted. The farmer approach including additional harrowing (1-3 times) only once resulted in a temporary lower weed ground cover at stem elongation (Pilot trial 2004 A) while not affecting final grain yield. Observed yield differences between treatments were mainly due to the varietal impact.

Table 1: Effect of two weed control strategies (FA = farmer's approach, DSS = WECOF-DSS approach) on crop and weed development in 5 pilot trials, Germany 2003 and 2004, Tukey's test (α< 0.05).

Parameter	Pilot trial 2003 A		Pilot trial 2003 B		Pilot trial 2004 A		Pilot trial 2004 B		Pilot trial 2004 C	
	FA[1]	DSS[2]	FA[3]	DSS[4]	FA[5]	DSS[6]	FA[7]	DSS[8]	FA[9]	DSS[10]
Crop density EC 13 (N° m^{-2})	255a	209b	255	263	288	293	378	353	416	383
Grain yield (t ha^{-1})	6.9b	7.6a	5.8	6.3	6.1	6.2	7.0	6.1	2.9	3.2
Weed density EC 13 (N° m^{-2})	2.0	0.9	9.9b	35.1a	203	242	253	303	182	156
Weed ground cover EC 25 - 31 (%)	0.0	0.3	0.2	0.1	12.5b	22.3a	9.5	9.3	2.3	2.4
Weed ground cover EC 51 - 83(%)	0.9	0.4	3.0	3.8	4.3	5.5	-	-	7.3	9.8

1=cv. *Ludwig* + harrowing, 2=cv. *Pegassos*, 3= cv. *Greif*, 4=cv. *Pegassos*, 5=cv. *Pegassos* + harrowing, 6= cv. *Pegassos* 7 cv. *Pegassos* + harrowing, 8=cv. *Ökostar*, 9 = cv. *Ludwig*, 10=cv. *Pegassos*.

Most of the pilot trials carried out during the project indicate that weed management in organic winter wheat is often possible by using a site specific combination of indirect control methods only. Reduced reliance on mechanical control is expected to increase farmers flexibility, while decreasing labour input and fuel consumption.

Conclusions

First field validations of key elements of WECOF-DSS on pilot farms have shown that the adoption of recommendations may have a beneficial effect on weed control in organic winter wheat production under temperate climate conditions. Harrowing turned out to be dispensable in many cases without substantial yield losses or an increase of weed pressure only by using a competitive variety. Further tests and adjustments under practical conditions are currently being carried out. Feed back of users will help to continually improve the tool. A weak point of WECOF-DSS consists in the inevitable fact that most recommendations are based on the expected weed abundance before sowing that may turn out to be wrong. However, most recommendations, in particular indirect control methods, generally have a positive impact on weed control, independent of the actual weed pressure. Flexible intensification of mechanical control decided and initiated by the farmer during crop growth has to keep weed pressure at a manageable level. Extensive knowledge offered by WECOF-DSS, in particular on individual weed species is expected to support the farmer in finding adequate solutions and underline the educational character of this type of tool (Wilkerson *et al*. 2002). The proposed selection of competitive varieties however may cause a problem, if corresponding genotypes are not available. For that purpose an integration of competitive ability into breeding programmes is urgently needed. There is also some evidence that internet driven decision tools such as WECOF-DSS, although relatively cheap and easily accessible, will currently mainly be used in western countries. The degree of acceptance by potential users will mainly depend on the ease of use and the consistency and success of any recommendation given.

To conclude, computerised decision tools have a potential for wider use in organic crop production in at least two ways. The main potential consist in designing tools for specific objectives such as high quality cereal production or weed management in crops. Other tools may help farmers in selecting appropriate varieties for specific conditions and objectives. The overall future development of Organic Agriculture, in particular with respect to profitability and quality requirements, will determine, whether sophisticated decision tools will gain increasing importance.

Acknowledgements

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WEED VEGETATION OF ORGANIC AND CONVENTIONAL DRYLAND CEREAL FIELDS IN THE MEDITERRANEAN REGION

Romero, A, Chamorro, L., Sans, F.X.

Departament de Biologia Vegetal, Universitat de Barcelona. Avda. Diagonal 645, 08028, Barcelona, Spain. E-mail, fsans@ub.edu

Key Words: Biodiversity, organic farming, conventional farming, comparison, conservation

Abstract

Weed abundance, species richness and diversity in conventional and organic dryland cereal fields in Catalonia (NE of Iberian Peninsula) were compared to assess the effect of intensification on the floristic composition and structure of weed vegetation and to evaluate the role of organic farming in preventing the continued loss of biodiversity caused by intensive farming practices. Between 1 and 3 closely paired fields (blocks) were selected at 10 agricultural sites. Each pair contained one long-established organic farm and one conventional farm. Weed abundance, taking into account the spatial pattern, was surveyed in spring 2003 and 2004 by means of a relative abundance index for each species, ranking from one to six. Results show that abundance, species richness and diversity were higher in organic than conventional fields. Low tolerance to herbicides and the dense crop swards of conventional fields may explain the lower abundance of broad-leaved weeds, while the increase in legumes in organic fields may be related to the absence of chemical fertilization. Species richness was higher at the crop edges than mid-field in both organic and conventional fields, whereas weed abundance was higher at field margins than mid-field in conventional fields.

Introduction

The intensification and expansion of modern agriculture is among the greatest current threats to worldwide biodiversity. Over recent decades, a dramatic decline in both range and abundance of many species associated with farmland has been reported in northern and central Europe, leading to growing concern over the sustainability of current intensive farming practices (Hole *et al.*, 2005). In this sense, several studies have recorded higher weed abundance and species richness in cereal fields under organic management (Moreby *et al.*, 1994; Andreasen *et al.*, 1996; Hald, 1999; Rydberg & Milberg, 2000; van Elsen, 2000; Hyvonen *et al.*, 2003). Thus, organic farming is now considered a potential solution to this continued loss of biodiversity (Albrecht, 2003; van Elsen, 2000).

Comparison studies between conventional and organic cereal fields reveal that differences are greater for broad-leaved weed species than grasses, which tend to show less variation between organic and conventional fields (Hald, 1999; Moreby *et al.*, 1994). In several studies, fields under organic management contain considerably more rare and/or declining species. In contrast, several generalist species are more prominent in conventional fields and are now considered to be serious agricultural pests (Hyvonen *et al.*, 2003; Rydberg & Milberg, 2000). Weed abundance is higher at field margins than mid-field under both organic and conventional systems, although the differences are generally more pronounced in conventional fields (Albrecht, 2003; Hald, 1999; Wilson & Aebischer, 1995).

This paper deals with the impact on biodiversity of organic farming as compared to conventional agriculture, through a study of the two systems in the Mediterranean area, in order to determine whether organic agriculture can contribute to maintaining biodiversity.

Methodology

The weed vegetation of organic and conventional farms at 10 agricultural sites in Catalonia (NE Iberian Peninsula) was analysed to evaluate the effect of agricultural practices on the floristic composition and structure of weed vegetation. Between 1 and 3 closely paired cereal fields (blocks) were selected at each site. Fields within each area were sown with the same crop, wheat or barley, and the sowing date was also similar for the various fields. The size, shape and slope of the fields were also similar.

Five transects, 15 m in length and more than 20 m apart, were randomly established perpendicular to the perimeter of each field. Four 1 x 1 m plots 5 m from the crop edge were established to estimate species richness and abundance. The floristic composition and the abundance of each species in each plot was estimated in spring 2003 and 2004 by means of a relative weed cover index for each species, ranking from one to six.

The split-plot model (Potvin, 1993), with agricultural site and management as the main factors and the block as the split-plot factor, was used to analyze the influence of agricultural site and management on species richness, abundance and diversity in 2004. Because only one pair of fields within each agricultural area was sampled in 2003, an analysis of variance with agricultural site and management type as main factors was used. Data were transformed where necessary to achieve normality and homoscedasticity of residuals. Analyses were carried out using the SPSS Statistical Package (2002).

Results and brief discussion

The analysis of variance shows that relative weed cover, species richness and Shannon diversity index (H') (Magurran, 1989) were significantly higher in organic than in conventional farms in 2004 (Tables 1 and 2). Only abundance and species richness were significantly higher in organic than in conventional fields in 2003. Interaction between management and site in both years was related to slight differences in relative weed cover, species richness and diversity between organic and conventional fields at some sites. Higher species richness and abundance in organic versus conventional cereal crops was also recorded by Hyvonen *et al.* (2003), Hyvonen & Salonen (2002), Menalled *et al*. (2001), van Elsen (2000), Hald (1999) and Moreby *et al.* (1994).

Table 1. Mean (± standard error) of relative weed cover, species richness and diversity per transect in organic and conventional dryland cereal fields in 2003 and 2004.

Year	Management	Relative weed cover (%)	Species richness	Diversity (H
2003	Conventional	26.62 ± 3.74	11.20 ± 1.12	2.76 ± 0.16
	Organic	78.35 ± 4.40	19.87 ± 1.28	3.13 ± 0.02
2004	Conventional	18.98 ± 1.40	11.16 ± 0.67	2.32 ± 0.10
	Organic	73.29 ± 5.48	22.49 ± 0.84	3.25 ± 0.03

Table 2. Relative weed cover, species richness and diversity comparison between conventional and organic dryland cereal fields. Asterisks indicate significant differences, *p* ≤0.05.

		Relative weed cover (%)		Species richness		Diversity (H')	
Year	Factor	F	*P*	F	*P*	F	*P*
2003							
	Site (S)	1.04	0.484	1.08	0.467	2.66	0.153
	Management (M)	22.48	0.005*	7.98	0.037*	1.64	0.256
	S x M	6.58	< 0.001*	6.65	< 0.001*	4.95	0.001*
2004							
	Site (S)	0.45	0.820	0.54	0.767	0.55	0.757
	Block (S)	1.76	0.236	1.62	0.269	1.44	0.319
	Management (M)	7.14	0.037*	15.53	0.012*	6.63	0.042*
	S x M	33.96	< 0.001*	9.05	0.005*	9.05	0.005*
	Block (S) x M	1.67	0.122	2.82	0.010*	1.96	0.067

Significant differences in floristic composition were detected between organic and conventional fields. While *Medicago* polymorpha, Medicago lupulina and Cirsium arvense were plentiful in organic fields, the prevalence of Avena sterilis, Galium aparine and Bromus diandrus were higher in conventional than organic fields. Note that Rapistrum rugosum only appeared in organic fields (Table 3).

The abundance of weeds characteristic of dryland cereal fields was higher in organic than in conventional fields (Table 4). The number of rare species is a good indicator of agroecosystem conservation and biodiversity (Albrecht, 2003). The abundance of broad-leaved species and legumes was also higher in organic than in conventional fields (Table 4). Greater abundance of broad-leaved species is consistent with the findings of Hald (1999), Hyvonen *et al.* (2003), Moreby *et al.* (1994) and Rydberg & Milberg (2000), suggesting that broad-leaved species are less able to tolerate the intensive weed control measures and denser crop swards of herbicide-treated, fertilised, conventional arable fields. Van Elsen (2000) indicates that the increase of legume species can be related to the absence of chemical fertilization.

Table 3. Relative cover of the weed community and the major species in conventional and organic dryland cereal fields. R_c and R_o are mean ± standard error relative cover in conventional and organic fields respectively, and Rk_c and Rk_o are species ranks in terms of relative importance assessed as relative cover in conventional and organic fields respectively.

	Organic RC_o	Rk_o	Conventional RC_c	Rk_c
Weed community	74.76 ± 12.22		21.23 ± 3.60	
Papaver rhoeas L.	11.70 ± 3.77	1	2.29 ± 0.98	2
Lolium rigidum L.	11.61 ± 3.59	2	5.03 ± 1.42	1
Polygonum aviculare L.	8.67 ± 3.24	3	1.14 ± 0.42	5
Medicago polymorpha L.	4.60 ± 2.92	4	0.15 ± 0.13	30
Convolvulus arvensis L.	3.51 ± 1.64	5	1.38 ± 0.91	3
Cirsium arvense L.	3.26 ± 1.87	6	0.45 ± 0.25	9
Avena sterilis L.	1.98 ± 0.76	7	1.30 ± 0.65	4
Medicago lupulina L.	1.89 ± 0.87	8	0.06 ± 0.05	48
Lepidium draba L.	1.37 ± 1.19	9	0.07 ± 0.07	44
Linaria spuria (L.) Mill.	1.28 ± 0.56	10	0.19 ± 0.09	24
Rapistrum rugosum (L.) All.	1.15 ± 1.04	11	—	
—				
Polygonum convolvulus L.	1.02 ± 0.53	15	0.08 ± 0.04	10
Anacyclus clavatus (Desf.) Pers.	1.00 ± 0.61	16	0.12 ± 0.08	7
Galium aparine L.	0.47 ± 0.38	29	0.16 ± 0.09	6
Bromus diandrus Roth	0.30 ±0.18	35	0.10 ± 0.04	8

Table 4. Importance of different functional groups, assessed as percentage of weed species and abundance, in conventional and organic dryland cereal fields. Data are mean ± standard error.

	Organic		Conventional	
	Species number	Relative cover	Species number	Relative cover
Broad-leaved species (%)	85.56 ± 1.36	80.55 ± 4.23	76.68 ± 3.39	60.29 ± 6.08
Grass species (%)	14.44 ± 1.36	19.45 ± 4.23	23.12 ± 3.39	39.71 ± 6.08
Characteristic species (%)	16.56 ± 1.96	37.00 ± 4.45	17.21 ± 2.18	26.11 ± 5.06
Legume species (%)	9.41 ± 1.57	9.40 ± 2.72	6.42 ± 1.71	2.42 ± 1.14

The pattern of spatial distribution shows that a high proportion of weeds colonize crop edges in conventional fields, whereas more even spatial distribution occurs in organic fields (Figure 1). In contrast, species richness was higher at the crop edges than mid-field in both organic and conventional fields. Hald (1999) indicates that significantly higher weed abundance occurs at crop edges than in main crops in both conventional and organic cereal crops, but species richness is only higher at crop edges in conventional cereal crops. Lower tillage intensity in organic cereal crops, and uneven herbicide distribution in conventional cereal crops, cause different environmental conditions at the crop edges favouring germination and establishment of species from boundaries, and rare weeds (Dutoit *et al*., 1999).

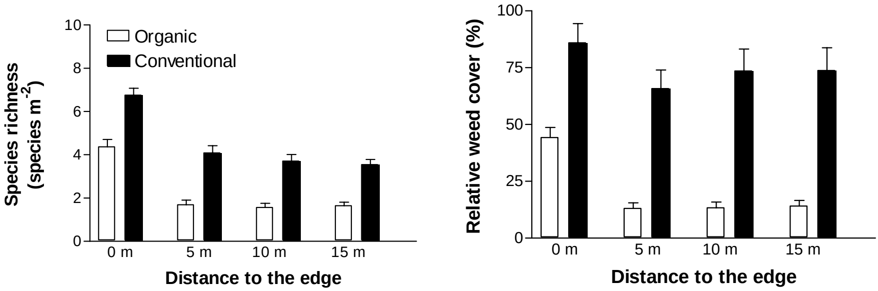

Figure 1. Weed abundance, assessed as mean relative weed cover, (right) and mean species richness (left) related to distance from the crop edge. Columns represent field means and error standard.

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CONTROL OF PESTS AND DISEASES

STUDY OF TRAPPING SYSTEMS FOR CONTROL OF *BACTROCERA OLEAE* (GMELIN)(DIPTERA:TEPHRITIDAE) IN CRETE OLIVE GROVES

V. Alexandrakis, K. Varikou & A. Kalaitzaki

Institute of Olive tree and Subtropical plants, Agrokipio, 73100, Chania, Greece, Tel.0032821083449
E-mail: valexandr@nagref-cha.gr, kvarikou@nagref-cha.gr, argkalaitzaki@yahoo.com

Key words: Bactrocera oleae, mass trapping, attractants, Saccharopolyspora spinosa.

Abstract

Studies have been carried out the last four years to search for improved mass trapping systems for the control of olive fruit fly in olive groves in Chania, Crete (Greece). Trapping materials, which include various food and sex attractants and different types of traps (liquid and paper traps), were tested for their attractiveness and effectiveness in field trials.

Among the tested attractants (Entomella 50 (E50), Entomella 75 (E75), Dacus bait 100 (Db100), Ammonium sulphate (As) and Sex pheromone (Sp)), the hydrolyzed protein 'Db100' showed the highest attractiveness regardless of the 'Sp'. Among the tested traps (Daidalos, Elcofon, Zervas, Agrisense & Ecotrap), Daidalos captured significantly more flies than the other traps.

When the traps were tested in mass trapping conditions, no statistical differences were observed among the tested traps (chemical control was applied when was necessary) , but all were different from the reference product (classical chemical control).

In addition, when Spinosad, a novel natural compound derived from fermentation of the bacterium *Saccharopolyspora spinosa,* was applied as complementary sprays in the Mass trapping field, it also provided comparable and significant control for *B. oleae* (Gmel.) in comparison to the classical control.

Introduction/Problem

The control of the olive fly, *B. oleae* (Gmel.) is based today on the use of organophosphorus insecticides either as bait or cover ground sprays, the extensive use of which has ecological and toxicological consequences for the olive agroecosystem.

Under the philosophy of pest control, the development of non-polluting trapping systems for olive fly has been pursued. For mass trapping, color (Economopoulos, 1979), sex attractants (Haniotakis *et al.*, 1983), color combined with ammonia- releasing sources (Delrio, 1981) and sex attractants combined with color and ammonia-releasing sources (Broumas *et al.*, 1983) have been tested for the development of an effective and specific trap. The combination of sex, food and color attractants in the same trap is the most promising for control purposes (Delrio, 1981). In unisolated groves and in areas where the fly develops high population densities, this method provides inadequate protection, and complementary bait sprays are needed to keep the fly population and the fruit infestation at low levels (Mazomenos *et al*, 2002). Thus, alternative pesticides that are environmental friendly, such Spinosad (Vergoulas P.V. *et al* 2004b), are needed to replace the chemicals in organic agriculture.

Success, the commercial name of Spinosad, is an insect control product derived from a biological source that combines effectiveness and reduced risk to the environment (Bret B.L. *et al*, 1997). It is of low risk to bees, has very low vertebrate toxicity, and will be soon listed in Annex 1.

In this paper we report the results obtained from the evaluation of the mass trapping method, which includes food and sex attractants, different types of traps and new products, with the goal of developing an environmentally safe method of pest control.

Methodology

Trapping materials and systems were tested for improvement concerning their attractiveness and efficiency.

I. Evaluation of effectiveness of food and sex attractants in McPhail traps

The effectiveness of various food and sex attractants was tested in McPhail traps in three replications. Hydrolyzed proteins such as 'E50', 'E75', 'Db100' and 'As' in 2 % formulation were tested alone or in combinations with 'Sp' for the olive fruit fly. The trap solution was changed once a week**.**

II. Evaluation of attractiveness of traps

Three liquid traps, Daidalos (Daida: a plastic one similar to McPhail), Zerva (Zerva: a plastic transparent bottle of 1.5 l capacity with four holes around the top) and Elcofon (Elco: with two holes around the top) were tested for their effectiveness and attractiveness compared to the reference trap (McPhail with 2% of 'As') in 6 replications. The filling solutions, 'As' and the ome recommended (M) by each trap company, were changed every second (1) (as well as McPhail) or seventh week (2).

The experimental design of the semi-field experiments I &II was a completely randomized block. The captured adults were counted and extracted once a week. In addition, the position of the traps was rotated one position at a time.

III. Evaluation of effectiveness of mass trapping combined with chemical control

In Chania olive groves (cv Koroneiki), two liquid (Daidalos & Elcofon) and paper (Ecotrap & Agrisense) traps were evaluated for their effectiveness in mass trapping conditions (180traps/ha). As far as the paper traps are concerned, they consist of a bag or carton that carries a food (ammonium bicarbonate) and sex attractant, and are dipped into an insecticide.

The population was recorded once a week with a network of 12 McPhail traps that was established inside the test area (each plot had about 4000 trees); olive fruit sampling was done twice a month to determine the live and total olive fruit infestation.

IV. Evaluation of mass trapping combined with friendly products

Mass trapping (Daidalos) combined with complementary Spinosad sprays was applied in an isolated organic olive grove (each plot had about 3000 trees). The methodology that was followed was the same as in field experiment III.

Results and brief discussion

I. Evaluation of effectiveness of food and sex attractants in McPhail traps

Our studies showed that 'Db100' captured significantly more olive fruit flies than the other treatments (Fig. 1). Zervas (1982) also recorded the high attractiveness of 'Db100' in contrast to the low attractiveness of 'As' in transparent plastic bottles of 1.5 l. Among the food-based attractants, protein-hydrolysates are highly attractive to a variety of fruit flies (Steiner et al., 1961), especially female Dacinae (Metcalf, 1990). Fruit fly pheromones have had limited success (Landolt & Averill, 1999) since their action is not understood completely (Kuba, 1991).

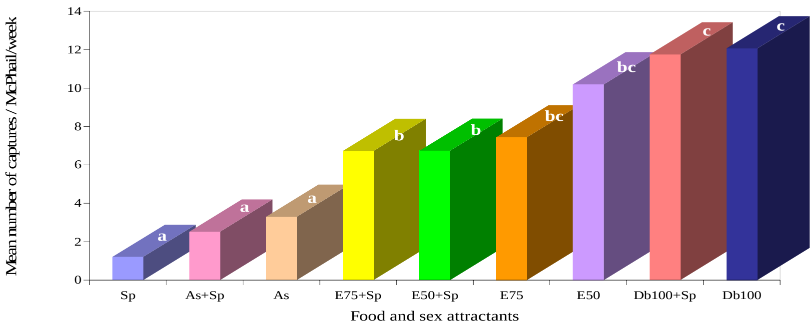

Figure 2. Mean number of captured adults per trap per week for each attractant or combination. Bars by the same letter (s) are not significantly different at P<0.05

II. Evaluation of attractiveness of traps

Thr Daidalos trap captured more flies regardless of the attractant solution and its renewing time (Fig. 2).

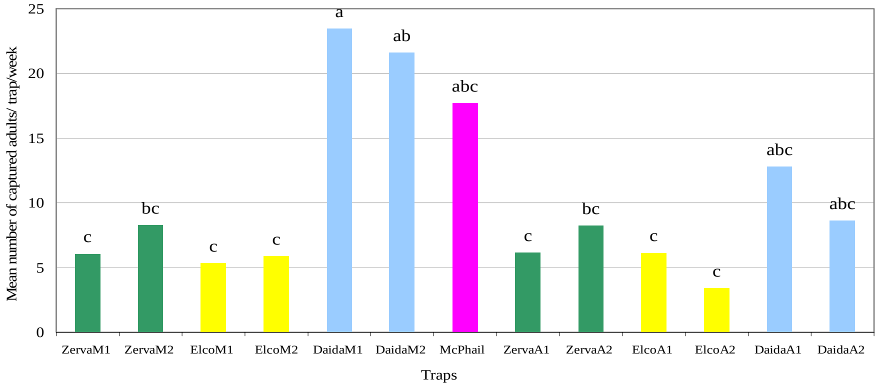

Figure 3. Mean number of captured adults per trap per week with two different food attractants. Bars by the same letter (s) are not significantly different at P<0.05

III. Evaluation of effectiveness of mass trapping combined with chemical control

However, with mass trapping, no differences were observed in recorded populations among trap plots but there were a statistical difference in the populations in the plot of the reference product. In 2001, the recorded population of B. oleae in the reference plot was about three times higher and next year two times higher than in the other plots (Table 1). The number of bait spray applications was two more in both years. Both live and total infestation was low in all treatments. Similar results were found in recorded populations when other trapping systems (plywood rectangles, etc) were used; the combination of sex and food attractants on a highly effective trap is desirable for mass trapping purposes (Haniotakis et al, 1986).

Table 4. Mean number of captured adults of *B. oleae* per trap per week in the test and control areas. Means followed by the same letter (s) are not significantly different at P<0.05

	Daidalos	Ecotrap	Fenthion	Elcofon	Agrisense
2001	13,58±2,58a	10,07±1,87a	33,67±6,25b		
2002	13,71±2,73ab	10,12±1,99a	24,50±5,48b	11,72±2,77a	11,19±2,11a

Our findings are in agreement with those reporting that in isolated olive groves or in regions where the fly develops low populations per year, the method is effective by itself, while in regions where the fly develops a high population density at least one insecticide treatment is necessary to keep the fruit infestation low (Broumas *et al*., 1983). In Cretan experimental regions, the olive fruit fly develops high population density (mild climate conditions), so the trapping systems provides inadequate protection and bait spray applications are necessary to keep the olive fruit fly population and infestation within acceptable bounds.

IV. Evaluation of Mass trapping combined with friendly products

There was a significant difference in captures in the monitoring traps among the treated areas with Spinosad and the reference product (Table 2). The number of bait sprays was almost the same in both the treated areas of mass trapping with Spinosad. In all cases the mean percentage of olives attacked by B. oleae was low and not significant. It should be noted that the cost of olive protection is reduced as it is not necessary to spray all the trees, only every second or fourth tree.

Table 5. Mean number of captured adults of *B. oleae* per trap per week in the test and control areas. Means followed by the same letter (s) are not significantly different at P<0.05.

Fenthion (0.6lt/hl per tree)	**Spinosad** (4lt/hl per 2nd tree)	**Spinosad** (8lt/hl per 4th tree)
22,39±3,81b	5,08±1,18a	4,76±1,171a

Its low risk to beneficial Coccinelidae predators and Hymenopterous parasitoids has been recorded (Vergoulas P.V. *et al* 2004a), as well as its great selectivity to the pest (Vargas, 2003), Sprays with Spinosad against sterile Mediterranean and Caribbean flies provided significant control comparable to standard malathion applications (Burns *et al*., 2001).

Conclusions

Nowadays the use of alternative methods of chemical control is inevitable. Emphasis is given to newer methods, which should not only be specific and effective but also impose little disturbance on the agroecosystem. The most appropriate method should be based on a combination of a trap and an attractant, combining high efficiency, long life, ease of application, low cost and low labour requirements. The idea of mass trapping is to place a sufficient number of traps in an olive grove and achieve a satisfactory level of control through reduction of olive fruit fly populations, the number of bait spray applications, and the percentage of live infestation.

Although the level of crop protection in olive groves varied depending on a number of parameters (degree of isolation, density of pest population, fruit load of the trees, irrigation, etc.), the application of mass trapping as a preventative method solves many problems when it is applied early in the summer and for many years. In organic olive groves and especially in regions of high population densities, the use of environmentally friendly and effective compounds in complementary bait sprays is necessary.

Spinosad as GF-120 has a good chance of being granted organic status in EU countries because it is of very low concentration and therefore does not get the N symbol. Spinosad has already been listed as approved for use in organic agriculture in a few jurisdictions by various certifying or listing bodies of several countries such as Australia, Canada, Egypt, New Zealand, Spain, the US and others, and recently got oral approval in Greece.

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Abbreviations

Entomella 50	'E50'
Entomella 75	'E75'
Dacus bait 100	'Db100'
Ammonium sulphate	'As'
Sex pheromone	'Sp'
Daidalos,	'Daida'
Elcofon,	'Elco'
Zervas,	'Zerva'
Agrisense	'Agri'
Ecotrap	'Eco'

DISEASE SUPPRESSION OF POTTING MIXES AMENDED WITH COMPOSTED BIOWASTE

Wim J. Blok (1), Aad J. Termorshuizen (1), Trudie G.C. Coenen (1), Vinnie de Wilde (2) and Adrie H.M. Veeken (2)

(1) Biological Farming Systems Group, Department of Plant Sciences, Wageningen University, Marijkeweg 22, 6709 PG Wageningen, The Netherlands, +31 317 483124, wim.blok@wur.nl
(2) Department of Environmental Technology, Wageningen University, P.O. Box 8129, 6700 EV Wageningen, The Netherlands

Key Words: disease suppression, compost, biowaste, potting mix

Abstract

Peat mining destroys valuable nature areas and contributes to the greenhouse effect. This warrants the search for alternatives for peat in potting mixes. Composted biowaste could provide such an alternative. An additional advantage of (partially) replacing peat by compost is the increased disease suppressiveness. In this study, nine commercial composted biowastes were tested for disease suppressiveness using the pathosystems *Pythium ultimum*-cucumber, *Phytophthora cinnamomi*-lupin and *Rhizoctonia solani*-carrot. Increased disease suppression was found in compost-amended potting mixes for all three pathosystems. The level of disease suppression ranged from slight stimulation of disease to strong suppression. Suppressiveness against one disease was not well correlated with that against the other diseases. The CO_2 production, a measure of general microbial activity, was the parameter most strongly correlated with the level of disease suppression.

Wetsieving the biowaste with tap water over a 4-mm sieve prior to composting yielded a compost with an 2.4-fold increase in organic matter and a twofold decrease in EC and Cl^--concentration of the compost. The latter reductions allow for an increase of the amount of peat that can be replaced by compost. A linear relation was found between the amount of compost added to the potting mix and the level of disease suppression indicating the potential for increasing disease suppressiveness of potting mixes by replacing peat by high-quality composted biowastes.

Introduction

Peat is the most important ingredient in most potting mixes. Peat-based potting mixes are used, also by organic growers, to raise seedlings and to grow various ornamentals and herbs that are sold in pots. High-quality peat is stable, free of plant pathogens and weeds, and combines a high water holding capacity with a high porosity. However, there are also negative aspects associated with the use of peat in potting mixes. Peat is harvested from peat bogs that are valuable nature areas. Harvesting of the peat destroys these areas and also starts the oxidation of the peat thus contributing to the greenhouse effect. Further, peat is a very stable type of organic matter that does not support much microbial activity (Hoitink and Boehm, 1999). As a consequence, disease suppressiveness of peat-based potting mixes is low which can result in considerable losses by soilborne plant diseases.

The drawbacks of the ample use of peat in potting mixes give rise to the wish to replace part or all of the peat by other organic materials. This wish is strongest for organic potting mixes as peat harvesting is often regarded as being in conflict with the sustainability claim of organic production and because effective means to manage soilborne plant pathogens are scarce or lacking in the absence of synthetic fungicides. One candidate material to replace peat is composted biowaste. Biowaste is the collective term used here for different organic waste streams including separately collected organic household waste, green waste and crop residues. In the Netherlands, municipalities are legally obliged to collect organic household waste to prevent that valuable organic matter from being incinerated. Instead, the waste is applied to soils. Some of the composted biowastes have the disadvantage that their composition is rather variable throughout the year and that organic matter levels are low while salt levels are relatively high. The latter limits the percentage of composted biowaste that can replace peat to about 20 volume percent. In this paper we provide information about the disease suppressiveness of compost-amended potting mixes and about a method, first proposed by Veeken *et al.* (2004), to increase the quality of composted biowaste.

Methodology

To study the variation in disease suppressiveness among commercial composted biowastes, a series of 9 composts was collected from different commercial composting facilities in the Netherlands. The composts were tested for diseases suppressiveness in bioassays within 1-2 weeks after delivery and again after an extra maturation period of several months. In the bioassays, disease suppression in non-amended peat mixes was compared to that in peat mixes with 20 vol.-% compost. Bioassays were performed in the greenhouse at 20ºC with three different pathogen-host plant combinations: *Pythium ultimum*-cucumber, *Phytophthora cinnamomi*-lupin and *Rhizoctonia solani*-carrot. These pathogens occur commonly in all kinds of crops, especially in potted plants. For the *P. ultimum* and *P. cinnamomi* bioassays, a randomized complete block design with five replicates was used. Each potting mix was tested at a low and a high infestation level or left uninfested. The low and high infestation levels were obtained by thoroughly mixing 0.03% and 0.3% (for *P. ultimum*) or 0.05% and 0.5% (*for P. cinnamomi*) respectively of soil-meal culture through the potting mixes. Five 500-ml pots were filled for each treatment combination and seven seeds per pot were sown of *cucumber (Cucumis sativus* cv. Chinese Slangen) or lupin (*Lupinus angustifolius* cv. Borsaja) for the *P. ultimum* and *P. cinnamomi* bioassays, respectively. The seeds were externally disinfested for 1 min in 1% sodium hypochlorite followed by thorough rinsing with tap water. Plants were regularly rated for disease symptoms and final evaluations were made after 14 days. To be able to compare levels of disease suppressiveness of composts tested in different bioassays, the disease intensity of the compost-amended potting mixes was related to that of the non-amended control mixture that was included in all bioassays. The percentage of disease suppressiveness (DS) was calculated as:

$DS = \{(DI_{MC0} – DI_{MCi}) / DI_{MC0}\} \times 100\%$

with: DI_{MC0}, disease intensity in the non-amended control mixture, calculated as:

(# healthy plants in the non-infested MC0) - (# healthy plants in the infested MC0)) / (# healthy plants in the non-infested MC0), and

DI_{MCi}, disease intensity in the compost-amended mixture, calculated as:

(# healthy plants in the non-infested MCi) - (# healthy plants in the infested MCi)) / (# healthy plants in the non-infested MCi)

To account for variation in disease intensity among bioassays, data of the infestation level that resulted in DIMC0 values between 0.75-0.95 was used to calculate the percentage of disease suppressiveness. For the R. solani bioassay, five seed trays (35 x 22 x 5.5 cm) per potting mixture were filled. In each tray, two rows of carrots (*Daucus carotus* cv. *Amsterdamse Bak*), with 13 groups of 10-15 plants per row, were sown. The sowing distance was 2.5 cm in the rows and 15 cm between the rows. After emergence of the carrot seedlings, a PDA-plug colonised by *R. solani* was placed against the base of the carrot plants of the first group in each row. The trays were randomly arranged in five blocks (one tray per treatment per block) on greenhouse tables with a plastic tent to ensure high air humidity. After inoculation, the distance (cm) colonised by the pathogen, scored as the distance over which carrot seedlings were attacked, was observed two times a week. The final evaluations were made when the pathogen had reached the last group of carrot seedlings in one of the trays. The percentage disease suppressiveness was calculated as: 100% – 100% x (disease spread in MCi) / (disease spread in MC0).

The composts and the potting mixes were characterised by determining general microbial activity, microbial biomass carbon, pH, EC, dissolved organic carbon and plant nutrients. General microbial activity was assessed by quantifying CO_2-production with an automated system in which a continuous air flow of 65 ml/min was led over 30.0 g fresh wt of compost or potting mix in glass tubes incubated at 20ºC for 24 h. The CO_2-concentration in this air stream was measured by means of a computer-controlled switching device and an infrared CO_2-analyser (ADC 7000, Analytical Development Corporation, Hoddesdon, UK) which allowed hourly measurements. Basal respiration was expressed as µg CO_2/g dw/h and determined in duplicate for all compost and potting mix samples. Microbial biomass in compost and potting mix samples was determined for duplicate samples with the fumigation-extraction procedure as described by Joergensen (1995). Ten gram dry weight equivalent of compost or potting mixture was extracted with 200 ml 0.5M K2SO4 and stored at -20ºC until determination of the organic carbon by ultraviolet persulphate oxidation (Joergensen, 1995).

In an attempt to improve the horticultural quality of composted biowastes we pre-treated four batches of commercial biowastes before composting in a composting reactor. The pre-treatment consisted of washing the biowaste over a 4-mm screen with tap water until the run-through water was clear, to remove mineral particles and salts. The wet-sieved biowastes were composted for 3 weeks under standard conditions to yield stable composts. The disease suppressiveness of the composts was tested in bioassays with *Pythium ultimum* and cucumber, comparing a non-amended control with peat mixes amended with 20, 40 or 60% composted wet-sieved biowaste.

Results and brief discussion

The results of the bioassays with the three pathogens are summarised in Figure 1. Most peat mixes amended with a commercial composted biowaste showed much less disease than the non-amended control mixes, proving that these composts have the potential to provide significant disease suppression. Significant disease suppression was found for all pathogen-host combinations and varied from slight stimulation of disease to strong suppression. However, suppressiveness against one disease did not correlatewell with that against the other diseases. This pathogen specificity was also found by other authors for various types of compost (Lumsden *et al.*, 1983; Hoitink and Boehm, 1999; Ryckeboer, 2001). The effect of an additional maturation period on disease suppressiveness was inconsistent.

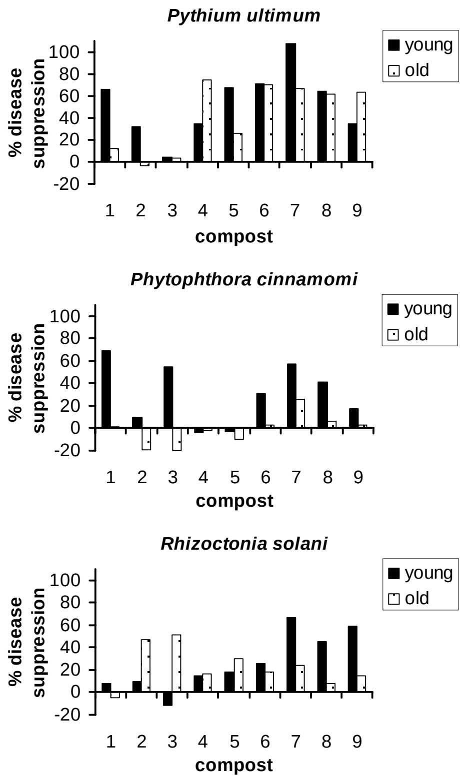

Figure 1. Percentage of disease suppression of nine commercial composted biowastes tested shortly after the end of the composting process (young) and after an additional 4-5-month maturation period (old).

Regression analyses showed that general microbial activity of the potting mix, measured as CO_2 production, was the parameter that significantly ($P< 0.05$) correlated with the level of disease suppression for all three pathogens with R^2 values of 37%, 72% and 53% for *P. ultimum*, *P. cinnamomi* and *R. solani*, respectively.

Pre-treating the biowaste before composting resulted in a 2.4-fold increase in organic matter and a 2-fold decrease in EC and Cl^--concentration of the compost (Table 1). The latter reductions allow for an increase in the amount of peat that can be replaced by compost.

Table 1. Composition of peat and of untreated and wetsieved biowaste before and after composting.

Parameter	Peat	Untreated-biowaste[1]		Wetsieved-biowaste[2]	
		Fresh	Composted	Fresh	Composted
OM (g kg^{-1} dw)	962 ± 18	522 ± 22	348 ± 12	892 ± 32	838 ± 50
pH (-)	3.6 ± 0.1	7.1 ± 0.1	8.3 ± 0.1	4.8 ± 1.1	7.7 ± 0.3
EC (mS cm^{-1})	0.34 ± 0.05	2.2 ± 0.1	3.0 ± 0.1	2.0 ± 0.2	1.6 ± 0.2
K^+ (g kg^{-1} dw)	ND[3]	ND	2.8 ± 0.2	ND	2.2 ± 0.2
Cl^- (g kg^{-1} dw)	ND	ND	22.0 ± 0.2	ND	10.9±0.6
Bulk density (kg m^{-3})	213 ± 16	ND	653 ± 27	ND	385 ± 28

[1]mean and SD for samples of one composting experiment, each determined in duplicate (n=2); [2]mean and SD of samples of four composting experiments, each determined in duplicate (n=8); [3]not determined

The four bioassays with peat mixes amended with 20, 40 or 60% composts consistently showed a linear relation between the amount of compost in the potting mix and the level of disease suppression with the highest composts rates providing a reproducible and almost complete disease control (Figure 2). No signs of phytotoxicity were found even at the highest compost rates, and plant dry weight did not differ significantly among the compost-amended treatments.

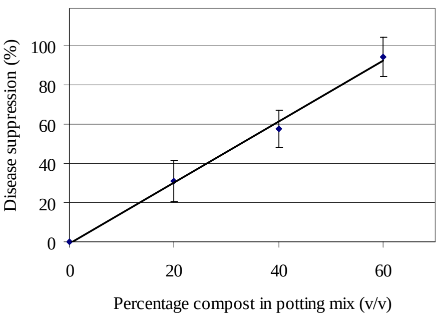

Figure 2. The relationship between the amount of composted biowaste in potting mix and the percentage suppression of Pythium root rot of cucumber. The data points are the mean (± SEM) of four bioassays.

Conclusions

The results of our study indicate that commercial composted biowastes have the potential to provide significant suppression of a number of important plant diseases to potting mixes. The level of disease suppression is, however, variable. If a grower aims to apply compost deliberately as a means of plant disease management he would like to be able to select the most suppressive compost. In this study we found that general microbial activity is a useful indicator of suppressiveness. However, more knowledge of the mechanisms of disease suppression is needed to predict the level of disease suppression more accurately.

The results of wet-sieving the biowaste prior to composting indicates that there are practical ways to improve the horticultural quality and homogeneity throughout the year of composted biowastes. These improved and more standardised composts can be added at higher rates to potting mixes without phytotoxicity problems. At the higher compost rates disease suppression will be higher and more reliable and moreover substantially less peat is to be used.

For a further stimulation of the use of composts in (organic) compost mixes more knowledge is needed about the mechanisms of disease suppression and about suitable and practical indicators for disease suppressiveness. For the organic potting mix industry the development of reliable certification schemes for compost to be used as a peat substitute is needed. Such a certification scheme should pay attention to the horticultural quality of the compost (chemical and physical parameters, including mineralization rate, bulk density and stability), to phytosanitary aspects and to disease suppressiveness.

Acknowledgements

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SLAKED LIME AGAINST EUROPEAN FRUIT TREE CANKER: EFFICACY AND INTRODUCTION INTO PRACTICE

Bart Heijne (1), Peter Frans de Jong (1), Marcel Wenneker (1), Pieter Jans Jansonius (2)

(1) Applied Plant Research, P.O. Box 200, 6670 AE Zetten, the Netherlands, +31488473718, bart.heijne@wur.nl

(2) Louis Bolk Institute, Hoofdstraat 24, 3972 LA Driebergen, the Netherlands, +31343523860 p.jansonius@louisbolk.nl

Key Words: organic, apple, pear, Nectria galligena, calcium hydroxide

Abstract

European fruit tree canker, caused by *Nectria galligena*, is a major disease in organic apple cultivation. No copper can be used in Denmark and the Netherlands to control the disease. Removal of cankers is the only remaining method to control the disease. Slaked lime (calcium hydroxide) was applied at 50 or 100 kg/ha three times during the leaf fall period to protect apple trees against the disease. Experiments under high inoculum pressure showed a reduction in newly formed cankers of 57, 35 and 60 % with respect to untreated for 3 years respectively. The chemical standard thiophanate-methyl further reduced the number of newly formed cankers by 99, 60 and 89 % with respect to untreated for these 3 years respectively in these experiments. These results showed that slaked lime was less efficacious than the chemical standard under these high inoculum pressure circumstances. Demonstration experiments showed an efficacy of 70 and 68 % for slaked lime and 62 and 62 % for the conventional standard (carbendazim and captan) with respect to untreated controls in 2 years respectively. The demonstration experiments, done in commercial orchards and under normal inoculum pressure, showed a similar efficacy as the conventional standard. It is concluded that the use of slaked lime to control European fruit tree canker can contribute to a more economic organic apple and pear production in temperate climate zones.

Introduction

European fruit tree canker, caused by *Nectria galligena*, is a serious problem in organic apple and pear orchards in countries in temperate climate zones. Infection takes place through wounds, e.g. leaf scars (Dubin and English, 1974), and produces cankers in twigs, branches and stems, which ultimately die. An efficacious control method is the application of substantial amounts of copper during leaf fall, which is detrimental to earthworms and negatively interacts with apple scab control. Moreover, the use of copper is no longer permitted in Denmark and the Netherlands. Therefore, the only remaining method is for organic growers to remove infested parts regularly from their orchards and cut wood from cankers on stems. This leads to imbalance in the trees and is not sufficiently efficacious. Lime treatment of apple is an old cultural practice. Different forms of lime have effects on apple scab (Spotts *et al*., 1997; Washington *et al*., 1998). Therefore we tested the more efficacious slaked lime against European fruit tree canker to make European canker controllable for organic growers.

Methodology

Experiments with a randomised block design were conducted at experimental apples orchards in three consecutive years in the Netherlands. Experiments took place at Wilhelminadorp in 1997 and at Lienden in 1998 and 1999, denoted as experiments 1 to 3 (exp. 1 to exp. 3). All cankers present were removed from the experimental field before the experiments started. Parts of branches with cankers were cut from abandoned and heavily infected orchards with cultivars Jonagold, Elstar, and Cox's Orange Pippin and suspended in the plots well before start of the experiments. Branches with heavily sporulating cankers were selected on uniformity in average twig diameter and the number of perithecia of *Nectria*. Per canker 25 to 50 perithecia were present. These parts of branches with one canker each were suspended in the top of trees during leaf fall as an inoculum source. This was done in October each year. Eight, 4 and 4 pieces of branches with cankers were suspended per plot for the experiments 1 to 3 respectively. Trees of the susceptible cultivar Cox's Orange Pippin on M.9 rootstock were planted in a single row system and pruned as slender spindles. Trees were 4, 12 and 13 years old for experiments 1 to 3 respectively. Plots consisted of 4 trees for all experiments. There were 9, 6 and 6 replicates for experiments 1 to 3 respectively. Each block was on a single row and there was always an untreated buffer row between treatment rows.

Applications with products took place during the leaf fall period each year. Treatments were applied at 10 %, 50 % and 90 % leaf fall, three times in total. Thiophanate-methyl, included in the experiment as a conventional standard, was applied only twice at 10 % and 90 %. Leaf fall was established by randomly selecting hundred extension shoots of untreated trees in buffer rows of the experiment. From these shoots the total number of remaining leaves and the number of leaf scars from already fallen leaves were counted. The sprayings were made with a hand held spray gun equipped with a hollow cone nozzles and operated at 8 to 10 bars, thereby applying a spray volume of 1200 l/ha. Treatments and dosages are given in Table 1. Slaked lime was applied as Fruitcal (95 % calcium hydroxide) in the experimental orchards.

Table 1. Treatments and doses for the experiments and demonstration trials.

	dosages				
	experimental orchards			demonstration trials	
	exp. 1	exp. 2	exp. 3	exp. 4	exp. 5
Untreated	-	-	-	-	-
slaked lime (calcium hydroxide)	100 kg/ha	100 kg/ha	50 kg/ha	100 kg/ha	
thiophanate-methyl (Topsin M, 70 %)	1 kg/ha	1 kg/ha	1 kg/ha		
carbendazim (Luxan carbendazim, 500 g/l)				0.5 - 0.6 l/ha	
captan (Luxan captan, 83 %)				2 – 2.5 kg/ha	

Demonstration trials were guided at three commercial orchards during two years, denoted as experiment 4 and 5 (exp. 4 and exp. 5). Applications were made by growers on large parts of their orchards. The minimum size plot was 0.6 ha per treatment. There were no replicates per orchard in the demonstration trials. Two demonstration trials took place in apple orchards with a mixture of cultivars, but consisting mainly of Jonagold and Elstar. The third demonstration trial was in a pear orchard with the main cultivar Conference. Treatments were untreated, slaked lime (as Supercalco, 95 % calcium hydroxide), and a conventional fungicide schedule. The conventional fungicide schedules consisted of one treatment with carbendazim and two to four treatments with captan during the leaf fall period (table 1). Slaked lime was applied three to five times during the leaf fall period. Naturally present cankers served as inoculum at the grower’s orchards.

The numbers of newly formed cankers were counted the following spring at the end of May and the beginning of June when symptoms appeared. All newly formed cankers were counted in all trees per plot in the experiments. Also, all newly formed cankers were counted on 25 randomly chosen trees in the demonstration trials. All data were statistically analysed with Genstat version 5, release 4.1. with analysis of variance. If significant effects were demonstrated, least significant differences were calculated for pairwise comparisons. All data from the demonstration trials were pooled and analysed as if orchards were replicates.

Results and discussion

The average number of newly formed cankers varied per year in untreated fields (figure 1). This reflected the weather conditions during the leaf fall period. Experiments 1, 2 and 4 had more rainy days during leaf fall than year 3 and 5. Rainy days are conducive for infections (Swinburne, 1971). Numbers of newly formed cankers were higher in the experiments (exp. 1 and 2) than in the demonstration trials. This was expected since only naturally present cankers served as inoculum in the demonstration trials, while a high inoculum pressure was created by suspending sporulating cankers in the trees in the experiments. Slaked lime treatments had significantly lower numbers of newly formed cankers than untreated in all experiments and demonstration trials (figure 1). The conventional fungicide treatments provided significantly fewer newly formed cankers than slaked lime in year 1 and 3, but not in year 2 in the experimental orchards.

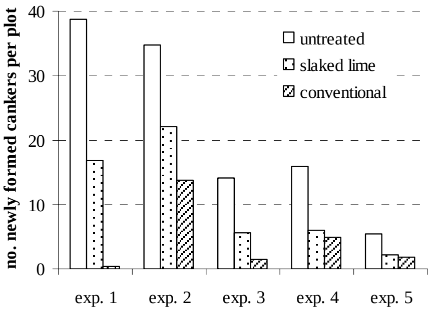

Figure 1. Average number of newly formed cankers per plot in 3 experiments (exp.1 to 3) and 2 demonstration trials (exp. 4 and 5).

On the other hand, the number of newly formed cankers in the slaked lime and the conventional fungicide schedules were not significantly different from each other in the demonstration trials (figure 1). Both schedules were significantly different from untreated plots in the demonstration trials.

The efficacy of slaked lime against European fruit tree canker varied between 37 to 60 % with respect to untreated in the experimental orchards under high infection pressure (Table 2). The efficacy was even better, up to nearly 70 %, in the demonstration trials at commercial orchards. The latter might be explained by the moderate infection pressure in the demonstration trials. Also, the number of applications of slaked lime was higher, up to five times, in the demonstration trials than in the experimental orchards. The conventional fungicide thiophanate-methyl had significant better efficacy than slaked lime in the experimental orchards. However, slaked lime was as effective as the conventional fungicide schedule in the demonstration trials.

Table 2. Percentage efficacy of treatments with respect to untreated. Different letters after data in the same column indicate significant differences at $P \leq 0.05$.

	experimental orchards				demonstration trials	
	year 1	year 2	year 3		year 4	year 5
slaked lime	56.6 a	36.8 a	59.9 a		69.8 a	68.2 a
thiophanate-methyl	99.2 b	60.3 b	89.4 b			
fungicide schedule					62.3 a	61.8 a

No comparison was made between copper and slaked lime in our experiments. Several comparisons have been made in the past between benzimidazole fungicides, such as thiophanate-methyl and carbendazim, and copper compounds (e.g. Bennett and Swait, 1977). Benzimidazole fungicides were always better than or as effective as copper compounds. Keeping this in mind and the results of our experiment, it might be expected that slaked lime is more or less equally effective as copper treatments during leaf fall.

Liming with calcium carbonate is a common measure in organic culture. It is believed that the calcium ions play a role in the physiology of fruit trees which, among other effects, improves natural resistance to diseases (Vogel, 2000). Another effect of lime is the decrease of acidity. It is known that high pH values reduce the germination of fungal spores (e.g. Pung *et al*., 1995). It was expected that slaked lime might be more efficacious than normal lime since it generates a higher pH value. This might be the explanation for the good efficacy of slaked lime against European fruit tree canker in these experiments.

Other cultural practices, such as drainage of soils (Swinburne, 1975), can be combined with the application of slaked lime and will further reduce damage by this serious disease. Slaked lime can also be applied through overhead sprinkler systems, which makes application under critical wet autumn circumstances feasible without damaging the soil structure in the interrows.

The Dutch government submitted our data to support placing slaked lime on Annex II of the European Union harmonisation of pesticides for release in organic fruit growing. By uptake of carbon dioxide, slaked lime becomes ordinary lime. No harmful effects of the slaked lime applications were observed during our experiments or in commercial orchards. A general principle of organic culture, however, is cycling of materials. To apply several slaked lime treatments would add new material from outside to the organic orchard. This is also done with the application of sulphur to control apple scab, although in lower quantities, and even more so by fertilising or liming soils, where tons of materials are introduced in the organic system. The latter two examples are in line with the IFOAM guidelines appendices 1 and 4. It is noted that a grower can produce his own slaked lime by burning limestone. It is expected that slaked lime will be released for use in organic culture but it is still being debated at this moment.

Conclusions

It is concluded that slaked lime had a substantial effect in reducing the number of newly formed cankers in organic apple and pear orchards. The experiments showed that slaked lime can contribute to prevent European fruit tree canker. This is a step forward in the control of European fruit tree canker and contributes to more economic organic apple and pear production in temperate climate zones.

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IDENTIFICATION OF MEASURES FOR PREVENTION OF BLACK SPOTS IN ORGANICALLY PRODUCED STORED CARROTS

Jürgen Köhl (1), Pieter Kastelein (1), Janneke Elderson (1), Wim J. Blok (2)

(1) Plant Research International, P.O. Box 16, 6700 AA Wageningen, The Netherlands, +31 317 476017, jurgen.kohl@wur.nl, www.plant.wur.nl

(2) Biological Farming Systems Group, Department of Plant Sciences, Wageningen University, Marijkeweg 22, 6709 PG Wageningen, The Netherlands, +31 317 483124, wim.blok@wur.nl

Key Words: Organic farming, carrots, black spots, Alternaria radicina, Rhexocercosporidium carotae

Abstract

In the Netherlands winter carrot for the fresh market is a cash crop for many organic growers of field vegetables. In the last few years blackish spots have been observed during storage of carrot roots. An inventory was carried out in 2001/2002 and 2002/2003 including in total 42 carrot lots from 22 growers. Statistical analysis was performed by multiple regression analysis to identify factors and variables that best explained the occurrence of black spots on stored carrots.

Rhexocercosporidium carotae was the dominating pathogen in black spots of carrots harvested in 2001. From carrots harvested in 2002, *Alternaria radicina* was isolated most frequently, followed by *A. dauci* and *R. carotae*. Multiple regression analysis indicated that the occurrence of *R. carotae* was associated with wild umbelliferous plants or carrot production during the previous year in the neighbourhood of the investigated carrot fields. A high occurrence of the symptoms of black spots was associated with increasing damage caused during harvest or with higher temperatures during harvest.

Introduction/Problem

For many organic arable farms in the Netherlands, carrot for the fresh market is an important cash crop. Especially when mature carrot roots are harvested before winter and held in refrigerated storage for several months, returns are profitable. However, in the last few years superficial dark brown or black spots have developed during storage of roots from carrot crops grown on clay soils. When 5% or more of the roots are affected, the whole lot is rejected for the fresh market. Due to this post-harvest blemish, several farmers are faced with serious financial setbacks, and methods to manage the blemish are needed.

In organic farming systems the possibilities to control diseases are limited. Application of cultivation measures interfering with disease cycles may be acceptable. However, current knowledge of the pathogen(s) causing the black spots and the effect of agronomic practices on their occurrence is lacking. To gain an insight into the blemish, black lesions on cold stored carrot roots were screened for fungi known to cause root spotting, and information on cropping patterns, crop husbandry, and harvesting conditions was analysed for relationships with disease occurrence.

Methodology

An inventory was carried out in 2001/2002 and 2002/2003 including in total 42 carrot lots from 22 organic growers. The farms were located on clay soils in the southwest, the centre and the north of the Netherlands. All crops were grown to yield roots of 50 – 250 g for long-term storage. Most crops were grown between mid-May and mid-October. The crops were grown on average 150 and 135 days in 2001 and 2002, respectively. Both growing seasons were warmer and wetter than normal.

Information on acreage, soil conditions and previous history of the parcel, tillage, sowing, crop husbandry (manuring, irrigation, weed and pest management) and harvesting conditions was obtained by means of questionnaires. Seeds were assessed for pathogen contamination according to rules of the International Seed Testing Association (ISTA). Two weeks before the planned harvest date of a crop the percentage of foliar necrosis was assessed and the crop was surveyed for occurrence of foliar diseases. On that occasion the adjoining plots were examined for the presence of umbelliferous crops and field margins were searched for umbelliferous plants. On the harvest day, a 100-root subsample was taken from the storage boxes to assess the pre-storage sanitary conditions, dirt tare, topping efficiency, crop damage (abrasions and other injuries) and contents of calcium, magnesium, potassium and sodium in the roots. Additionally, a sample of the topsoil was taken to determine the water content, and the harvest weather was described. Another subsample of 100 to 200 roots was taken on the harvest day; the roots were crated unwashed and the crates were wrapped in perforated plastic foil and stored within 48 h after harvesting in a cold room at 1 to 5 °C and 95% RH for 4 to 5 months. After storage, samples were washed and visually inspected for pests and diseases, which were identified by the appearance of lesions or damage. For each pest or disease the number of affected roots was recorded. Pieces of skin showing a superficial dark brown to blackish lesion were excised from the washed carrot roots and incubated at 15 °C in humid chambers for two weeks under NUV-illumination with a daily photoperiod of 12 h. Incubated lesions were examined with a stereomicroscope for presence of conidia or chlamydospores of fungi known to cause root spotting (Snowdon, 1991). Statistical analysis was performed by multiple regression analysis (Genstat 6.1; Nummeric Algorithmus Group. Inc., Oxford) to identify such factors (out of 14 factors investigated) and variables (out of 21 variables investigated) that best explained the occurrence of black spots or certain pathogens on stored carrots.

Results and brief discussion

In 2001 no black spots were found on carrots at harvest, whereas in 2002 black spots were already found in 26% of the lots at harvest. Such lesions were mainly caused by *Alternaria radicina* or *Chalaropsis* spp. After storage, all lots harvested in 2001 showed black spots. On average, 2 to 21% of the carrots of the different lots were diseased. Eighty-three percent of the lots harvested in 2002 showed black spots, but only 1 to 10% of the carrots of individual plots were diseased. *Rhexocercosporidium carotae* (syn. *Acrothecium carotae*; Årsvoll 1965) was the dominating pathogen in black spots of carrots harvested in 2001 (Table 1). From carrots harvested in 2002, *Alternaria radicina* was isolated most frequently, followed by *A. dauci* and *R. carotae*. *Mycocentrospora acerina* and *Chalaropsis thielavioides* were found only occasionally. Attempts were made to distinguish among several types of black spots according to size, shape or colour. No relationships were found between lesion type and pathogen species isolated from such lesions.

The occurrence of *R. carotae* in a huge number of organically produced carrot lots was unexpected. Damage of stored carrots caused by *R. carotae* was found occasionally by Årsvoll (1965; 1971) in Norway, Edwaldz (1997) in Sweden and more recently by Shoemaker (2002) in Canada. The broad occurrence of *R. carotae* has not previously been reported for The Netherlands.

Table 1. Occurrence of pathogens in black spots on cold stored carrot roots and their distribution among the samples collected in 2001 and 2002.

Root spotting pathogen	Percentage lesions with pathogen		Percentage samples with pathogen	
	2001	2002	2001	2002
Alternaria dauci	6	14	47	13
Alternaria radicina	8	23	26	35
Chalaropsis thielavioides	1	5	5	4
Mycocentrospora acerina	1	0	11	0
Rhexocercosporidium carotae	50	11	74	22
Sterile or other fungi	34	47	16	39

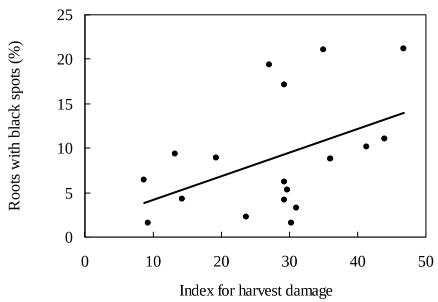

Figure 1. Relationship between mechanical damage during harvest and occurrence of black spots. Carrot roots harvested in 2001. $R^2_{adj.}$ = 40%.

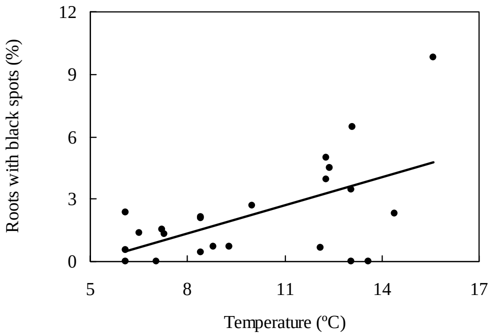

Figure 2. Relationship between aerial temperature during harvest and occurrence of black spots. Carrot roots harvested in 2002. $R^2_{adj.}$ = 29%

Differences in level of symptom development on carrots after harvest were observed in the two seasons. This is in line with observations of Dutch growers who experienced such variable levels of damage in stored carrots in recent years. Also, the occurrence of the different pathogens causing black rot varied considerably between the two years. It is not known under what circumstances certain pathogens are favoured and which factors cause an increase of damage in storage.

In collaboration with growers, factors and variables were identified that may affect the occurrence of black spots or stimulate certain pathogens. Although the number of variables and factors considered was high with respect to the low number of carrots lots that could be evaluated, multiple regression analysis helped to indicate several issues that partly explained the occurrence of black spots or *R. carotae.*

A high occurrence of symptoms of black spots was associated with increasing damage caused during harvest (2001; Fig. 1) or with higher ambient temperatures during harvest (2002; Fig. 2). Both variables indicate that harvest conditions and handling of the produce during and shortly after harvest may have an impact on the occurrence of black spots. This implies that further experimental research primarily should focus on the effect of harvest conditions on the susceptibility of carrots for infection, on wound healing processes, and the presence and development of pathogens under the prevailing harvest conditions.

The occurrence of *R. carotae* in black spots was associated with wild umbelliferous plants (2001; Fig. 3) or carrot production during the previous season (2002; Fig. 4) in the neighbourhood of the investigated carrot fields. Both factors indicate that infected umbelliferous plants or their remains may be a source of inoculum that is carried by wind or otherwise to susceptible carrot crops. A systematic inventory of the presence of the pathogen on wild and cultivated umbelliferous plants is needed to verify this hypothesis.

Conclusions

An inventory was carried out on organically managed farms to identify factors or variables that may affect the occurrence of a major disease complex in stored carrots. Our research helped to define hypotheses for further experimental work. This work will aim at the development of preventive measures during and shortly after harvest to reduce the risk of post-harvest losses in organic carrot production.

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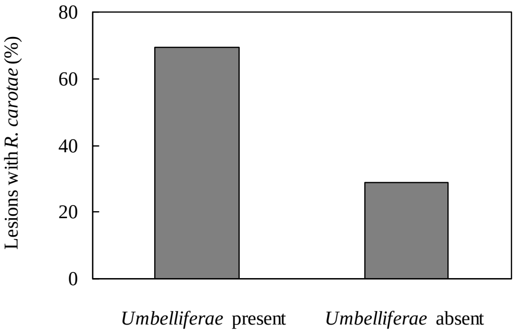

Figure 3. Occurrence of *Rhexocerco-sporidium carotae* in carrot lots from parcels with edges in which umbelliferous weeds are present or absent. Carrot roots harvested in 2001.

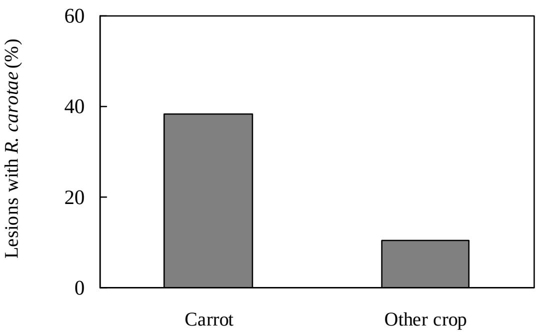

Figure 4. Occurrence of *Rhexocerco-sporidium carotae* in carrot lots from parcels bordering a parcel on which carrot or another crop was grown during the previous season. Carrot roots harvested in 2002.

IMPLEMENTATION OF BIOHERBICIDES AND SEED TREATMENT IN ORGANIC FARMING

Stefan Kühne (1), Arnd Verschwele (2), Dieter v. Hörsten (3), Marga Jahn (1)

(1) Biological Research Centre, Stahnsdorfer Damm 81, 14532 Kleinmachnow, Germany, s.kuehne@bba.de, m.jahn@bba.de, (2) Biological Research Centre, Messeweg 11/12, 38104 Braunschweig, a.verschwele@bba.de, (3) University Göttingen, Gutenbergstr. 33, 37075 Göttingen, dhoerst@gwdg.de

Key Words: Organic Farming, plant protection, bioherbicides, seed treatment methods

Abstract

The paper gives an overview over the prospects and risks of the application of bioherbicides in Organic Farming and wants to support the general acceptance by the EEC Council Regulation on Organic Production of Agricultural Products. Another problem of current importance is the maintenance of seed health. Several methods of seed treatments and their practical use are described (hot water, hot air, microwave steam, radio-frequency**,** low energy electrons, micro-organisms and natural substances).

Introduction

In Germany, the marked expansion of Organic Farming has far-reaching implications for crop production. Even when proper prophylactic plant protection measures are taken, mass reproduction of weeds and pests can occur, resulting in losses of yield quantity and quality. The implementation of direct weed and pest control measures has therefore become an important and indispensable component of plant protection management. Within this process, the search for new, environmentally friendly natural substances suitable for use as active ingredients in pesticides must be pursued intensively. In Europe, there are still many “ideological barriers” to overcome. The use of bioherbicides should be considered as they provide a means of cost-effective weed control in harmony with nature. Seed health is another problematic area where new, modern and environmentally-friendly treatment methods exist but still cannot be implemented in Organic Farming due to ideological restrictions.

Results and brief discussion

Utilization of Bioherbicides

Unlike the EEC Council Regulation on Organic Production of Agricultural Products, the use of certain weed control products is allowed in the IFOAM Guidelines (International Federation on Organic Agricultural Movements). In the USA, the Organic Materials Review Institute (OMRI 2004) includes the following products in its list of approved herbicides: AllDown (citric acid, acetic acid), BioWeed (corn gluten meal), and Xpress (thyme oil, clove oil). In Canada, organic farmers are also allowed to use these herbicides under certain conditions. In New Zealand and Australia, “Organic Interceptor” (pine oil) is approved for use in Organic Farming (Bio Gro New Zealand 2005, Australian Certified Organics 2003), and natural vinegar (acetic acid) is blanket-approved in Japan (Japanese Ministry of Agriculture, Forestry and Fisheries 2003). Although export products from these countries are usually subject to stricter production requirements when intended for import into the European Union, these differences in the regulatory framework can lead to an undesirable distortion of competition.

Natural Substances with Herbicidal Activity

A great number of relatively harmless natural substances with herbicidal activity can be considered for use in ecological agriculture (Verschwele 2004). This includes the aforementioned bioherbicides acetic acid, thyme oil, clove oil, wheat gluten and pine oil as well as other compounds like EDTA, urea, pelargonic acid and citronella oil, which have been authorized for certain indications in some countries. In Germany, for example, acetic acid (e.g., Filacid, TEM 123) is authorized for weed control in lawns or fruit plants in home gardens and gardening plots. Pelargonic acid (Finalsan) is also used here in similar indications. In Great Britain, citronella oil (Barrier H), another simple plant extract, is approved for control of common groundsel (Senecio vulgaris). Corn gluten, to name another example, is a by-product of corn milling. In the USA, it is supplied in powder form and is used to control weeds in parks and tree nurseries.

Compared to conventional herbicides, these natural substances have a better environmental profile but frequently lack high levels of efficacy and selectivity. In controlled studies on the management of wild oats and other grass weeds, Young (2004) determined the efficiency of acetic acid and pine oil to be 31 % to 89 %; thus, the natural herbicides were much weaker and more unreliable than the reference product, glyphosate, and they required multiple applications. Tworkoski (2002), on the other hand, found that essential oils from clove, cinnamon and other aromatic plants achieved complete weed shoot control in certain weed species within up to 24 hours. Wiecko (2003) demonstrated that even sea water with natural salinity levels had highly phytotoxic effects on certain salt-sensitive weed species, such as large crabgrass (*Digitaria sanguinalis*).

Allelopathic strategies will also be increasingly used in direct pest-control in the future. It has long been known that rye, oats and sunflower have allelopathic effects, i.e., that they excrete chemicals that impair the germination, growth, and development of other plants. It is possible to exploit the herbicidal effects of allelopathic plants by selectively implementing them in the framework of crop rotation or selective mulch management. However, it is more effective to apply the allelopathic substances extracted from these plants. Artemisinin, a phenolic compound derived from annual wormwood (*Artemisia annua*), has a high herbicidal potential. Many allelopathic compounds inhibit photosynthesis and resemble the conventional synthetic herbicides in regard to their structure and mechanism of action (Singh et al. 2003). Large-scale production of artemisinin has already started but, outside of experimental applications, the amount of this and other allelopathic chemicals actually used in practice is still insignificant.

Mycoherbicides are another type of natural bioherbicide consisting of microorganisms, especially fungal pathogens. Because of the frequent formulation, storage and efficacy problems with these products, only a few mycoherbicides have been put on the market to date. These include Camperico, which is used to control weeds in lawns in Japan and the USA, and Collego, which is used in rice and soybeans in the USA. Mycoherbicides are also subject to additional requirements (e.g., high host specificity) to ensure that their use is organically acceptable (Rosskopf & Koenig 2003).

Potentials and Risks of Bioherbicides

Similar to fungicides and insecticides, bioherbicide use can be regulated and restricted so as to ensure compliance with the principles of good organic farming practice. It is, for example, possible to have all herbicide treatments subject to approval by the responsible control authority, who would approve such treatments only if crops were severely endangered. Potential environmental risks could be significantly reduced by selectively treating only isolated field sections or individual plants, e.g., Canada thistle (*Cirsium arvense*) or dock species (*Rumex* spp.). Bioherbicides could at least partially dispense with the usual practice of manual weed control, thereby reducing manpower and cost requirements. This would allow organic farming businesses to increase their efficiency and, thus, to better adapt to the changing economic conditions.

Seed Treatment Strategies

Seed health is another problem in Organic Farming. Because the use of non-organically grown seed has been sharply restricted since the beginning of 2004, the risk of diseases caused by seed-borne pathogens has risen accordingly. The smuts, especially common bunt (*Tilletia caries*), are the main disease-causing organisms in grain, but germination and emergence-inhibiting pathogens like *Fusarium* ssp. and *Septoria nodorum* can also play a major role in wheat. Seed-borne diseases also have a significant impact on vegetable and sugar beet growing, and must be treated as needed. The range of available alternative seed treatment methods is described below.

Thermal Seed Treatment Methods

The basic principle of thermotherapy (Baker 1962) is the application of heat, usually in conjunction with moisture, to kill harmful pathogens on the surface and interior of a seed without impairing the functional capacity of the seed. Because of its higher thermal capacity and better heat transmission properties, water is a much better medium for thermal seed treatment than air. The optimum treatment effect is achieved when the selected temperatures and treatment times induce a maximum reduction of infestation without relevant impairment of germination capacity and shoot growth.

Various thermal seed treatment techniques are used. In **hot water treatment**, the “classical” method, the often pre-soaked seeds are treated at temperatures of 50°C to 55°C for 10 to 120 minutes, depending on the specific seed type. The optimal treatment range for the main vegetable species was determined to be 50°C to 53°C for 10 to 30 minutes (Nega *et al.* 2003). Because of the high energy costs, especially those required for subsequent drying, attempts are being made to replace hot water treatment with more efficient methods, such as **hot air treatment**. In the last decade, a humid hot air seed treatment system in which the variables treatment temperature, treatment time and relative humidity are controlled by sensors and computer technology has been developed and is now ready to be put on the market. This method dispenses with the need to dry the seed after treatment (Forsberg *et al.* 2002). It is currently being tested in vegetable seed (Jahn *et al.* 2005).

Microwave steam treatment is another thermotherapy technique in which steam is used to keep the seed stock from drying out without actually wetting the seed. Microwave irradiation makes it possible to completely kill seed-borne pathogens at temperatures of around 67°C to 75°C within very short treatment times of 3 to 10 minutes. **Radio-frequency treatment**, which is based on the same principle, uses different irradiation wave lengths that penetrate to greater seed layer depths. This makes it possible to heat thicker seed layers of up to several decimeters at a time, which is a considerable technical advantage. Radio-frequency treatment makes it possible to completely kill fungal pathogens while preserving the germination capacity of the seeds using temperatures of 65°C to 70°C within treatment times of less than 10 minutes (von Hörsten 1995, Cwiklinski 2001). An advantage of all the thermal seed treatment techniques is that they kill pathogens both on and in the seeds.

Electron Seed Treatment

Electron seed treatment is an innovative technique that selectively exploits the biocidal effect of low-energy electrons. Although ready-to-use solutions for seed treatment with low energy electrons are available, and although these systems have successfully demonstrated good control of seed-borne diseases in grain (Tigges *et al.* 2002), this technique has yet not become established in Organic Farming. This is mainly due to reservations against radiation, which could potentially alter the genetic material of the seeds. However, it is possible to avoid embryonic damage using proper dosage and species-specific dose adjustment.

Microorganisms Used for Seed Treatment

The possibilities for utilizing microorganisms for biological seed treatment are still limited. Different biological seed treatment products are being tested throughout the world. Cedomon (*Pseudomonas chlororaphis*, strain MA 342), a biological seed dressing that was developed in Sweden for treatment of grain seed, is ready for marketing (Hoekeberg *et al.* 1997) and has already been marketed successfully in some countries. *Pseudomonas fluorescens* and *Bacillus subtilis*-based products, which can be used, for example, to treat *Rhizoctonia solani* in potato seed stock (Steiner *et al.* 1999), are also important for field agriculture.

Natural Substances Used for Seed Treatment

In Germany, the increasing frequency of common bunt (*Tilletia caries*), in particular, since the 1990s has resulted in the development of seed treatment agents based on natural substances. Certain plant extracts, e.g. from garlic, horseradish and mustard plants (Spiess & Dutschke 1991), and natural products like skim milk powder and wheat flour (Becker & Weltzien 1993) achieve good levels of efficacy when used to control common bunt. A yellow-mustard powder product (Tillecur) available for use in Organic Farming has also shown excellent efficacy in the treatment of this disease, even in cases where infestation was severe (Waldow & Jahn 2005).

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PREDICTION OF GRAIN YIELD OF SPRING BARLEY VARIETIES BY DISEASE AND GROWTH CHARACTERISTICS FROM VCU TESTING

Hanne Østergård (1), Kristian Kristensen (2), Jakob W. Jensen (3)

(1) Risø National Laboratory, P.O. Box 49, 4000-Roskilde, Denmark, +4546774111, hanne.oestergaard@risoe.dk, www.risoe.dk

(2) Department of Genetics and Biotechnology, Danish Institute of Agricultural Sciences, Post Box 50, DK-8830 Tjele, Denmark, kristian.kristensen@agrsci.dk, www.agrsci.dk

(3) Department of Variety Testing, Danish Institute of Agricultural Sciences, Post Box 7, DK-4230 Skælskør, Denmark, Jakob.Willas@agrsci.dk, www.agrsci.dk

Key Words: organic varieties, organic and conventional growing systems, grain yield, disease and growth characteristics, spring barley, genotype-environment interactions, organic and conventional variety testing

Abstract

Fifty spring barley varieties grown under organic as well as conventional growing conditions in experimental fields in four combinations of year and site were studied. The yield varied greatly within and between environments (years and sites) and systems. Furthermore, the variation among varieties was substantial and differed among different environments and systems. Associations between observed grain yield of these varieties and disease and growth characteristics assessed in the official conventional variety testing were compared between the organic and the conventional system. Using factorial regression analysis, the best model was found for predicting the observed grain yield each year from these characteristics in the previous year. In this model, the residual variance component for varieties was lower for observations from the conventional growing system than from the organic growing system, implying that the VCU-characteristics better predicted the results from conventional growing system. The implications for organic variety testing are discussed.

Introduction/Problem

Modern spring barley varieties have been developed with the aim of combining high productivity and standardised product quality under high-input conditions. The organic growing system is a system where pesticides and inorganic fertilizers are generally not allowed. Hence, biotic and abiotic stresses have to be controlled by growing appropriate varieties and by good farm management practices. An important question is whether modern spring barley varieties possess the right combinations of traits to ensure a stable and acceptable yield of good quality when grown under different organic growing conditions. We know that varieties often perform and yield differently in different environments due to genotype-environment interactions, so it may be important to evaluate characteristics of varieties in organic as well as in conventional farming systems. However, it remains unclear to date whether the differences between conventional and organic growing systems are large enough to justify testing of varieties in both environments.

In many countries, varieties are officially evaluated on a number of traits for Values of Cultivation and Use (VCU-testing). This evaluation takes place under conventional conditions and the traits selected are those of relevance for conventional farming. However, in a few countries (e.g. The Netherlands and Austria) testing is also performed under organic conditions. In this case, characteristics of special relevance under organic growing conditions are included. Here we investigate how well disease and growth characteristics from conventional VCU-testing may predict grain yield for a large number of varieties grown under specific organic as well as conventional growing conditions without fungicides.

Methodology

Field trials were conducted on experimental research fields at two Danish locations (Flakkebjerg and Foulum) in two years (2002, 2003) in two types of growing systems resembling either organic or conventional (without use of fungicides) conditions chosen to be optimal for each site and year. As a consequence, the two types of system differed mainly in type and amount of nutrients available and in the way of controlling weeds. The four combinations of years and sites are denoted ‘environments’. More than 100 varieties with different expectations for performance in organic systems were included in the trials, representing current varieties and new varieties becoming available, as well as varieties from other sources regarded as potential ‘organic’ candidates.

Varietal characteristics of 50 of these varieties were obtained from official conventional VCU-testing for each of the two years 2001 and 2002. These consist of 1) disease severity assessment for each variety for each of four prevalent diseases (barley powdery mildew, barley leaf rust, scald, and net blotch) observed in trials without fungicide treatment; and 2) other growth characteristics assessed in trials with fungicide treatment: culm length, tendency to lodging, tendency to breakage of straw and ear, and date of ripening (Anonymous 2001,2002). In addition, a combined measure for the years 2002-2004 for competitive ability of each variety against weeds (Hansen 2002) calculated from information on canopy height and Leaf Area Index from herbicide-treated trials was included as a competition index. This index has been part of the VCU-testing since 2002.

Variation in grain yield for the 50 varieties in the four enviroments and two types of systems was analysed by analysis of variance, including main effects as well as interactions among the independent variables: varieties, type of system and environment (year x site).

Associations between grain yield and varietal characteristics were analysed by means of slightly modified factorial regression analysis (Denis, 1988). In the analyses shown here each regression coefficient was described as a sum of one or more components, a general one, three specific for the environment (separated into year, site and interaction) and the one specific for the growing system. At first, the parameters of the model were calculated with all varietal characteristics included.

$$Y_{ijk\ln} = \mu_{jkl} + \sum_m (\alpha_m + \beta_{jm} + \gamma_{km} + \delta_{jkm} + \eta_{lm}) x_{ij'm} + V_{il} + U_{ijk1} + E_{ijk\ln}$$

Y_{ijkl} = observed yield measurement for variety i, in year j, location k, system l, and replicate n

$x_{ij'm}$ = registered $m'th$ characteristic (or its squared value) from VCU-testing for variety i in year $j' = j-1$.

For $m =$ 'weed competitive index' values for the two years are identical

Squared terms were only included for 'barley powdery mildew' and 'competition index'

For disease characteristics the 3rd root of the registered characteristics were used

μ_{jkl} = mean yield in year j, location k and system l

$\alpha_m + \beta_{jm} + \gamma_{km} + \delta_{jkm} + \eta_{lm}$

= regression coefficient for the association between yield and $m'th$ characteristic

V_{il} and U_{ijkl} are a random effect of residual variety effect and residual interaction effect which is assumed normal distributed with mean 0 and variance, σ^2_{Vl} and σ^2_{El}, respectively.

$E_{ijk\ln}$ is the error associated with the experimental design which is assumed normal distributed with mean 0 and variance σ^2_E

The model was reduced step by step by leaving out the least significant term until all remaining terms were significant at the 5% level of significance. In the reduction steps some restrictions were imposed to ensure that higher order terms were removed before lower order terms could be considered as candidates for removal. Terms including interactions were assumed to be of higher order than their components, and square terms were considered to be of higher order than linear terms.

Results and brief discussion

The observed grain yield varied between the environments and systems with the highest yield in the conventional system at Flakkebjerg in 2003 and the lowest yield in the organic system at Flakkebjerg in 2002 (Table 1). In both years, the site Flakkebjerg was superior in the conventional system.

Table 1. Mean grain yield (hkg/ha) for 50 varieties according to system and environment

	2002		2003	
	Foulum	Flakkebjerg	Foulum	Flakkebjerg
Conventional	51.7	55.9	54.2	63.2
Organic	55.7	50.9	53.8	53.8

The analysis of variance showed a very significant effect for all main effects and interactions except for year*site*system (Table 2). The largest contribution to variation in yield measured by mean squares was due to the interaction between site and system. The largest interaction between varieties and any of the other factors was between varieties and sites; a somewhat smaller value was found between varieties and years and an even smaller one between varieties and systems.

Table 2. Analysis of variance for observed grain yield in different growing systems and environments

Source	DF	Mean Square	F Value	Pr >F
year	1	731.58	196.50	0.0000
system	1	722.82	194.15	0.0000
site	1	438.80	117.86	0.0000
site*system	1	2002.33	537.81	0.0000
year*site	1	577.28	155.04	0.0000
year*system	1	479.97	128.92	0.0000
year*site*system	1	0.06	0.02	0.8783
variety	49	108.80	29.22	0.0000
variety*site	49	12.10	3.24	0.0000
variety*year	49	11.07	2.98	0.0000
variety*system	49	10.20	2.75	0.0000
variety*year*system	49	9.94	2.68	0.0000
variety*site*system	49	8.88	2.39	0.0000
variety*year*site	49	7.46	2.00	0.0001
variety*year*site*system	49	8.74	2.35	0.0000

Factorial regression analysis showed that many VCU varietal characteristics (all disease assessments, ripening date, and competition index) had a significant effect on prediction of grain yield the following year (Table 3). For powdery mildew and net blotch, the regression coefficients were significantly different between sites and years, respectively; none of the coefficients was significantly different between growing systems. The latter implied that the best linear combination of VCU-characteristics to predict grain yield production were identical in the two systems.

Table 3. Significant parameter values in the factorial regression

	General effects		Changes in linear effect for environment			
	Linear	Quadratic	2002	2003	Flakkebjerg	Foulum
Powdery mildew	3.53	-3.49			0.59	-0.59
Leaf rust	-3.52					
Net blotch	-6.54		1.27	-1.27		
Scald	1.62					
Date of ripening	-1.14					
Competition index	5.64	-0.028				

When this best regression model was used for predicting yield, the residual variance component for varieties was lower for observations from the conventional compared with the organic growing system (Table 4). Thus, the characteristics observed in the official conventional VCU-testing, including the competitive index, better predicted the grain yield of varieties within the conventional growing system. In conclusion, a variation of 2.5 hkg/ha (organic) compared to 2.1 hkg/ha (conventional) was not accounted for in the prediction of variety yield. The interaction between varieties and environments was, on the other hand, better described by the VCU-data for the organic than for the conventional system. This may be because the prediction of difference in yield between two varieties in one environment compared to another environment was better in the organic system.

Table 4. Variance components for variation among varieties and for interaction between varieties and environments when variety characteristics are used to describe grain yield

	Variance component	
	Variety	Variety×environment
Conventional system	4.45	6.39
Organic system	6.19	4.63

The results depend on the varieties and systems chosen. A broad spectrum of varieties was included; however, most of the varieties were conventional varieties bred for high-input conditions. Further, the systems considered may differ from each other by less than actual conventional high-input farms compared with certified organic farms. Therefore, even bigger differences may be found between the explanatory value of VCU-test characteristics for conventional and organic systems.

Conclusions

Many conventional VCU-testing varietal characteristics had a significant influence on grain yield; this influence was for most characteristics not significantly different for the different environments and was not significantly different for the two systems. However, the traits used for official variety testing that were shown to have a significant influence on the prediction of yield the following year described the observed grain yield better in the conventional system considered than in the organic system. This indicates that a traditional VCU-testing supplemented with the competition index as defined by Hansen (2002) is not fully sufficient to predict variety yield when varieties are grown under organic farming conditions. Other characteristics of special importance for organic farming may be included in the conventional variety testing, e.g., nutrient uptake efficiency. However, the final decision for implementation of independent organic VCU-testing is based on an evaluation of the economic costs and benefits, including assessment of quality traits. The possible establishment of organic VCU-testing in Denmark starting in 2006 will be decided partly based on these trials.

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VEGETABLE PRODUCTION

EFFECT OF ORGANIC FERTILIZERS ON REGENERATION OF BIODIVERSITY AFTER SOIL STEAMING IN ORGANIC GLASSHOUSES

Cuijpers, W.J.M. (1), F. Smeding (1), J. Amsing (2), J. Postma (3) and C.J. Koopmans (1)

(1) Louis Bolk Institute, Hoofdstraat 24, 3972 LA Driebergen, The Netherlands, Tel. +31-343-523860, E-mail: w.cuijpers@louisbolk.nl, Internet: www.louisbolk.nl
(2) Applied Plant Research, Kruisbroekweg 5, 2650 AA Naaldwijk, The Netherlands
(3) Plant Research International, Droevendaalsesteeg 1, 6708 PB Wageningen, The Netherlands

Key Words: Organic farming, greenhouse horticulture, soil biodiversity, microbial biomass, yard waste compost (YWC), spent mushroom compost (SMC), goat manure (GM)

Abstract

Four months after application of sheet steaming to the soil in an organic greenhouse, the treatment had still a significant effect on the diversity of the soil microflora (bacterial and fungal populations). Also four months after steaming, two fertilizer types differed significantly in their effect on microbial composition. Goat manure had a positive effect on bacterial diversity, while spent mushroom compost had a stimulating effect on fungal diversity.

Introduction

As cultivation in heated glasshouses becomes more intensive, crop rotation schedules are narrowed down and comprise mainly crops like tomato, sweet pepper and cucumber. The BIOKAS project is set up as a participatory research project together with 11 organic growers with the aim of optimizing production strategies. Sheet steaming is used as an emergency measure to control soil-borne pathogens, especially nematodes. As other measures prove insufficient, soil steaming has gained popularity, but with varying results. The application of soil steaming leads to loss of diversity of soil life, and the system may become more susceptible to pathogenic organisms. As steaming is in some situations considered unavoidable by the farmers, the question was raised whether the application of organic fertilizers may stimulate the redevelopment of microflora biodiversity in the soil. The following experiment was set up in order to gain insight into the redevelopment of microorganisms as well as plant pathogenic nematodes after steaming the soil during the cultivation of sweet pepper. The main research question posed is: “Does the application of specific organic fertilizers offer opportunities to stimulate the (re)development of soil microbial diversity?”.

Methodology

In an on-farm trial in a commercial organic greenhouse, sheet steaming (for 6 hours - without loosening the soil prior to the experiment) was applied to part of the research plot before the start of sweet pepper cultivation. A non-grafted variety of bell pepper (Special) was grown. The glasshouse is equipped with a closed hot water circuit for heating. The greenhouse is located in the southern part of the Netherlands on a sandy soil at Middelbeers, Noord Brabant. The soil is a humus rich (5.4 % organic matter), calcium-poor sandy soil. The effects of 5 organic fertilizers (goat manure (GM), three types of commercially produced yard waste compost (YWC) and one type of experimentally produced spent mushroom compost (SMC)) on the development of soil microflora and plant pathogenic nematodes were investigated by measuring the composition at several time intervals. Laboratory experiments were carried out in order to estimate C-turnover rates of the soil organic matter (SOM) and organic amendments. The amount of organic fertilizer applied was calculated based on the farmers’ aim to keep organic matter content of the soil at a constant level. To meet nutrient demands of the crop, additional fertilization was carried out with bloodmeal.

Total and active biomass of bacteria and fungi, and numbers of ciliates, flagellates and amoebae were determined in 4 instances. The diversity of bacterial and fungal populations was investigated by polymerase chain reaction (PCR), followed by denaturing gradient gel electrophoresis (DGGE) (Postma *et al*., 2000) in the following soil samples:

- treatment C*st* and C*ns* (control *steamed* and *not steamed*) on 01-12-2003 (before steaming, t = -1)
- treatment C*st* and C*ns* (control *steamed* and *not steamed*) on 16-12-2003 (just after steaming, t = 0)
- treatment Cst, Cns, YWC-CP*st* and YWC-CV*st* on 12-01-2004 (t = 1)

- *all* 12 treatments were analysed on 29-3-2004 (4 months after steaming, t = 2)
- treatment Cst, Cns, YWC-CP*st* and YWC-CV*st* on 09-06-2004 (t = 3)

PCR-DGGE patterns were analysed using canonical correspondence analysis (CCA) in CANOCO. Diversity was calculated based on the number and intensity of ladder bands, using the Shannon-Weaver diversity index. Samples of soil microflora were classified using TWINSPAN (Hill, 1979). Plant pathogenic nematodes (*Meloidogyne hapla*) were counted in soil samples in 6 instances during the growing season. The experimental design is shown in table 1.

Table 1. Experimental design with numbers and codes of the plots. Plots measure 8x4 m^2. The left site of the trial (plots 1-6) was steamed at the beginning of the experiment, the right site (plots 7-12) was not.

6	SMC*st* 26.0 tonnes/ha	12	C*ns* (control) (no organic fertilizer)
5	YWC-CV*st* 33.5 tonnes/ha	11	SMC*ns* 26.0 tonnes/ha
4	YWC-CP*st* 33.5 tonnes/ha	10	YWC-IR*ns* 30.5 tonnes/ha
3	YWC-IR*st* 30.5 tonnes/ha	9	GM*ns* 48.5 tonnes/ha
2	C*st* (control) (no organic fertilizer)	8	YWC-CP*ns* 33.5 tonnes/ha
1	GM*st* 48.5 tonnes/ha	7	YWC-CV*ns* 33.5 tonnes/ha

Results and brief discussion

At the start of the experiment, mean values of organic matter turnover rates obtained in previous experiments were used to determine the level of fertilizer application necessary to keep soil organic matter at a stable level. Also, a couple of biotic characteristics of the applied fertilizers were determined (table 2).

Table 2. Biotic characteristics of the organic fertilizers applied. GM = goat manure; YWC-IR = Yard Waste Compost – Iersel, YWC-CP = Yard Waste Compost – Compara; YWC-CV = Yard Waste Compost – Conviro; SMC = Spent Mushroom Compost.

Code	Active bacterial biomass (µg/g)	Total bacterial biomass (µg/g)	Active fungal biomass (µg/g)	Total fungal biomass (µg/g)	Flagellates (numbers/mg)	Amoebae (numbers/mg)	Ciliates (numbers/g)
GM	2783	24,957	9	856	486	972	112
YWC-IR	177	4,844	55	826	9	74	0
YWC-CP	126	2,027	23	926	6	50	0
YWC-CV	189	3,134	51	842	460	460	23
SMC	3	24,978	0	3,121	9,252	4,626	0

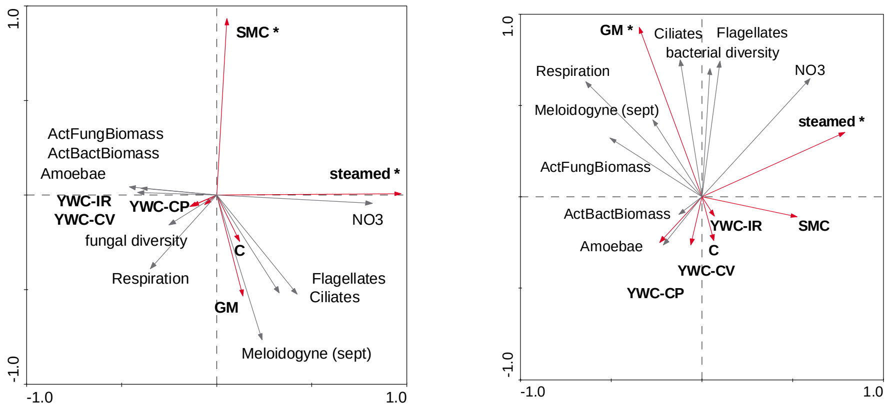
Directly after the application of soil steaming (t = 0), the number of bacteria and fungi in the soil has sharply decreased (table 3). For bacteria, only 11 out of the 26 initially present ladder bands were left directly after steaming. For fungi, no ladder bands were present after steaming, while before steaming, 10 ladder bands were present. Soil steaming also had a significant influence on bacterial and fungal populations at later time intervals. Statistical analysis with canonical correspondence analysis of all analysed soil samples shows that steaming has a significant effect on both bacterial and fungal populations (figure 1). Steaming resulted in a lower diversity of bacteria and fungi (number of ladder bands) as well as a lower Shannon-Weaver diversity index. After four months, the diversity of bacterial and fungal populations was still significantly less developed in the steamed soil than in the undisturbed soil. Analysis with Canoco at 29-3-2004 (t = 2) shows a significant effect ($P<0.05$) of goat manure on bacterial diversity and of spent mushroom compost on fungal diversity.

Table 3. Number of bands and Shannon-Weaver diversity index of PCR-DGGE patterns of bacterial and fungal populations in Control treatment with (C*st*) and without application of steaming (C*ns*)

bacterial population					fungal population			
	n bands		shannon		n bands		Shannon	
time	C*ns*	C*st*	C*ns*	C*st*	C*ns*	C*st*	C*ns*	C*st*
t = -1	26	26	3.03	3.03	10	7	1.78	1.64
t = 0	26	11	2.88	2.20	10	0 *	2.02	*
t = 1	29	26	3.04	2.89	13	6	1.94	1.48
t = 2	25	21	2.88	2.83	8	6	1.89	1.46
t = 3	27	23	3.05	2.94	15	6	2.15	1.09

* sample contained not enough fungal DNA

For each moment of sampling, data of microbial biomass and numbers of protozoa and nematodes in the 12 treatments were standardized to the group maximum and compared with TWINSPAN. TWINSPAN distinguished steamed and unsteamed plots at 2 weeks and 7 weeks after steaming. At the end of the growing season, TWINSPAN no longer distinguished plots based on steaming. In figure 2, development of foodweb structures are shown in circle diagrams for all treatments in steamed and unsteamed plots.



Bacterial DGGE

Fungal DGGE

Figure 1. Canonical correspondence analysis of bacterial and fungal PCR-DGGE patterns of all treatments on 29-3-2004 (t = 2). Arrows with bold text indicate environmental factors (fertilizer types, steaming); other arrows indicate supplementary factors (soil respiration, active fungal and bacterial biomass, Meloidogyne, diversity of DGGE ladder bands and various other soil organisms). Interpretation of the figure is as follows: (A) arrows that point in the same direction are correlated with each other and (B) longer arrows have a stronger influence. Factors designated with * have a significant influence (P<0.05) on the bacterial population (left figure) or fungal population (right figure).

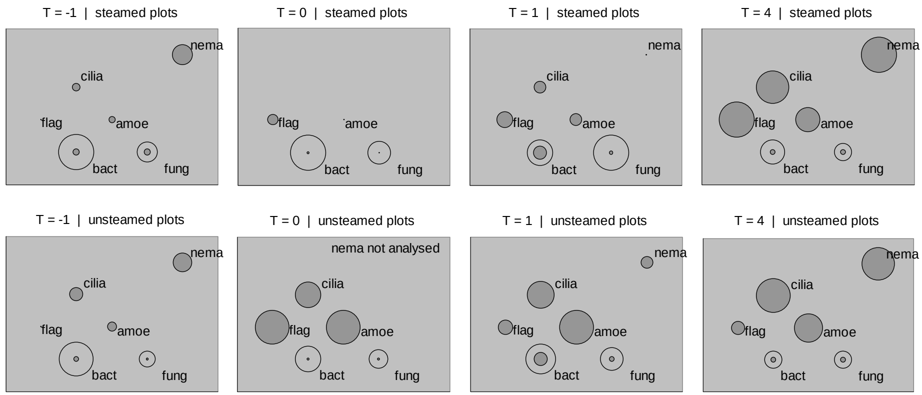


Figure 2. Foodweb structures in steamed treatments (upper row) and unsteamed treatments (lower row). Data are standardized to the group maximum and the radius of a circle is a measure of the relative abundance of the species compared to other time-intervals. The left side of the foodweb structure shows the bacteria (bact) and bacteria-feeders such as flagellates (flag) and ciliates (cilia). The right sight shows the fungi (fung) and fungal feeders such as amoebae (amoe). Small circles inside bact and fung circles indicate the amount of bacteria and fungi active within the population. At the top right, the plant pathogenic nematodes (*Meloidogyne hapla*) are shown. T = -1 (1-12-2003) is the foodweb composition before steaming was applied. T = 0 (16-12-2003) is two weeks after the moment of steaming. T = 1 (19-1-2003) is 7 weeks after steaming, and 5 weeks after fertilizer application. T = 4 is at the end of the growing season (28-9-2004).

The t = 0 and t = 1 foodweb structures of the steamed treatments show lower amounts of protozoa as well as lower amounts of nematodes compared to the unsteamed plots. It may be hypothesized that this foodweb structure is deprived of the upper layers of the foodweb, and that it will therefore be a less stable system that may be more vulnerable when plant pathogenic organisms are introduced. Both predators and competitors of pathogenic species may be absent in such a foodweb. PCR-DGGE analysis showed that the diversity of both bacteria and fungi was significantly less developed at least until four months after steaming. On the other hand TWINSPAN analysis showed that at the end of the growing season, no significant differences were found between steamed and unsteamed treatments regarding abundance of organisms in specified groups. Diversity within groups (number of bacteria species or fungal species) was however not determined at the end of the season by PCR-DGGE. Steaming sharply reduced the number of nematodes at the beginning of the season. This may have stimulated vegetative growth of the sweet pepper crop, which was stronger in the steamed treatments. At the end of the growing season, slightly more nematodes were present in the steamed plots than in the unsteamed ones. The result may be due to the abscence of nematodes at the beginning of the growing season. This in turn may have stimulated stronger root development in the steamed plots, thus providing a better food source for nematodes afterwards. Soil steaming was not optimized by the farmer, as the soil was not tilled beforehand. This leads to lower soil temperatures during steaming and may favour the survival of nematodes in the soil.

Conclusions

The analysis of soil bacterial and fungal populations before and after soil steaming shows that four months after steaming, there is still a significant effect of steaming on diversity of both bacterial and fungal populations. After four months, bacterial diversity was significantly more stimulated by goat manure, while fungal diversity was more stimulated by the application of spent mushroom compost.

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ORGANIC VEGETABLE PRODUCTION IN GERMANY – STATUS QUO

Peter von Fragstein und Niemsdorff (1), Bernd Geyer (2), Hans-Jürgen Reents (3)

(1) University of Kassel, Dept. Organic Farming & Cropping Systems, Nordbahnhofstr. 1a, D37213, Witzenhausen, Germany, Tel. +49 5542 98 1567, E-mail: pvf@mail.wiz.uni-kassel.de
(2) Humboldt-Universität zu Berlin, Institut für Gartenbauwissenschaften, Fachgebiet Gemüsebau, Lentzeallee 75, D14195 Berlin, Tel. +49 30 3147 1101, e-mail: bernd.geyer@agrar.hu-berlin.de
(3) Technische Universität München, Lehrstuhl für Ökologische Landwirtschaft, Alte Akademie 16, D85350 Freising-Weihenstephan, Tel. +49 8161 71 3778, e-mail: reents@wzw.tum.de

Key Words: Organic Vegetable Production, Germany, survey, production techniques

Abstract

A survey about common practice in organic vegetable production was carried out on 100 farms in 2002 and 2003 that ranged from small to big scale vegetable holdings and reflected all important growing regions in Germany. Aspects of structure and production techniques were considered. Evaluations were made by categorizing (a) into three regional groups – *South* (Bavaria and Baden-Württemberg) |S|, *East* (New Länder) |E| and *North/West* (other Old Länder) |NW| - (b) into seven groups of producer organisations and (c) into eight groups of cultivation area for vegetables. The visited farms were either pure market gardens or farms with agricultural and horticultural crops or farms with or without production in greenhouses.

Farms with more UAA were located in |E| and |NW|. In |S| there was a higher proportion of vegetables in arable crop rotations. The smaller the farm, the more surface could be found for sheltered production. The cultivation programmes of field vegetables were based on a high diversity of different species, leaded by crucifers and umbellifers and legumes, mainly as green manures. Outdoor crop rotations are structured according to the guidelines of organic cultivation. The N provision of crop growing in greenhouses was based on the use of farm yard manure or other external N sources. Purchased N fertilizers were partly of animal-based, partly of crop-based origin. Fertilization of P and Ca was seldom mentioned. Soil analyses were less made (a) in |E| compared to other regions, (b) in small holdings compared to farms of bigger size. Low nutrient status' in soil (class A or B) demand a reconsideration of nutrient management in organic vegetable production. Applied plant protection products had mainly insecticidal activity. Compared to other organisations Bioland farms had higher levels of plant protection, related to surface grouping, smaller farms used more plant strengtheners as supplement to plant protection. Mainly used beneficial organisms were lacewings and predatory mites, much more in |S| than other regions.

Perspectives for further development of the farms were mainly linked to improvement of equipment, labour efficiency and marketing. Essential key words were less hand weeding, more efficient working processes and better connections to other farms for common organisation and marketing. Special wishes to politicians and administrators were better aids for marketing and less bureaucracy, to producer organisations less organisations and less fees, to scientists more references to practical issues and more holistic approaches in running scientific trials for organic agriculture.

Introduction/Problem

In order to update knowledge and facts about the current practice of organic farming in Germany the German Ministry for Consumer Protection, Nutrition and Agriculture initiated various status quo projects within the Federal programme *Organic Farming*. One of the subjects were dedicated to organic vegetable production. Members of the University of Kassel, Humboldt University of Berlin and Technical University of Munich carried out a survey that ranges from small to big scale vegetable holdings and reflected all important growing regions in Germany. Basically aspects of structure and production techniques were considered (1).

Methodology

A questionnaire was built up out of 25 different thematic fields, i.e. agro-sociological and structural data, machinery equipment, crops, cultivars & plantlets, cropping systems, rotational design, fertilizer input, plant protection methods, post harvests aspects, processing & marketing, experiences & expectations, differentiated into various depths. 100 organic vegetable holdings and organic farms with substantial vegetable shares were interviewed during personal visits. All data were transferred into a mysql databank. Statistical evaluations were mainly done by SPSS.

Results and brief discussion

Off the 100 interviewed farms (see table 1) most of the small holdings were located in the Southern regions (median: 8,1 ha) whereas the biggest holdings were found in Eastern regions (median: 15,9 ha and 850 ha maximum).

Table 1: Farm size by region

Region	*Farms*	*Farmsize (ha)*			
	(No.)	Mean	Median	Min.	Max.
South	25	30.6	8.1	0.6	230
North/West	40	38.3	13.2	1.8	205
East	35	108.6	15.9	0.4	850
Total	100	61.0	12.5	0.4	850

The opposite is true for the share of outdoor vegetable area related to farmsize within the regions: |S| 60 %, |N/W| 53 %, |E| 36 %.

Nutrient management continues to be one of the main questions in organic vegetable production. Partially very low soil nutrient status and the insufficient routine of regular soil analyses (as demanded by the German declaration of fertilization) indicate the need for intensive training, demonstration and communication between extension services or other teaching bodies and farmers' groups (see figure 1). Mainly East German farmers showed deficits in regular soil status documentations.

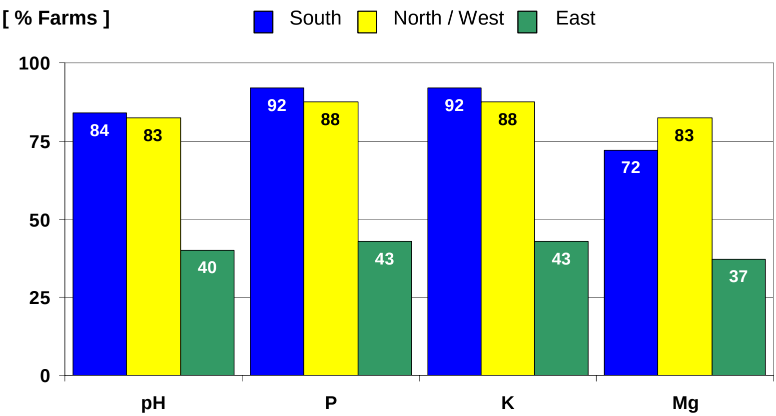


Figure 1: Soil analyses: Frequency of basic analysis related to regions (outdoor areas

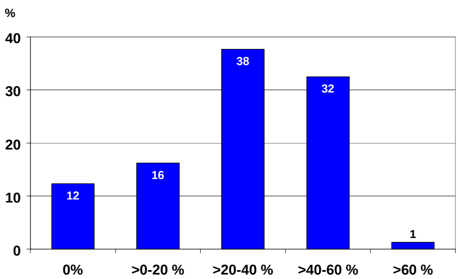
Specifically the application of purchased N fertilizers is a useful indicator for the intensity of the system. 60 % of all purchased fertilizers were N fertilizers; 57 % of which were of plant origin. The coarse meal of *Vicia faba* and *Rizinus communis* were the main components of these crop based fertilizers. Related to farmsize and organisation, evidently farms with limited surface, in East and North/West up to 10 ha, in South up to 20 ha, mainly used N fertilizers for the improvement of crop performance (see table 2). Of the organisations in South and North/West, N fertilizers were mostly used in Bioland farms, distinctly less in biodynamic farms. In East, due to the high number of Gäa farms, the sequence was different: Gäa > Bioland > Demeter.

Table 2: Application of purchased N fertilizers related to farmsize and organisation (% Farms per region)

Area [ha]	South	N / W	East
>0 – 1	10	9	33
>1 – 2,5	15	23	19
>2,5 – 5	26	19	5
>5 – 10	5	26	24
>10 – 20	33	3	5
>20 – 50	0	9	5
>50 – 100	10	7	10
>100	0	4	0
Total	39	74	21

Organisation	South	N / W	East
Bioland	56	85	29
Biopark	0	0	5
Demeter	36	11	24
EU-Farm	0	0	0
Gäa	0	1	43
Naturland	8	3	0
Ökosiegel	0	0	0
Total	39	74	21

The rotational design in stockless systems is mostly jeopardized in sheltered growing systems. Herein the N supply by leguminous crops, as can be recognized in outdoor systems (see figure 2), must be nearly completely replaced by the amendment of organic fertilizers (see figure 3). A similar tendency in outdoor rotations of very intensive holdings can be partially noticed.



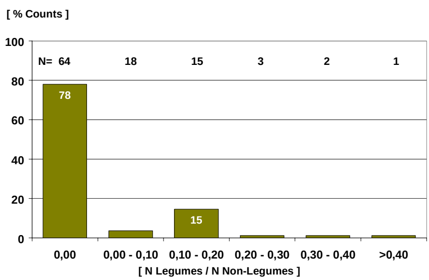


Figure 2: Share of legumes in outdoor crop rotations

Figure 3: Ratio of legumes to non-legumes in crop rotations in sheltered production

Plant health and weed regulation are important aspects and greatly determine daily practice. Specific demands were mentioned for the improvement of existing and the need for new means. Applied plant protection products had mainly insecticidal activity. Compared to other organisations, Bioland farms had higher levels of plant protection, related to surface grouping, smaller farms used more plant strengtheners as supplement to plant protection (see table 3). The beneficial organisms used most were parasitic hymenopterae and predatory mites, especially in the South due to more area of sheltered production.

Table 3: Frequency of used plant protection products related to organisations {italic [% Counts per group]}

Organisation	Fungicide	Insecticide	Molluscicide	Total
Bioland	*79*	*62*	*22*	*63*
Biopark	*4*	*3*	*0*	*3*
Demeter	*0*	*24*	*67*	*23*
Gäa	*14*	*9*	*11*	*10*
Naturland	*4*	*1*	*0*	*1*
Total [N]	28	127	9	164

Market gardens of very limited size live in a conflict of economic pressure and ecological needs for higher biodiversity. Government incentives are needed to overcome the problem of small scale farming. Equipment is often old, particularly on holdings smaller than 50 ha (see table 4). On the one hand, it reflects highly technical knowledge and good skill for maintenance of the machines; on the other it can be understood as an indicator of the need for substantial investments in the future. Correspondingly, adequate income has to be ensured for the replacement of old machinery and the reconstruction of old buildings. New sources of income by CSA-systems or improved models of intensified co-operation between holdings can be relevant for the survival of small enterprises especially, and were on the list of the practitioner's expectations for the future.

Table 4: Age of technical equipment related to farmsize (% counts per farmsize group) (A) 1-5 years, (B) 6-10 years, (C) 11-29 years, (D) >30 years, (E) not determined

Farmsize	(A)	(B)	(C)	(D)	(E)
<1 ha	27.1	7.4	10.1	51.6	3.7
1-2,5 ha	13.0	11.0	8.4	59.1	8.4
2,5-5 ha	16.6	14.1	10.2	44.3	14.7
5-10 ha	24.0	15.3	5.4	46.3	9.0
10-20 ha	23.1	15.6	5.3	52.4	3.6
20-50 ha	16.5	12.4	2.1	50.5	18.6
50-100 ha	34.0	23.9	13.2	27.0	1.9
>100 ha	37.5	26.4	11.1	12.5	12.5
Total	21.7	14.5	8.1	46.8	8.8

Perspectives for further development of the farms were mainly linked to improvement of equipment, labour efficiency and marketing. Essential key words were less hand weeding, more efficient working processes and better connections to other farms for common organisation and marketing. Special wishes to politicians and administrators were better aids for marketing and less bureaucracy; to producer organisations less organisations and less fees; to scientists more references to practical issues and more holistic approaches in running scientific trials for organic agriculture.

Conclusions

The results demonstrate both weak and strong points in the current practice in organic vegetable production in Germany. Politicians, farmer's organisations and scientists, can benefit from the open-mindedness of the practitioners and use that information tool for further political strategies, organisational aspects and scientific approaches.

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Acknowledgements
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ENHANCING SORGHUM (SORGHUM BICOLAR L)-COWPEA (VIGNA UNGUICULATA L.) INTERCROP PRODUCTIVITY THROUGH ROW ARRANGEMENTS AND ORIENTATION

[1]Muwanga, S., [1]Tenywa, J. S., [1]Owuori, C., [2]Esele, P. and [3]Woomer, P.L

[1] Department of Soil Science Makerere University, P. O. Box 7062 Kampala, Uganda.
[2] Serere Agricultural and Animal Research Institute, P .O. Soroti Uganda.
[3] SACRED Africa, Bungoma, Kenya.

Key Words: Intercropping, sorghum, cowpea, row arrangement row orientation

Abstract

Currently there is a concern over use of agrochemicals, particularly regarding residual effects. Sorghum and cowpea are staple crops as well as income earners in Uganda, but low yields characterize their output. Limited research has been done to ameliorate this situation. This study was designed to improve the yields of intercropped sorghum and cowpea. Treatments included row arrangement (1:1 vs 2:2) and orientation (north south vs.east west) and pure stands of both cowpea and sorghum. Parameters measured were dry matter and grain yield of intercrops, solar radiation interception, leaf area index and net benefits accruing from both intercrops. East west row orientation accesses greater light interception. Staggered row spacing boosted access to light by the cowpea understorey, leading to improve yield vis-à-vis an alternate row strategy. Finally, it is economically most beneficial to intercrop sorghum-cowpea in staggered double row arrangements.

Introduction

Traditionally crop production improvement involved inorganic inputs like fertilizers and insecticides. Currently, there is a concern over use of agrochemicals particularly regarding residual effects. Therefore those agronomic manipulations which improve crop performance with little or no addition of external inputs are preferred.

The importance of sorghum (*Sorghum bicolor* L. Moench) and cowpea globally are well documented. Sorghum ranks fifth as a cereal crop and feeds over 500 million people directly or indirectly. Similarly, cowpea (*Vigna unguiculata* (L. Walp) is a major crop for millions of people in sub Saharan Africa, Asia and Oceania (Fery, 2002). This versatile crop is cultivated between 35^{o}N to 30^{o}S where it provides cheap nutritious food (cowpea grain 23-25% protein, 50-67% starch), animal feeds, groundcover, cash, as well as being regarded as a fulcrum for sustainable farming. While land devoted to sorghum annually is constant, production is declining, for instance from 407.000 t in 1978 to 375.000 t in 1992 (Esele, 1995). In addition, on-farm yield per hectare is very low compared to on-station, 600-800 kg ha-1 and 4,500 kg ha-1, respectively (Esele, 1988). Sorghum is commonly intercropped with crops such as common beans (*Phaseolus vulgaris* L) and cowpea. However, the optimum sorghum-cowpea mixture has not been established. The emphasis of this research is to increase sorghum cowpea intercrop yield by manipulating row arrangement and orientation.

Methodology

The study was conducted on-station in Soroti, Uganda for two rainy seasons (2001B and 2002A). The area is located between 1^{o}30' N and 33^o 30' E. The district experiences bimodal rainfall (March-July and September-November). The mean annual rainfall is approximately 1000 mm and the mean annual temperature ranges from 16-30^{o}C.

Physiographically, the region has gentle slope (<2%). The soils are light textured, ranging from sandy to sandy loam, low in N, available P and organic matter. Each site was sampled at 0-20 and 20-30 cm before establishing the experiment, and characterized for both physical and chemical properties using the procedures described by Okalebo *et al*., 2002.

The treatments comprised of (i) pure stands of sorghum and cowpea (ii) two row arrangements alternating rows (1row of sorghum: 1 row of cowpea, and 2 rows of sorghum: 2 rows of cowpea) (iii) row orientation, east-west (EW) and north-south (NS) laid out in a randomized complete block design (RCBD). The treatments were replicated three times per farmer in each district. Sekedo was the sorghum cultivar used in the study. This cultivar is a recent release by the National Agricultural Research Organisation (NARO). It matures in 105 days. The large eye (Ebelat) cowpea variety was used. The variety matures in 90-100 days and yields up to 2,000 kg ha^{-1}. Plant spacing was 60 cm by 20 cm for both intercrop component and pure stand/control. The experimental seeds were obtained from the (Serere Agricultural and Animal Research Institute (SAARI) seed section, already treated with pesticides against soil born diseases and insects. The experiment was maintained using recommended agronomic practices (weeding, thinning and pest control). Cowpea pests were controlled by hand picking. Sorghum smut affected plants were rogued out. Avian pests for both intercrops were controlled using audio-radio tapes stretched across the entire site. The tapes produced sound from blowing winds and their black glittering nature led to a snake like appearance, which deterred the birds. Furthermore, human guards scared thieves, monkeys and squirrels.

All the costs involved in the experiment were recorded for purposes of net benefit analysis. Similarly, farm-gate price for the grain of each crop species were obtained both immediately after harvesting when the prices were low and during dry seasons when prices were highest. The two extreme prices were averaged to obtain the values used in the economic assessment. The costs of production and selling prices were monitored over a period of 6 months (November 2002- March, 2003).

Plant parameter assessed included (i) sorghum and cowpea dry matter yield (DMY) (ii) sorghum and cowpea grain yield (iii) solar radiation interception (measured using a digital light sensor), Leaf area index (LAI) and (iv) economics using the formulae; Net benefits = (Y * P) - CV

Where: Y = Yield

P = farm gate price for the product

CV = cost that vary

Results and discussion

Soil pH values, Kjeldhal N and available P (Bray I) were generally favourable for crop production. Cowpea intercrop significantly ($p<0.05$) influenced sorghum DMY at 105 days after planting (DAP). Cowpea suppressed sorghum DMY by up to 63% and grain yield by 17%. These results suggest aggressive competition between the sorghum-cowpea intercrop. It is important that the root architecture of the two crops is clearly understood in order to elucidate the lack of compatibility between sorghum and cowpea as intercrops. Sorghum is thought to root deeply and explore both top and sub-soil layers. Similarly, cowpea is thought to exploit both the top and sub-soil layers. Total overlap in rooting systems of sorghum and cowpea is likely to have given sorghum in the sorghum mono cropping a yield advantage over sorghum-cowpea intercrop. These postulations exclude allelopathetic interactions between sorghum and cowpea. Further investigation is needed.

Possibly, too, sorghum yield reduction could result from cowpea light interception. Cowpea lost its bush type (determinateness) especially in the alternating single rows in the EW orientation. Ebelat, the cowpea variety used, is typically determinate (bush type). This could have affected the photosynthetic capacity of sorghum plants and subsequently their yield. Determinateness (bush type) of crops often breaks down when plants are denied adequate access to solar radiation.

Row orientation had a significant ($p<0.05$) effect on cowpea LAI, with N-S having 2.8 and E-W. This has obvious implications on the photosynthetic machinery and eventually crop yields. Light interception by the cowpea understorey was greater ($p<0.05$) in the E-W row orientation diurnally. Light interception ranged from 60% at sunrise to 43% at sunset. In contrast, for the N-S orientation, the range was almost 0% at sunrise and 3% at sunset. Furthermore, all treatment combinations attained a maximum of 78% at 12.00hrs (noon). Orienting cowpea intercrop rows E-W maintained near ambient incident light levels throughout the day, with slightly pronounced deviations before and after mid-day. Understorey light interception values were consistently less than that of the above storey intercepted light.

In the N-S row orientation cowpea crept and quickly fused its canopy with that of sorghum. This likely led to cowpea self-shading as well as shading of sorghum. Consequently, this possibly affected the yield performance of both intercrop components.

Sorghum-cowpea rows oriented N-S suppressed cowpea DMY by 54% relative to the control while rows oriented E-W suppressed DMY by 56%. Cowpea, it appears the supposedly understorey (cowpea) in the N-S rows had greater solar radiation utilisation than did the E-W oriented rows. This could be attributed again to the extensively induced indeterminateness in otherwise sorghum shade affected cowpea plants in the early stages of growth. Nevertheless, because cowpea DMY was less in the intercrop than in the pure stand, it is apparent that intercropped cowpea still suffered some stress due to resource inadequacy. Therefore, below-ground competition for resources by both inter- and intra-species is likely to abound.

Cowpea grain yield was not significantly ($p \geq 0.05$) influenced by row orientation, although the north-south rows yielded 983 kg ha^{-1}, while, east-west 1,107 kg ha^{-1}. On the other hand, cowpea grain yield of alternate single rows was barely 30% of the staggered double rows (567 and 1,523 kg ha^{-1}, respectively).

Generally, alternating single rows gave less net benefit than staggered double rows, in sorghum-cowpea intercrop. The net benefits were $525, 455, 571, 577, 349 and 407 for alternate N-S, E-W, staggered N-S, E-W and monocropped cowpea and sorghum, respectively. On the other hand, the staggered rows oriented either N-S or E-W gave the same range of revenue. The highest benefit accruing from staggering double rows of sorghum-cowpea intercrop could be associated with higher grain yield of both intercrop components. The sorghum-cowpea intercrop staggered double rows are associated with higher solar radiation capture and intercrop performance.

The opportunity cost of growing cowpea monocrop or intercropping it with the sorghum was more or less the same. Therefore, the decision by a farmer to grow either cowpea monocrop or sorghum-cowpea intercrop should be based on non- monetary benefits. Generally, the experimental results were in agreement with Ahmed and Raos' (1982) findings, which showed that intercropping increased the monetary return when soybean was intercropped with maize in Hawaii.

Conclusions

Generally, access to light is greater for rows oriented E-W than N-S. Staggered rows in the form of 2:2 greatly boosted access to light by an cowpea understorey crop. Increased shading by an upper storey forces *Ebalat* cowpea in alternate single rows to lose its bush nature and to intertwine and affect the performance of sorghum. Finally, it is economically more beneficial to intercrop sorghum-cowpea in staggered row arrangements

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COMPARING FERTILIZATION REGIMES UNDER THREE ONION FARMING SYSTEMS IN A SEMIARID TROPICAL AREA

Martha-Cecilia Perez (1) and Hugo Ramirez-Guerrero (2)

(1), (2) Posgrados de Agronomia, Universidad Centroccidental Lisandro Alvarado, Cabudare, Zip Code 400, Barquisimeto, Venezuela, Tel 00 58 251 2618939 or 00 58 251 2592592, E-mail (1) marthaceciliaperez@hotmail.com, Email (2) hramirez@ucla.edu.ve

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Abstract

An experiment at the University experimental station at Cabudare, Venezuela compared six fertilization regimes in three onion (*Allium cepa* L.) production systems (two organic (OS), two integrated (IS) and two conventional (CS) systems), for their effects on crop growth, productivity, and soil properties. Fertilization regimes (two per system) consisted of (i) 3 Mg ha^{-1} sugarcane filtercake compost (fc) (OSfc), (ii) 3 Mg ha^{-1} chicken manure compost (chm) (OSchm), (iii) 0.6 Mg ha^{-1} mineral compound fertilizer (mf) (CSmf), (iv) without any fertilizer (nf) (CSnf), (v) mf + chm (ISchm), and (vi) mf + chm + fc (ISchmfc). Additionally, farming systems included nonchemical (OS), chemical (CS) and integrated pest management. Results indicated that the onion growth and productivity was higher from plots managed under integrated systems (mainly ISchm). However, when comparing the effect on soil properties, differences were not found. The organic onion production in the semiarid area was highly productive during the dry season studied

Introduction

In the tropics, onion is generally the second most important vegetable crop after tomato. The world's semiarid lands are a major resource for expanding food production in tropical countries as a result of their long growing seasons and the opportunities for multiple cropping associated with them, provided water is available (Ramirez *et al.,* 1999). Short-day onions have been introduced to semi-arid environments in the last five decades and have become important crops in some tropical countries including Nigeria, Niger, Brazil and Venezuela. However, during this period in Venezuela, only conventional production systems have been used, relying on synthetic chemicals for pest control and fertilization. Most areas with semiarid ecosystems are undergoing degradation mainly due to the agricultural production systems applied. Consequently, political, economic and resource base pressures on farmers have increased, and many growers are considering changing from conventional to low-input (reduced use of fertilizers and pesticides) or organic farming systems which use no synthetic fertilizers or pesticides (Colla *et al.* 2002). Organic farming is often suggested as a remedy to address farmers' problems in developing countries. However, little hard evidence is available on the comparative performance of organic versus conventional farming techniques (van der Werf *et al.,* 1997). As there is little reported research about organic onion cultivation under tropical conditions in general, or in Venezuela specifically, this study was done to compare the effect of six fertilization regimes under three production systems on the onion growth and yield and some soil properties.

Methodology

The experiment was carried out under tropical field conditions at the experimental station in Lara State, Venezuela (10º 2' N, 60º 16' W, 510 masl). The climate is semiarid with mean annual temperature of 25 ºC, rainfall of 500 mm and potential evaporation of over 3000 mm. A representative sandy clay loam soil was used. The 0–20 cm layer had 21 mg kg^{-1} P, 75 mg kg^{-1} K, 105 mg kg^{-1} Mg, over 3000 mg kg^{-1} Ca and 2.3 g kg^{-1} organic matter with a pH of 7.2.

Forty-two day old seedlings of the short day onion hybrid cv. Century (Seminis Seed, USA) were transplanted in January 2004 (dry season) for studies on onion growth and soil properties under three production systems including six fertilization regimes. Treatments consisted of (i) 3 Mg ha^{-1} sugarcane filtercake compost (fc) (OSfc), (ii) 3 Mg ha^{-1} chicken manure compost (chm) (OSchm), (iii) 0.6 Mg ha^{-1} mineral fertilizer (mf) (CSmf), (iv) without any fertilizer (nf) (CSnf), (v) mf + chm (ISchm), and (vi) mf + chm + fc (ISchmfc). All fertilizers (Table 1) were incorporated 5 days before transplanting. The experiment was drip irrigated, and and used either nonchemical (OS, mechanical weeding, mulching, plant extracts), chemical (CS) or integrated pest management. Treatments were compared using a randomized complete block design with four replications. Each plot was 20 m x 1.5 m.

Table 1. Nutrient content of fertilizers and some other fertilizer properties.

Fertilizer	N (%)	P (%)	K (%)	Ca (%)	Mg (%)	Cu (ppm)	Zn (ppm)
Chm compost	2.9	1.6	3.1	4	0.7	197	488
Fc compost	0.9	0.6	2.9	2.1	0.4	33	152
Mineral	12	5.2	14.2	-	-	-	-
	Fe (ppm)	Mn (ppm)	B (ppm)	Na (%)	pH	EC (dS m^{-1})	Bulk density (Mg m^{-3})
Chm compost	5121	639	72	0.6	7.2	14.4	0.87
Fc compost	4596	459	9	0.1	6.7	3.2	0.92

Chm: chicken manure, Fc: Sugarcane filtercake and Mineral: compound fertilizer applied at the doses of 0.6 Mg ha-1**.**

Growth was assessed from a sample of ten plants per plot, which were harvested and washed with tap water at 25, 40, 47, 67, 82 and 90 days after transplanting (dat). Bulb and neck diameter, number of green leaves, leaf area, plant (bulb and leaves), fresh and dry weights and mineral content of leaves (only at 67 dat) were determined. Additionally, bulbing ratio (BR) was calculated as the ratio of the maximum bulb diameter to the minimum pseudostem (neck) diameter. Plants were harvested (90 dat) and yields determined from the 4 central rows (2 m long) of each plot.

Five days after harvesting, soil samples taken from each plot were air-dried and sieved (2mm) for subsequent analyses. Tissue and soil analyses followed standard methodologies (Allen, 1989).

Results and discussion

Onion growth and productivity:

Onion bulb growth and productivity responded to all the fertilization plans and production systems evaluated: the integrated fertilization plan (mineral fertilizer and chicken manure compost, ISchm) treatment produced the best results. Table 2 shows the effects of fertilization on some of the growth characteristics at some of the sampling dates. At 67 dat, leaf fresh weight (Lfw) from onion plants fertilized with the mineral compound fertilizer (CSmf) and chicken manure compost (OSchm) were greater than those from plants given no fertilizer. Bulb fresh weight for plants receiving organic and mineral fertilizers was significantly higher than those plants receiving no fertilizer at 67, 82 and 90 dat. Additionally, bulb dry weight was significantly higher in plants from ISchmfc (67 dat) and ISchm (82 dat) than from all the plants with mineral, organic (filtercake) and no fertilization. There were no significant differences in bulb and neck diameters (BD, ND), number of green leaves (Ln), leaf area (LA) and BR among the fertilization treatments. Increased plant biomass was attributed to enhanced soil fertility (better nutrients availability) and improved soil physical condition. Inorganic fertilizers are very advantageous compared with manure; they are concentrated forms of soil nutrients, which can be transported much more readily than can manure, but inorganic fertilizers also has the disadvantages of, for example, potentially causing acidification or salinity. However, this effect can be counteracted if smaller quantities of inorganic fertilizers are used in combination with manure (Harry, 2002). These experimental results are comparable to those of Matsi et al. (2003) who found that applications of liquid cattle manure and mineral fertilizers resulted in a significant increase in dry biomass at two growth stages and in a grain yield and nutrient uptake of winter wheat growing on a calcareous loam soil of Greece. Our experiment showed that bulbing began from 40 to 43 days after transplanting. Similar observations were reported by Wickramasinghe et al. (2000) and Ramirez-Guerrero (2002) in tropical onions. Knowledge of the development cycle of a vegetable and the practical key stages is a very important tool for the timing of the application of cultural (irrigation and fertilization) and agrochemical treatments.

Table 2. Effects of 6 fertilizers and 3 production systems on onion growth, leaf analysis and yield.

Dat	Fertilizer and production system	Lfw (g 10pl^{-1})	Bfw (g 10pl^{-1})	Bdw (g 10pl^{-1})	K (%)	Mg (%)	Na (%)	Yields (kg ha^{-1})
	None (CSnf)	158 **b**	455 **b**	36 **c**	2.81 **c**	0.33 **a**	0.21 **a**	-
	Mineral f. (CSmf)	227 **ab**	614 **ab**	46 **bc**	3.42 **abc**	0.24 **bc**	0.09 **c**	-
67	ISchm	307 **a**	779 **ab**	59 **ab**	4.03 **a**	0.25 **bc**	0.10 **bc**	-
	ISchmfc	233 **ab**	891 **a**	70 **a**	3.84 **ab**	0.22 **c**	0.12 **bc**	-
	Filtercake (OSfc)	245 **ab**	623 **ab**	47 **bc**	3.16 **bc**	0.28 **b**	0.11 **bc**	-
	Chicken m. (OSchm)	275 **a**	725 **ab**	56 **abc**	4.03 **a**	0.24 **bc**	0.17 **ab**	-
	None (CSnf)	209	792 **b**	53 **c**	-	-	-	-
	Mineral f. (CSmf)	190	1158 **ab**	80 **ab**	-	-	-	-
82	ISchm	213	1349 **a**	96 **a**	-	-	-	-
	ISchmfc	164	1213 **ab**	85 **ab**	-	-	-	-
	Filtercake (OSfc)	197	1052 **ab**	76 **b**	-	-	-	-
	Chicken m. (OSchm)	194	1094 **ab**	80 **ab**	-	-	-	-
	None (CSnf)	117	913 **c**	66	-	-	-	16519 **b**
	Mineral f. (CSmf)	126	1105 **abc**	78	-	-	-	15877 **b**
90	ISchm	114	1128 **abc**	86	-	-	-	20320 **a**
	ISchmfc	107	1417 **a**	98	-	-	-	17061 **ab**
	Filtercake (OSfc)	132	995 **bc**	69	-	-	-	16519 **b**
	Chicken m. (OSchm)	110	1268 **ab**	87		-	-	16309 **b**

Means followed by the same letter are not significantly different by Duncan test at the 0.05 level. dat: days after transplant, Bfw and Lfw: bulb and leaf fresh weights respectively, Bdw: bulb dry weight. CSnf: without any fertilizer, CSmf: 0.6 Mg ha-1 mineral compound fertilizer, ISchm: mf + chm, ISchmfc: mf + chm + fc, OSfc: 3 Mg ha-1 sugarcane filtercake compost and OSchm: 3 Mg ha-1 chicken manure compost. CS, IS and OS: conventional, integrated and organic system respectively.

Fertilizers and production systems both influenced K, Mg and Na concentrations in onion leaves (Table 2), but there were no significant effects on N, P, Ca or micronutrient (Cu, Zn, Fe, Mn and B) concentrations. Chicken manure compost either alone or with mineral fertilizer, and sugarcane filtercake compost, significantly increased K uptake by onion. No fertilizer resulted increased Mg and Na concentrations in leaves. The greater K uptake by plants receiving chicken manure could be attributed to a much higher K content of this fertilizer (Table 1). Van Quyen and Sharma, (2003) and Matsi *et al.* (2003) also found that K concentration in rice and wheat straw was increased by organic (farmyard manure) and mineral fertilizers. Regarding Mg and Na contents, various authors (Ruiz *et al.* 1999) have found that increasing K concentration in the soil solution can decrease other cation concentrations in the plant tissue (such as Ca, Mg and Na). Ramirez-Guerrero, (2002) working with short-day onions under similar semiarid tropical conditions also found this antagonistic effect between K and the cations Mg and Na. Onion yields were affected by fertilization regime and production system. Bulb yields of plants receiving chicken manure and mineral fertilization under an integrated production system were greater than from plants receiving no fertilizer or sugarcane filtercake compost and chicken manure alone. The combination of chicken manure compost and mineral fertilizer may be a good fertilization practice, in addition to integrated pest management. Several other studies show crop yields were increased by organic and mineral fertilizers and their combination (Maynard and Hill, 2000; Wells *et al*., 2000; Bulluck *et al*., 2002; Matsi *et al.*, 2003).

Soil properties:

Treatments did not significantly affect pH, electrical conductivity, organic matter content, K, P, Ca and Mg content, bulk density or hydraulic conductivity. Other authors have reported that organic practices change most soil characteristics. However, all these responses have been associated with high application rates over long periods of time. For example, long term vegetable crop production trials by Bulluck *et al*., (2002), Colla *et al*., (2002), and Wells *et al*., (2000) did not find any effect of fertilization and production systems on the soil properties studied in the first years of the trials.

Conclusions

Onion bulb growth and productivity in the semiarid tropics may be affected by fertilization regime and production system. Chicken manure compost improved growth, nutrition and productivity, so using this fertilizer alone and in combination with other organic or mineral fertilizers could potentially be a good practice under our climatic conditions. Organic onion production in semiarid areas has great potential for good productivity during the tropical dry season. Further short-term experiments and a long-term experiment should be carried out to clarify residual and beneficial effects from the cultivation systems compared (mainly organic fertilization) on the soil quality.

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EFFECT OF MELIA AZEDARACH ON APHID (*Brevicoryne brassicae*) OF ORGANIC CABBAGE FARMING

Basanta Rana Bhat (1), Yubak Dhoj GC (2)

(1) Team Leader, Ecological Service Centre, Bharatpur-2, Chitwan, Nepal,
Tel. +977-56-524574, E-mail: ecoscentre@wlink.com.np
(2) Collaborator, Institute of Agriculture and Animal Science, TU, Rampur, Chitwan, Nepal, Tel. 9855056755, E-mail: gcyubak@yahoo.com

Key words: Antifeedants, active ingredients, plant extract and nymphs

Abstract

In order to assess the effectiveness of botanical plant material use in reducing cabbage aphid population (*Brevicoryne brassicae*), an experiment was conducted in the research command area of Ecological Service Centre at Devghat-9, Gaight, Tanahun during the winter of 2001/2002. Two levels of concentration, 1:5 and 1:10, from the fresh green leaves of Bakaino (*Melia azedarach* L.*)*, were applied to the aphid population in cabbage at five and ten days intervals. The result indicated that the 1:5 concentrated solution of Bakaino (*Melia azedarach* L.*)* extract at five day intervals was most effective in lowering the aphid population and scale of leaf damage as compared to other treatments. Even the 1:10 concentration sprayed at the shorter period of interval was found to be effective. Similarly, the research indicated that both concentration of plant extract and spraying interval are equally important for effective pest management, indicating the possibility of using botanical plant materials in the development of organic insect pest management methods in vegetables.

Introduction

Pests (including insects, diseases, weeds, rodents, and mites) are the major biotic constraints to increasing agricultural production. According to one estimate, the loss due to pests (insect pests and diseases) ranges from 30-35% (G. C. and Ranabhat, 2001). Application of pesticides to control pests has disturbed the natural balance, caused monetary losses through the need for more pesticide purchases. This in turn has led to further outbreaks of secondary pests and increasing concern about environmental hazards. Pesticides are responsible for some 20,000 accidental deaths each year, and 200,000 suicide deaths, according to the World Health Organisation (WHO). They also account for about three million cases of acute poisoning each year (John, 2002).

Nepal is rich in botanical diversity and there are many indigenous plants of pesticidal value (Regmi and Karna, 1988). Their use against insect pests and diseases is an age-old practice, where more than 50 species of plants have been used in Nepal (Gyawali, 1993). An indigenous weed such as *Chenopodium botrys* L. used against the potato tuber moth has been found as effective as modern insecticide (Fenvelerate 0.02%) and even superior to *Pyrethrum* sp. (0.2%) (Pradhan, 1988). Farmers use *Euphorbia pulcherrima* W. to control weevils in cereals (Sahu, 1997). It is also reported that the majority (>70%) of farmers use wood ash for disease and pest control in the western hills of Nepal (Lohar and Budhathoki, 1992). Other plant materials like neem (*Azadirachta indica* A. Zuss.), marigold (*Tagetes minuta* L.), and titepati (*Artemisia vulgaris* L.) are popular for their pesticidal value against different types of pests. Application of twigs and leaves of "khirro" (*Sapium insigne*) and titepati (*Artemisia vulgaris* L.) were found effective in lowering the effects of red ant while planting potato inside the furrow (GC *et. al*., 1997). Similarly, the extract prepared from parts of the sisnu (*Urtica dioca* L.) plants and fruits of timur (*Zanthoxylum armatum* DC.) is used to control many kinds of chewing, biting and cutting insects, like the larvae of cabbage butterfly, hairy caterpillars, cut worms, red ants and termites (Budhathoki *et al.*, 1993). Garlic clove extract and kerosene are also used for caterpillars, cutworms and aphids in many vegetable crops.

Botanical pesticides are attractive alternatives to chemicals for a variety of reasons, most significantly because most of the solely chemical-based technologies are likely to have limited worth, as insects build up resistance after a few years. By contrast, the use of natural resources is more sustainable and cost effective, as there is less chance of resistance build-up by the pests. The strategy seems more stable and sustainable from the technical, ecological, economical and environmental viewpoint. However, the efficacy of these materials, possible changes during storage, optimum extraction methods and chemical composition are yet to be studied to a greater depth. Therefore, systematic research on these aspects is urgently needed.

Among the plant species used for crop protection purposes, *Melia azedarach* is one of the most popular. *Melia azedarach* is a moderate sized deciduous tree. It grows to a height of 9-12 metres. The bark is dark grey having shallow longitudinal furrows. Leaves are bipinnate or occasionally tripinnate with ovate or lanceolate, serrate leaflets. Flowers are lilac and fragrant. The fruits are ellipsoid globose having 4-5 seeds. It is grown on the plains as well as hilly areas of Nepal as firewood and fodder. It has a spreading crown. It can tolerate a colder climate than Neem (*Azadiracta indica*). In coffee plantations it can be grown for shade. It flowers during hot weather and the fruit ripens during the cold weather. The plant freely regenerates from seeds during the rainy season.

In the current scenario, farmers are looking for effective, economically viable, safe and ecologically friendly alternatives to chemical pesticides. These alternatives in the form of plants are available in every village. But the most effective plant parts, its methods of preparation, accurate doses (concentration) and interval of spraying for effective pest management still need to be identified through farm level research.

This research was conducted to collect information on different pesticidal plants, identify the most common and locally available pesticidal plants, select effective plant parts and develop effective methods for preparation of plant extracts, its dose (concentration) and interval of spraying to insect pests of vegetables. This would help researchers to develop effective methodologies and procedures especially in the area of organic pest management. Development of effective organic insect pests management method and adoption of this technology in farmers' fields will improve the economic condition and social value of farmers. It is particularly important to farmers who have small land holdings from which they generate cash income. New technology would reduce the losses that result from the outbreak of insect pests and would also decrease the investment in chemical pesticides. The research outcome would have positive impacts on the environment by reducing the use of chemical pesticides, help maintain biodiversity, and conserve plant species for their pesticidal value.

Methodology

Cabbage seedlings (var. Green Stone) were planted at a distance of 45 x 60 cm (row to row and plant to plant) applying farmyard organic manure and other cultural practices. No external input, such as chemical fertilisers and pesticides, were applied during the crop life. Immediately after transplanting they were caged in with the nylon nets, ensuring whole plot coverage. A total of twelve seedlings were planted in a plot and altogether there were five plots in a replication. Aphid (*Brevicoryne brassicae)* of the same age, 50 per plant, were inoculated and allowed to feed on the plant parts.

The experiment was conducted in a Randomised Complete Block Design (RCBD) with five treatments and three replications. The treatments used in the experiments were different concentrations of leaf of Bakaino (*Melia azedarach* L.*)* crude extract diluted with different proportion of water and spraying schedules.

For the preparation of plant extracts, fresh green leaves of Bakaino (*Melia azedarach L*.) were collected and the primary solution was prepared with one kg of plant leaves by pulverising them over a stone grinder. Upon getting the slurry, the same amount of water (that is, one litre) was added and the slurry was screened through thin muslin cloth. Since boiling reduces the chemical content of plant extract, cold water was used for the preparation of the primary solution and also for its dilution.

The crude extract (i.e. primary solution) was diluted in two different concentrations, 1:5 and 1:10, with water and two different spraying schedules were implemented: 5 and 10 days intervals. The treatments were arranged into factorial combination such as T1= 1:5 concentration at 5 days spraying interval, T2= 1:5 concentration after 10 days spraying interval, T3=1:10 concentration at 5 days spraying interval, T4= 1:10 concentration at 10 days interval and control (water application). The effect of botanical materials was recorded every day of spraying. Biological information such as number of insects per plot, number of dead insects per plant, scale of damage and total marketable yields were taken.

Randomisation in RCBD with 5 Treatments and 3 Blocks (Replications)

Block 1	T3	T5	T2	T4	T1
Block 2	T2	T3	T1	T5	T4
Block 3	T4	T1	T5	T3	T2

Field layout and assignment of blocks and treatments

The insects were reared on the cabbage in the un-caged plots nearby the experimental plots. They were then transferred into the experimental plots and allowed to feed on the caged cabbage plants. The insect pests were also counted at the end of the experiment. While doing so, the active insects were counted. The effectiveness of plant materials was assessed in the percentage of leaf damage using a scale of 1-5 in descending order. Recorded parameters were analysed using MSTAT-C software.

Results and brief discussion

The summary of recorded observations with related statistical parameters is presented in Table 1.

Table 1. Efficacy of Bakaino (Melia. azedarach) to the cabbage aphid (*Brevicorynae brassicae*) in Gaighat, Tanahun, during the winter of 2001/2002 (Mean of three replications)

Treatment number	Treatments	No. of insect released / plant	No. of dead insect/plant	Leaf damage (1-5 scale)	Marketable yield t/ha
T1	1:5, 5 days	50	25	1.43	7.51
T2	1:5, 10 days	50	19	1.58	7.90
T3	1:10, 5 days	50	17	1.63	7.66
T4	1:10,10 days	50	15	2.75	7.33
T5	Control	50	12	3.53	3.43

Analysis of Variance

Marketable yield of cabbage (ton/hac.)

Source of Variance	Degree of Freedom	Sum of Square	Mean Square	Computed F-value	Tabular F-value (5%)
Blocks	2	0.60	0.30	6*	4.46
Treatments	4	42.25	10.56	211.2**	3.84
Error	8	0.40	0.05		
Total	14	43.25			

Although treatments from T1 to T4 were found to be insignificant, these treatments were highly significant with control ($P< 0.05$) in terms of marketable yield of cabbage. However, fewer insects were found in treatments 1 to 3 compared to more diluted crude materials and water spraying.

This research found that 1:5 concentration of plant extract and five days interval of spraying was most effective in reducing the number of insects (aphids) and the scale of leaf damage. Similarly, 1:5 concentration with ten days interval of spraying and 1:10 concentration with five days interval were found to be quite similar in effectiveness in order to control the number of insects and scale of leaf damage. From these observations, it is clear that both concentration of plant extract and spraying interval are equally important for the effective management of insect pests in vegetables.

Similarly, the control plot resulted in very low marketable head yield compared to the treated plots. However, there is no correlation observed with the percent leaf damage with that of total marketable yield as shown in the four treatments. The result has indicated the need for further verification of the experiment using different types of insect pests.

Conclusion

In general, Bakaino (*Melia azedarach)* possess growth inhibitors to the sucking types of insects to some extent. All the treatments resulted in some sort of effect on the normal development of the aphid and scale of leaf damage. However, more concentrated crude plant material spraying in short duration showed more promising results. Bakaino (*Melia azedarach)* was identified as a good indigenous plant material, having pesticidal properties under field conditions. However with the use of such materials, the insect nymphs and adults may not be killed instantly as with insecticide, but normal development may be interrupted. This could be one the reasons for the better yield. This experiment has indicated the possibility of using plant materials against sucking types of insect pests. It has also shown potential as a suitable component of organic pest management.

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FOOD QUALITY

INFLUENCE OF MANAGEMENT PRACTICES ON QUALITY AND BIODIVERSITY OF TOMATOES IN GERMANY

Daniela Klein (1), Ramesh Kumar (2), Ulrich Köpke (1)

[1]Institute of Organic Agriculture, University of Bonn, Katzenburgweg 3, D-53115 Bonn, Germany, E-mail: daniela.klein@uni-bonn.de, Internet: www.iol.uni-bonn.de

[2]Department of Vegetable Crops, Dr. Y.S. Parmar, University of Horticulture and Forestry, Nauni, Solan, HP. 173 320 India

Key words: old cultivars, organic fertilisation, secondary metabolites, taste, consumer preference

Abstract

Four old and endangered tomato cultivars were cultivated under greenhouse conditions with different levels of organic N-fertilisation and harvest at different maturity stages in order to develop a conclusive concept to preserve the diversity of old, endangered and multicolour cultivars. First results of several physio-chemical and sensory parameters were analysed to describe product quality. In order to assess consumer acceptance, 550 consumers were interviewed. The individual attributes of the cultivars, which differ in size, shape, colour, taste and health-related, beneficial physio-chemicals, are promoted by optimal harvest time. A combination of these cultivars distributed in regional markets is considered as a suitable concept for saving these endangered cultivars.

Introduction

Tomato (*Lycopersicon esculentum* Mill.) is one of the most commonly grown vegetables in the world. About 14.4 kg are consumed in German households per year (Statistisches Bundesamt, 1998). Red, round and firm cultivars dominate in mainstream production, and farmer-designed diversity is low. There has been a continuous genetic erosion of agricultural crops in the last few decades. Due to inappropriate management practices and exploitation of old and valuable genetic resources, development of hybrid cultivars to obtain early and remunerative returns is necessary. Undoubtedly, modern hybrid cultivars are uniform in colour and shape and have a longer shelf-life, yet they often have a poor taste. Preserving the diversity of old, endangered, multicolour cultivars rich in flavour and taste for the consumers will definitely help conserving the biodiversity of the tomato crop (KÖPKE, 2003). Since the shelf-life of these cultivars is often limited when the optimal ripening stage is used for harvest, short distribution distances might help to give these endangered cultivars a chance in regional markets.

Methodology

Four tomato cultivars were selected from a large collection of endangered old genotypes. The cultivars *Ananas, Auriga, Green Zebra* and *Lukullus* were cultivated under organic conditions in a greenhouse experiment at the organic research farm 'Wiesengut' in North-Rhine Westphalia, Germany (50°48’N, 7°17’O) in 2004. The experiment was arranged in a three-factorial split plot design with four replications. Plot size was 8 x 5.6 m (44.8 m^2) with 2.5 plants m^{-2}. Treatment factors were cultivar, organic fertiliser level (zero and 100 kg N/ha horn splinter) and harvest time [two different ripening stages, early (comparable with colour no. 8; The Greenery, 2004) and optimum harvest time (comparable with colour no. 12; The Greenery, 2004)]. All cultivars differed in colour, shape, size and maturity. Seven tomatoes (three from *Ananas*) of each variety were analysed to describe general physio-chemical parameters, *viz*. fruit size, shape, colour, average fruit weight, firmness, acidity (by titration), sugar content (enzymatic with test kit) and phyto-chemicals [ascorbic acid (enzymatic with test kit); lutein, chlorophyll b, β-carotene and lycopene (HPLC)]. In order to describe the taste of the cultivars, customer preference was assessed by interviewing more than 550 consumers using a questionnaire (by semantic differential). Results from chemical analyse were evaluated by analysis of variance (ANOVA, $p<0.05$) using SAS 9.1 for Windows. The significant differences in the analytical data were calculated with the Tukey HSD test (α = 5 %).

Results and brief discussion

Ascorbic acid and carotenoids

The red- and orange-coloured cultivars *Lukullus* and *Auriga* had a high concentration of ascorbic acid (23 and 21.9 mg 100 g^{-1}, respectively) compared with the yellow and green cvs. *Ananas* and *Green Zebra* (15.1 and 11.3 mg 100 g^{-1}, respectively) (Table 1). Optimal harvest time gave a higher vitamin C content compared with early harvest. Increased organic nitrogen fertilisation had no influence on vitamin C content, confirming other results where increased levels of N-fertilisation were shown to have no effect or to decrease the vitamin C content of many fruits and vegetables (Köpke, 2005).

The highest concentrations of chlorophyll b and lycopene were found in *Lukullus,* while *Auriga* had the highest concentration of β-carotene. No β-carotene or lycopene was detected in *Green Zebra.* Nitrogen fertilisation had no significant influence on chlorophyll b and β-carotene, whereas lycopene content was significantly increased by organic N-fertilisation. No significant interactions between the experimental factors and ascorbic acid or carotenoid content were noted.

Table 1: Effect of cultivars, harvest time and organic N-fertilisation on ascorbic acid and carotenoids (lutein, chlorophyll b, ß-carotene and lycopene) content of tomatoes (mg $100g^{-1}$FM). (Tukey-test)

	Phytochemicals				
Treatments	**Ascorbic Acid**	**Lutein**	**Chlorophyll b**	**ß-carotene**	**Lycopene**
Ananas	15.1 b	0.0 a	0.0 b	0.4 c	2.0 b
Auriga	21.9 a	0.0 a	0.2 c	4.8 a	1.2 c
Green Zebra	11.3 c	0.1 a	0.4 b	0.0 d	0.0 d
Lukullus	23.0 a	0.1 a	0.5 a	0.8 b	8.9 a
with fertilizer	18.0 a	0.1 a	0.3 a	1.5 a	3.3 a
without fertilizer	17.4 a	0.1 a	0.2 a	1.5 a	2.9 b
early harvest	16.9 b				
optimum harvest	18.6 a	Only optimal harvested tomatoes were analysed			

Citric acid and sugar content

The citric acid concentration of the four cultivars showed a large variation and was significantly different (Table 2). *Auriga* had the highest concentration (0.48 g $100g^{-1}$) followed by *Green Zebra* (0.43 g $100g^{-1}$), while *Lukullus* and *Ananas* exhibited a lower citric acid content (0.25 and 0.20 g $100g^{-1}$). The average content of citric acid given in the literature is 0.44 g $100g^{-1}$ (Souci *et al*., 1994). Neither organic N-fertilisation nor harvest time resulted in significant influence on citric acid. No significant interactions between the experimental factors were observed for citric acid content.

Table 2: Effect of cultivars and different harvest times on the citric acid and sugar (glucose, fructose, total) content of tomatoes (g $100g^{-1}$FM). (Tukey-test)

	Ingredients			
Treatments	**Citric Acid**	**Glucose**	**Fructose**	**Total Sugar**
Ananas	0.20 d	3.25 a	3.91 a	7.15 a
Auriga	0.48 a	1.25 c	1.90 b	3.15 c
Green Zebra	0.43 b	1.54 bc	1.71 b	3.25 c
Lukullus	0.25 c	1.88 b	1.97 b	3.85 b
with fertilizer	0.34 a	1.97 a	2.37 a	4.34 a
without fertilizer	0.34 a	1.99 a	2.39 a	4.35 a
optimal harvest	0.33 a	2.01 a	2.56 a	4.65 a
early harvest	0.34 a	1.84 a	2.18 b	4.05 a

The cultivar *Ananas* had the highest glucose content (3.25 g $100g^{-1}$). The other three cultivars had a lower concentration, whilst *Lukullus* (1.88 g $100g^{-1}$) showed a significant difference to *Auriga* (1.25 g $100g^{-1}$) but not to *Green Zebra* (1.54 g $100g^{-1}$). The harvest time had no influence on glucose content. A similar result was gained for the fructose content. The cultivar *Ananas* had the highest fructose concentration (3.91 g $100g^{-1}$) while *Lukullus, Auriga* and *Green Zebra* had lower contents and were not significantly different (1.97 g $100g^{-1}$, 1.90 g $100g^{-1}$ and 1.71 g $100g^{-1}$, respectively). The sugar content of these three cultivars is comparable with results from Auerwald *et al.* (1999). Whether the high sugar content of *Ananas* can be confirmed will be shown in the following trials. One possible reason could be the high share of pericarp in this cultivar, because the sugar content of the pericarp is higher compared with that of the lucolar (Winsor *et al.*, 1962; Stevens *et al.*, 1977). In contrast to the results determinated for glucose, the optimal harvest gave a higher fructose content compared with early harvest. This difference is attributed to the high fructose content in *Ananas*, where the optimal harvest (4.66 g $100g^{-1}$) is significant to the early harvest (3.16 g $100g^{-1}$). The other three cultivars did not differ significantly.

Consumer survey

The cultivar *Ananas* was characterised as a sweet and smooth tomato with an appealing appearance. The high glucose and fructose content and the low citric acid content (Table 2) support the test results from the consumers (Figure 1). A high sugar content and low acid content generally result in a bland taste (Atherton and Rudich 1994). The sensoric attributes of *Auriga* were described as aromatic and flavoursome. The peel was felt as harder and a little bit firmer in comparison to the other cultivars. The high citric acid content and the low sugar content were not described by the consumers. A possible reason for this were other secondary metabolites, which were responsible for a sweeter taste sensation.

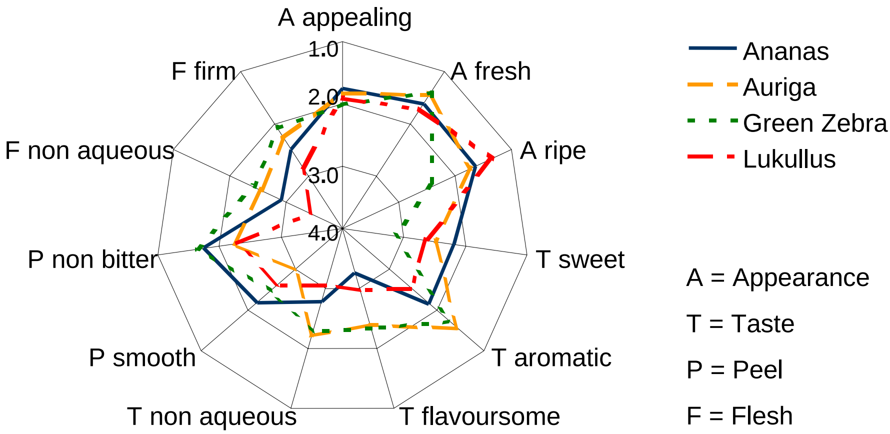

Figure 1: Radar diagram of the consumer survey given by 550 interviewed persons in a range between 1 (very good/ preferred) to 6 (very bad/rejected) on the four cultivars *Ananas*, *Auriga*, *Green Zebra* and *Lukullus*.

Green Zebra was identified and ranked as acidic and aromatic, additionally as a rather immature fruit due to its green colour. Nevertheless, the consumers described the appearance as appealing and the high citric acid and the low sugar content were confirmed. *Lukullus* was described as soft and a little bit aqueous, thus this cultivar had no true tomato taste. The relative high sugar contents were not identified in the tasting. The consumers generally scored *Auriga* as the best tomato with respect to flavour and taste.

Conclusions

With an average yield of 12 kg m^{-2} these old cultivars were competitive with those tomato cultivars currently dominating the organic market (Lindner, 2004; Koller, 2005). The cultivars *Lukullus* and *Auriga* contained the highest concentration of various health-promoting phytochemicals (ascorbic acid, β-carotene and lycopene). *Auriga* and *Green Zebra* had the highest citric acid content, while *Ananas* showed the highest sugar concentration. The management practices (fertiliser and harvest time) had no evident influence on the analysed ingredients. The consumers characterised the cultivar *Ananas* as sweet and smooth while *Green Zebra* was characterised as more aromatic.

Each of the multicoloured cultivars has its typical properties. Therefore, we recommend a set of the different tomato cultivars to be sold and prepared in order to combine flavour, taste and shape with higher concentrations of beneficial phytochemicals. Furthermore, this strategy applied in regional markets could guarantee biodiversity in tomatoes through organic farming under economic conditions.

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ORGANIC FOOD AND HEALTH – STATUS AND FUTURE PERSPECTIVES

Charlotte Lauridsen[1], Henry Jørgensen[1], Ulrich Halekoh[2] and Lars Porskjær Christensen[3]

[1]Danish Institute of Agricultural Sciences, Research Centre Foulum, P.O. Box 50, 8830 Tjele, Denmark, +45-89 99 12 38, charlotte.lauridsen@agrsci.dk, http://www.agrsci.dk
[2]Danish Institute of Agricultural Sciences, Research Centre Foulum, P.O. Box 50, 8830 Tjele, Denmark, +45-89 99 11 30, henry.jorgensen@agrsci.dk, http://www.agrsci.dk.
[3]Danish Institute of Agricultural Sciences, Research Centre Foulum, P.O. Box 50, 8830 Tjele, Denmark, +45-89 99 18 250, ulrich.halekoh@agrsci.dk, http://www.agrsci.dk.
[4]Danish Institute of Agricultural Sciences, Research Centre Aarslev, Kirstinebjergvej 10, 5792 Aarslev, Denmark, + 45-89 99 33 67, larsp.christensen@agrsci.dk, http://www.agrsci.dk.

Key Word: Cultivation methods, rats, vitamin E, rapeseed oil, activity, immunity

Abstract

The effect of three iso-energetic and iso-nitrogeneous diets composed of ingredients originating from three different cultivation systems (“Organic”, low input of fertilizer without pesticides; “Minimally fertilised”, low input of fertilizer and high input of pesticides, “Conventional”, high input of fertilizer and high input of pesticides) was investigated with respect to several physiological responses and biomarkers of health using a rat model. The diets were optimized according to the nutritional requirements of rats, except for a high content of fat. The diets consisted of equal proportions of potatoes, carrots, peas, green kale, apples, and rapeseed oil, which were grown according to three different cultivation systems. Even though most of the measured variables (biomarkers of health) showed no differences between the experimental diets, the actual recorded differences were all likely to be in favour of the “organic” diet contrasted with the “conventional” diet. However, the results presently obtained cannot be extrapolated to all organic and conventional cropping systems, mainly because crops were grown only in one replication. Thus, it is of outmost importance that future investigations on the effect of organic food in relation to human health and well-being should be based on well-defined and controlled food produce system with replications.

Introduction

Quality and safety of food are important issues which receive ever-increasing attention in the general public. The consumption of organic foods has been steadily increasing during the last decade, particularly in Western countries (Meier-Ploeger 2005). Many consumers perceive organic foods as being of better quality, healthier and more nutritious than food produced using conventional methods. However, research on possible impacts on animal and human health is sparse (Williams 2002). Moreover, the majority of studies reported in the literature are outdated because the practices in both organic and conventional agriculture have changed over time. According to a Danish knowledge-synthesis reviewing the scientific literature (O’Doherty Jensen *et al.* 2001), there is no evidence which in an incontestable way support or refute such perceptions.

A large number of studies have addressed the question “whether organic food is more beneficial for health than conventional one”, and most of these studies have measured the content of well-known vitamins or minerals in plant foods of more or less controlled origin and conclude that there are relatively small but often significant differences. There are reasonably consistent findings for higher nitrate and lower vitamin C contents in conventional vegetables (amongst others Woese *et al.* 1997). However, since the optimal dietary intakes are still unknown both for nitrate (McKnight *et al.* 1999) and for vitamin C (Benzie 1999), it is not yet possible to extrapolate from such composition differences in the food to possible effects on health. Other studies indicate that the most systematic differences between organic and conventional crops are the contents of secondary metabolites (Brandt & Mølgaard 2001). Besides the Danish knowledge-synthesis evaluating the relationship between organic food and human health (O’Doherty Jensen *et al.* 2001), the issue has been studied in some recent publications: Finamore *et al.* (2004) concluded that conventional wheat represented a higher risk for lymphocyte function than those grown organic. In addition, the growing conditions of fruits and vegetables (conventional vs. organic) affected the content of five selected flavonoids and resulted in differences in the urinary excretion of major dietary flavonoids that are markers of oxidation in humans (Grinder-Pedersen *et al.* 2003).

When addressing the question if "organic foods are more healthy than conventional foods", it is essential to consider the term "health". According to WIKIPEDIA, "health can be defined negatively, as the absence of illness, functionally, as the ability to cope with everyday activities, or positively, as fitness and well-being. In any organism, health is a form of homeostasis. This is a state of balance, with inputs and outputs of energy and matter in equilibrium (allowing for growth). Health also implies good prospects for continued survival. In sentient creatures such as humans, health is a broader concept". The present study was conducted using a well-controlled rat-feeding experiment comparing three iso-energetic and iso-nitrogeneous diets composed of vegetables and a high content of rapeseed oil (13 %), produced according to each of three different cultivation systems. The purpose of the study was to investigate whether a difference in growing conditions of the feed plants would affect any of a range of physiological responses indicative of "health" using a rat model, being characterized as non-insulin dependent diabetes mellitus, type II diabetes and non-obese.

Methodology

The experiment was performed with 36 rats that were fed on three diets consisting of potatoes, carrots, peas, green kale, apples, and rapeseed oil. The difference between the three diets was the three combinations of cultivation strategies used to grow the used ingredients:

- "Organic": low input of fertiliser through animal manure and without pesticides
- "Minimally fertilised": low input of fertiliser primarily through animal manure and with pesticides
- "Conventional": high input of mineral fertiliser and with pesticides

Each ingredient type was cultivated according to standard practice for the crop in terms of e.g. levels fertilizer and timing of pesticide applications. For each crop all treatments were carried out on the same or adjacent experimental fields, which were divided according to the three cultivation strategies, so that the cultivation took place in similar soils and under similar climatic conditions, and the ingredients were harvested and treated at the same time.

The three experimental diets had exactly the same formulation (300.0 g kg^{-1} potato, 50.0 g kg^{-1} carrot, 472.4 g kg^{-1} pea, 10.0 g kg^{-1} green kale, 10.0 g kg^{-1} apple, 130.0 g kg^{-1} rapeseed oil, 6.4 g kg^{-1} DL-methionine, 12.5 g kg^{-1} $CaCO_3$, 0.7 g kg^{-1} salt, and 8.0 g kg^{-1} vitamin/mineral mixture), and the diets were iso-energetic (gross energy 21.2 ± 0.14 MJ kg^{-1} DM, metabolisable energy 18.0 ± 0.14 MJ kg^{-1} DM) and iso-nitrogeneous (crude protein 160.7 ± 0.2 g kg^{-1}), and contained in addition the following main nutrients (mean ± SD): dry matter 966.7 ± 5.0 g kg^{-1}, HCl-fat 156.5 ± 1.6 g kg^{-1}, ash 41.4 ± 0.5 g kg^{-1}, crude fiber 56.3 ± 1.6 g kg^{-1}, dietary fiber 179.3 ± 2.1 g kg^{-1}, calcium 6.8 ± 0.1 g kg^{-1}, total phosphorus 3.4 ± 0.1 g kg^{-1}, lysine 10.8 ± 0.2 g kg^{-1}, and methionine + cystine 9.7 ± 0.4 g kg^{-1}. The pesticide level was determined by the Regional Veterinary and Food Control Authority Copenhagen, Danish Veterinary and Food Administration, and was found to be below the detection limit. The rats received the same diets throughout their entire life and the measurements of their health status started after weaning of their first litter (age, 19 weeks; weight, 212 g). The following measurements were used to assess rats' health status:

- Clinical health and disease
- Utilisation of nutrients
- Energy metabolism
- Physical activity
- Functions of organs and intestine
- *Post mortem* evaluation of organs
- Analyses of biomarkers and nutritional status in blood and tissues
- Analyses of immune response

Results and Discussion

Analyses of the primary nutrients showed no differences between the three diets. However, with regard to the analyzed contents of vitamins and fatty acids, differences among the three diets appeared as the content of vitamin E and C18:2 were lower, and the C18:1 higher in the "minimally fertilised" than the other dietary treatments. The rats thrived on all three diets, and showed only minor differences with respect to utilisation of energy and nutrients. Even though the rats were genetically disposed for diabetes, there was no visual sign of this disease among the rats. The rats had only a slight increase in weight after eating the diets for 25 weeks. However, the data showed a tendency towards a lower weight and a lower content of adipose tissue in the rats that were fed on the organic diet as compared to the other diets.

Concurrently with the measurements of energy utilisation, the physical activity of the rats was measured using infrared sensors. Rats are active at night, and there were no differences between the dietary groups with respect to activity at night. However, during daytime, when the rats are supposed to rest, the data indicated that rats fed on the organic diet were more relaxed (less active) than rats fed on the other diets. This result may therefore be interpreted as positive, in the sense that more uninterrupted sleep could indicate that the rats were less stressed. It appears that physical activity is influenced by a number of parameters (Tou & Wade 2002). In their review, it was found that regardless of the parameter involved, body weight appears to play an underlying role in the regulation of activity, and furthermore, the regulation of activity associated with body weight appears to occur only after the animal achieves a critical weight. However, in the present study it cannot be excluded that the obtained trends regarding the dietary influence in the physical activity of rats was indirectly related to the weight differences and accumulation of adipose tissue.

Rapeseed oil comprised 25 pct. of the energy content of the diets, and as expected from previous studies on monogastric animals (Lauridsen *et al.* 1999) the differences in dietary fatty acid composition clearly reflected the higher proportion of oleic acid and lower proportion of linoleic acid in adipose tissue of rats fed the minimally fertilised diet. Also, the vitamin E content was lower in blood plasma from rats that received the minimally fertilised diet. The content of vitamin E in the "organic" and the "conventional" diet was similar. Yet, there was a higher content of vitamin E in the blood of the rats that were fed the "organic" diet. This could be health beneficial as vitamin E is an antioxidant protecting the cells from oxidative injury. There were no differences in the vitamin E content of liver and adipose fat tissue between rats from the three dietary groups.

Immune status of the rats was measured as the total content of immunoglobulins in the blood serum. The results showed that rats fed on "organic" and "minimally fertilised" diets had a higher content of immunoglobulin G (IgG) than rats fed on the "conventional" grown diet. There were no differences in the serum contents of immunoglobulins A and M. At present, no explanations are available with regard to the lower content of IgG in the rats that were offered the conventional grown diet. Yet, it is noteworthy that the conventional diet had a higher content of the secondary metabolite falcarindiol than the other diets. Carrots are the source of falcarindiol and other closely related polyacetylenes, such as falcarinol, in the diets with falcarinol clearly being the most bioactive of the carrot polyacetylenes having for example immune stimulating properties (Hansen *et al.* 1986). However, as the physiological effects of falcarindiol are expected to be qualitatively similar but quantitatively less than for falcarinol (Kobæk-Larsen *et al.* 2005), it cannot be excluded that falcarindiol may interact with falcarinol in an antagonistic manner thereby affecting its bioactivity. This could explain the lower content of IgG in the rats that were offered the conventional grown diet, as the content of falcarinol was not significantly different in the three diets. Further, it cannot be excluded that falcarindiol by it self can have an inhibitory effect on initiation of the immune response (Seon *et al.* 2002).

Conclusions

The primary conclusions from our study can be summarised as follows: The organic and conventional foods showed differences in immune status, sleep/activity pattern, accumulation of adipose tissue, liver function and vitamin E status, while traditional measures of nutrient value were unaffected by the production method of food (organic vs. conventional). All the observed differences were likely to indicate favourable effects of the organic diets.

The findings cannot be linked to organic nor conventional production systems in general because this study suffered (like most other studies reported in the literature) from the fact that only one replication per food produce was used in the animal studies. Hence, differences could not be evaluated with respect to important sources of variation as field-to-field variation. In addition, it was not possible to relate the responses of animals to the diet composition due to the limited number of replicates. Thus, it is of utmost importance that future investigations on the effect of organic food on human health and well-being should be based on experimentation of well-defined and well-controlled food produce system with replications of the food production systems, with special emphasis on both the systematic and random variation between different systems of food produce. Special emphasis should be given to explore links and explain overall relationships between the nutritional quality and biomarkers of health.

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EFFECT OF AGRONOMIC MANAGEMENT PRACTICES ON LETTUCE QUALITY

Sabine Rattler[1], Karlis Briviba[2], Barbara Birzele[3], Ulrich Köpke[1]

[1]Institute of Organic Agriculture, University of Bonn, Katzenburgweg 3, 53115 Bonn, Germany, E-mail: Sabine.Rattler@uni-bonn.de, Internet: www.iol.uni-bonn.de

[2] Federal Research Centre of Nutrition and Food, Karlsruhe

[3] Institute for Nutrition and Food Science, Food Microbiology and Hygiene, Bonn

Key Words: lettuce, food quality, agronomic strategies, nitrate, secondary metabolites, enteric bacteria

Abstract

The effect of different agronomic strategies on the nutritional quality of head lettuce was investigated. The factors included were irrigation type, fertiliser input type and level. The assessed ingredient parameters were nitrate, lutein, ß-carotene and polyphenols. Hygiene was described by total aerobic bacterial count and number of coliform bacteria, *Escherichia coli, Salmonella enteritidis, Enterococcus* and *Enterobacteriaceae*. Lettuce treated with mineral nitrogen fertiliser (calcium ammonium nitrate) displayed a higher nitrate content than lettuce treated with organic manures (fresh farmyard manure (FYM), rotten FYM (fermented nettle extract). Nitrate concentration in lettuce tended to increase with increasing amounts of fertiliser, independent of fertiliser type. Fertiliser type and level also affected the carotenoid content. Rapidly available nitrogen from mineral fertiliser gave higher lutein levels compared with slowly released nitrogen. Similar results were observed for ß-carotene. There were no obvious differences regarding polyphenols for the different modes of fertiliser input. The bacteriological quality was only marginally or not at all influenced by the type of fertiliser.

Introduction

Public concern about food quality and safety is steadily increasing. The judgement of fresh vegetables depends on visual characteristics as well as on nutritional quality. The idea of nutritional quality includes beneficial and harmful ingredients, taste, fragrance, freshness and shelf-life (Köpke, 2005) as well as the risk of toxic pathogens (Sagoo *et al*., 2001). Regarding lettuce, the marketable and nutritional quality depends heavily on the agronomic strategy used. Fast release of nitrogen (N) from fertilisers or a surplus of N can lead to an increase in nitrate content of plant tissues (Vogtmann *et al*., 1984; Sørensen *et al*., 1996), synthesis of N-containing compounds and a decrease in beneficial phytochemicals (Brandt *et al*., 2001). Contamination with enteric bacteria has been postulated for lettuce and other vegetables (Doyle, 1990). Therefore, the aim of our study was to assess the effect of different fertiliser types and application levels on desirable and undesirable ingredients, including the risk of transfer of enteric bacteria from organic fertilisers by the splash effect of raindrops or overhead irrigation.

Methodology

Field experiments

Head lettuce was grown in a three-factorial field experiment with 4 replications in two different seasons during 2004. The field trials were located on the organic research farm 'Wiesengut' in North-Rhine Westphalia, Germany (50°48'N, 7°17'O). Treatments were fertiliser input types (fresh farmyard manure (FYM), composted FYM, fermented nettle extract (*Urtica dioica*), calcium ammonium nitrate (CAN) combined with fertiliser input levels of 85 kg N/ha and 170 kg N/ha, respectively. During the rainy summer 2004, no differentiation by the third factor, irrigation (overhead vs. tap irrigation), was given, resulting in 8 replications for the fertiliser treatments. Fertilisers were incorporated into the soil using a mouldboard plough. The first trial was planted in May and the second in August. With the exception of mineral N-fertiliser application, the experiments were conducted according to the rules of Organic Agriculture. The plants were harvested at optimal maturity. The assessed parameters were nitrate, lutein, ß-carotene, polyphenols, level of total aerobic bacterial count (CFU: colony forming units), numbers of coliform bacteria, *E. coli*, *Enterobacteriaceae*, *Enterococcus* and *Salmonella enteritidis*.

Analysis

For nitrate and secondary metabolites analysis, lettuce heads were quick-frozen and shredded after removal of outer leaves. The nitrate content was determined by continuous-flow techniques, carotenoids were analysed by HPLC techniques, and polyphenols by Folin-Ciocalteu assay. For microbiological investigations, lettuce heads were shredded under sterile conditions. A pooled sample was analysed using standard microbial detection and quantification assays. Results were statistically evaluated by ANOVA and Tukey test.

Results and brief discussion

Nitrate content was a function of fertiliser type and input level. In the spring trial, lettuce treated with mineral N-fertiliser had a higher nitrate content than the organically fertilised lettuce. This can be explained by the slower and continuous release of nitrogen from organic manures. Several studies confirmed that the nitrate content of organically grown vegetables is often lower than of vegetables treated with mineral-N fertiliser (Augustin *et al.*, 1977; Leclerc *et al.*, 1991). An increased level of all fertiliser types tended to result in an increased nitrate content. A conclusion about significances in the spring trial was not possible, because the data were not normally distributed. In the summer trial, lettuce treated with mineral-N fertiliser had a significantly higher nitrate content than organically fertilised lettuce. The increased level of mineral N-fertiliser resulted in a significantly higher nitrate content, while that of organic fertiliser (composted manure only) resulted in a significantly lower nitrate content. On the other hand, increased levels of fresh manure and nettle extract tended to lead to higher nitrate contents.

Fertiliser type and level also affected the lutein content (Table 1). In both trials, the application of fresh and composted manure resulted in significantly lower lutein contents than with fertilisers that release nitrogen more rapidly. Increased fertiliser levels caused significantly higher lutein content. Fertiliser type and level also affected the ß-carotene content. The spring trial showed an interaction between fertiliser type and level. Low levels of fresh and composted manure resulted in a significantly lower ß-carotene content than the same levels of nettle extract and mineral N-fertiliser. An increased level of composted manure showed a significantly increased ß-carotene content, while a higher level of fresh manure, nettle extract and mineral fertiliser showed no effect. In the summer trial, no interactions between fertiliser type and level were determined. Lettuce treated with fresh and composted manure had a significantly lower ß-carotene content compared with lettuce treated with nettle extract and mineral N-fertiliser. An increased level of all fertiliser types resulted in a significant increase in ß-carotene content. The polyphenol content was not affected by fertiliser type and amount in the spring trial. In the summer trial, fresh and composted manure application resulted in significantly lower levels compared with mineral N-fertiliser. A higher fertiliser level did not affect the polyphenol content for all fertiliser types. While there were no differences between the seasons with respect to lutein content, significant interactions between the experimental factors and the seasons were assessed for fertiliser and season for the parameters ß-carotene and polyphenol. The polyphenol content of lettuce fertilised with organic fertilisers was lower in plants grown in late summer than in crops grown in late spring. An application of mineral N-fertiliser in the spring trial resulted in a lower polyphenol content than in the summer trial. Similar to the polyphenols, the ß-carotene content of lettuce fertilised with organic fertilisers was lower in summer-grown plants than in spring-grown plants. The ß-carotene content of lettuce fertilised with mineral N-fertiliser was not affected by the season. These findings suggest an environmental influence on the ß-carotene and polyphenol formation in lettuce treated with organic fertilisers. Seasonal differences in ß-carotene and lutein levels between winter- and summer-grown kale cultivars were also reported by Mercadante and Rodriguez-Amaya (1991).

In the spring trial, no effect of fertiliser input type on bacteriological quality was observed. *Escherichia coli* and *Salmonella* e*nteritidis* were not detected in any sample. When lettuce was fertilised with mineral N-fertiliser in the summer trial, total aerobic bacterial count and the level of coliform bacteria and *Enterobacteriaceae* were significantly lower compared with lettuce treated with organic manures. Independent of the type of fertiliser, *Escherichia coli* was only isolated in very low numbers (>10< 100 CFU/g). There were three positive *Escherichia coli* samples in lettuce treated with fresh FYM, one positive sample in lettuce fertilised with composted FYM, two samples in lettuce fertilised with fermented nettle extract, and four positive samples in lettuce treated with CAN. *Salmonella enteritidis* was not detected in any sample.

Table 1: Lutein, ß-carotene and polyphenol content (µg per g fresh weight) of lettuce growing in late spring and late summer 2004.

Treatment	Lutein		ß-carotene		Polyphenols	
	Spring	Summer	Spring*	Summer	Spring	Summer
Fresh FYM	5,83 b	4,76 b	6,30 b*	3,68 c	80,75 a	75,76 b
Composted FYM	6,64 b	5,30 b	7,02 ab*	3,79 c	90,92 a	72,03 b
Nettle extract	8,16 a	7,49 a	8,04 a*	5,92 b	89,93 a	82,95 ab
CAN	7,95 a	8,88 a	7,83 a *	7,69 a	86,79 a	95,28 a
Fertiliser level 85 kg/ha	6,68 b	6,07 b	6,95 b*	4,76 b	84,42 a	80,35 a
Fertiliser level 170 kg/ha	7,60 a	7,15 a	7,64 a*	5,78 a	89,77 a	81,16 a

Significance of differences (α=0.05) between treatments within season (column) are denoted by different letters (Tukey test)

*significant interactions between fertiliser type and level

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Table 2: Total aerobic bacterial count, coliform bacteria, *Enterobacteriaceae* and *Enterococcus*, *Salmonella* and *E. coli*, for lettuce growing in late spring and late summer 2004 ($\log_{10}$ colony forming units/g).

Enteric bacteria		Fresh FYM	Composted FYM	Nettle extract	CAN
Total aerobic bacterial count	Spring	6,76 a	6,24 a	6,33 a	6,35 a
	Summer	6,36 a	6,39 a	6,35 a	5,68 b
Coliform bacteria	Spring	5,78 a	6,07 a	5,40 a	5,89 a
	Summer	5,21 a	5,30 a	5,12 a	4,03 b
Enterobacteriaceae	Spring	6,20 a	6,08 a	5,63 a	6,01 a
	Summer	6,27 a	6,26 a	6,13 a	5,28 b
Enterococcus	Spring	2,82 a	2,67 a	2,85 a	3,08 a
	Summer	1,10 b	2,42 a	1,88 a	2,36 a
Salmonella	Spring	0*	0*	0*	0*
	Summer	0*	0*	0*	0*
E. coli	Spring	0*	0*	0*	0*
	Summer	3*	1*	2*	4*

Significance of differences (α=0.05) between treatments within season (lines) are denoted by different letters (Tukey-test)
*number of positive samples with >10<100 CFU/g (n=16)

The results of the spring trial are in agreement with results published by Johannessen *et al.* (2004), which did not detect any impact of fertiliser type on the bacterial quality of lettuce. These findings suggest that there is no negative effect of untreated manure on bacteriological quality. Differences observed in the summer season trial are probably due to weather impact. Johannessen *et al*. (2004) explained variations between two trials through different temperatures and precipitation. The absence of *Salmonella enteritidis* in both trials is in agreement with studies of McMahon and Wilson (2001), which did not detect any Salmonella in organic vegetables.

Conclusion

The results confirm that readily available N from mineral fertiliser can increase the nitrate content of lettuce tissue. On the other hand, the level of anticarcinogenic carotenoids also tended to increase after mineral N-fertiliser application. The microbiological results suggest that fertiliser type does not, or only slightly, affect the hygienic quality of lettuce when manures are incorporated into the soil and not left on the soil surface or in the upper soil layer. Thus, an adequate agronomic practice of cultivating lettuce can ensure a high hygienic quality of the produce.

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THE CONSISTENTLY SUPERIOR QUALITY OF CARROTS FROM ONE ORGANIC FARM IN AUSTRIA COMPARED WITH CONVENTIONAL FARMS

Alberta Velimirov

A – 1020 Vienna, Franz-Hochedlingergasse 3/11, albiveli@yahoo.com

Key Words: Organic Farming, product quality, carrots, food preference test, decomposition test, sensory evaluation, P-value

Abstract

The aim of this 5 year investigation was to compare quality parameters of differently cultivated carrots of the same cultivar grown in the same region as well as to compare the relevance of different methods of analysis to differentiate between these products.

The following quality tests were applied: Sensory tests (all harvests); Food preference tests with laboratory rats (all harvests); Decomposition tests (all harvests); P-value determination (all harvests); Single-Photon-Counting (1999) and Chemical analysis of the main components (1998 and 1999).

It could be shown that carrots (var. *Tarvil*) grown using an organic farming method were significantly preferred by humans and laboratory rats, lost significantly less dry matter during decomposition, had lower P-values, indicating better bioelectrical properties, revealed a significantly better capacity to store biophotons, but showed no conclusive differentiation concerning their main components. Holistic methods were well qualified to distinguish organic from conventional carrots on significant levels.

Introduction/Problem

Ever since organically produced food has reached the markets, gaining higher prices for environmentally friendly production, the dispute about possible quality advantages has been going on. In the last 10 years, a number of comprehensive revisions of relevant scientific investigations have been published with the aim of coming to a final conclusion about “organic quality” (Woese *et al.* 1995; Alföldi *et al.* 1998; Worthington 1998; Heaton for the Soil Association 2001; Bordeleau *et al*. 2002; Bourn & Prescott 2002; Tauscher *et al*. 2003; AFSSA 2003; Velimirov & Müller 2003b). In short, the data on nutritional quality of organic in comparison to conventional produce are inconclusive, whereas the results of holistic methods seem to be more promising to reflect quality differences. In other words, there is enough cumulative evidence to indicate better quality in organic food for anyone who wishes to be convinced, such as lower levels of pesticide residues and nitrate, higher contents of minerals and secondary metabolites, better flavour and so on. But there are also enough conflicting results for anyone who is not a fan of organic to reach the conclusion that the reported differences do not justify any claims to a superior quality of organic food.

Methodology

The purpose of the studies presented here was yet again to investigate quality differences induced by production methods. Organic and conventional carrots (cultivar *Tarvil*) from 5 harvests (1998, 1999, 2001-2003) have been compared in relation to different quality aspects. They were grown in the same region near Vienna (Marchfeld), thus assuring comparable sites and climatic conditions. The production methods were monitored each year, soil samples were compared in the first 2 years to ascertain the comparability of soil type and physical soil properties.

All carrots were of good commercial quality according to the Austrian market regulations and are sold in Viennese supermarkets. In the first 2 years, the test carrots were also routinely analysed for their main components: nitrate, carbohydrates (glucose, fructose, saccharose), K, P, Fe, organic acids (malic and citric acids), carotinoides, dry matter and ash. A more global understanding of biological systems and interactions has led to the thesis, that life is more than the sum of all parts. Therefore, the comparison has been focussing on holistic methods:

Sensory evaluation

The applied difference test was the Extended Triangle Test with the following procedures: three samples of grated carrots are presented, two are alike, one is different. The different sample has to be defined and characterised. The third task is to state any preferences. Thus, objective – differentiation – and subjective –

preference – aspects can be tested in one test. 20-70 test persons (untrained consumers) have participated. For the preference evaluation only the choices of the participants who could identify the aberrant sample in the Triangle Test have been used.

Food preference tests with laboratory rats

The food preference tests are carried out with 20 - 40 adult male laboratory rats (Long Evans strain), kept separately in Macrolon cages size III, under air conditioning at 22°C and 55% rel. humidity. The basic diet for all test animals (conventionally feed mixture T 779 by Tagger Co.) is supplied in the cages, in order to prevent any deficiency symptoms. A partition containing the water bottle divides the feeding rack into a right and a left section, into which a defined amount of the two test products is apportioned simultaneously. The remainders of the feed are weighed 24 hours later in order to determine the quantity consumed. At this time, new feed is also supplied. Differences in the rate of evaporation of the examined feeds are quantified with control samples used in every test run. The sides are changed with every meal in order to prevent the effect of "position preference". Each test run is conducted over a period of one week.

Decomposition test

The samples are washed, dried and shredded with a coarse household shredder. 20 g each are weighed into petri dishes. At the beginning the dry matter content of the shredded material is determined. After a defined period of incubation (at 20° C, 50 rel. humidity, in darkness), the samples are dried at 85°C and weighed to determine the loss of dry matter.

P-Value determination

(The measurement of the electrochemical parameters have been carried out at the Institute of Fruit Growing and Horticulture, University of Agricultural Sciences in Vienna with the help of R. Krautgartner, B. Meltsch and R. Kappert)

The juice of washed plant material is extracted from the plants using a customary household juicer, homogenised and immediately measured by usual electrodes connected to compatible meters. In terms of the calculation of temperature-compensated values, the temperature of the samples is noted. The data for pH-value and conductivity are noted after the electrodes have come to their level. For the redox potential there is a continuous data collection during a certain period of time. From these three measured parameters the so called P-value (Hoffmann 1991) is calculated.

Single-Photon-Counting

(M. Lenzenweger conducted this investigation at the Atomic Institute of the Technical University of Vienna, with the help of Prof. Dr. H. Klima).

Carrot slices of the same size were put under a 100 Watt light bulb for 2 minutes. After 30 seconds the biophoton emission was measured for 10 minutes.

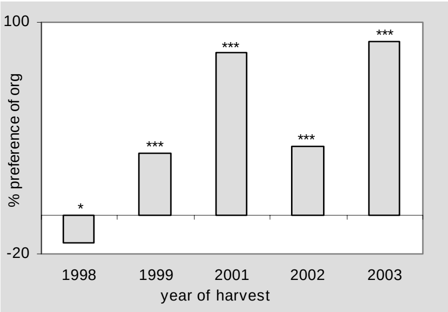
Results and brief discussion

The organic carrots were certified according to the regulations of the farmers´ association "Ernte", the conventional method used was customary in the Marchfeld. Main differences were the use of mineral fertilisers and biocides in the conventional cultivation as well as the use of treated seeds (Thiram / Iprodione Metalaxyl). In the first two years, soil samples and carrots were routinely analysed. There was more NO_3-Nitrogen, potassium, and lead in the conventional soil, the other values were similar. The analytical values corresponded with the soil contents as far as potassium was concerned. Accordingly, there was also more malic acid in the conventional carrots. The sugar and dry matter contents were higher in the organic variant, whereas the contents of phosphorous, ash and carotinoides were lower. The contents of nitrate, iron, and citric acid showed hardly any differences.

The taste of products is a very important determinant of consumer choices. Published sensory tests with carrots resulted in either no difference (Minnaar 1996), a preference of the conventional variant (Kopp 1993) or a preference of organic carrots resp. products from low input systems (Abele 1987).

The results of the sensory tests presented here showed that in all cases significantly more testers were able to differentiate between the test samples and in that four out of the five tests the organic carrots were significantly preferred by mixed groups of consumers, not expert tasters (Fig. 1). According to the participants the organic carrots excelled in their carrot-typical taste and intense flavour as well as in juiciness and sweetness.

These results correspond to the significant preferences of the organic carrots by laboratory rats. It has been well documented that animals are able to select a diet appropriate to their metabolic needs. So far it has been postulated that for animals to be able to choose, at least one of the offered foods has to be nutritionally unbalanced, otherwise there would be no benefit in choosing (Sclafani 1995). But food preference tests with laboratory rats have shown that even in cases of no apparent imbalance significant preferences take place (Fig. 2).



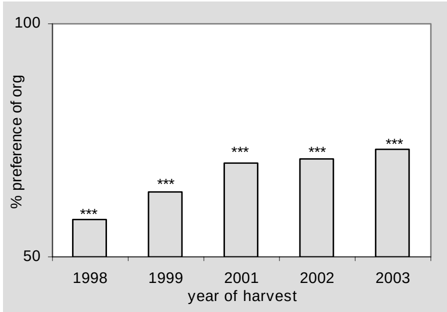
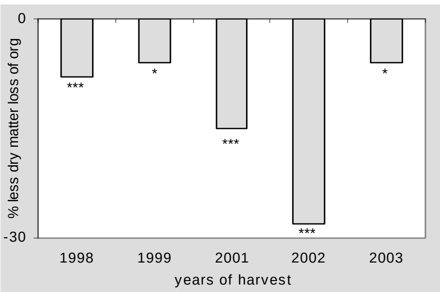


Fig. 1: Sensory tests (p = 0, 215) **Fig. 2: Food preference tests (p = 0,003)**

(* p=0,05; ** p=0,01; *** p=0,001)

Different after-harvest-behaviour in connection with growing methods has often been observed (e.g. Samaras 1978, Abele 1987, Peschke 1994, Raupp 1997). The dry matter loss during decomposition indicating better storage quality was significantly higher in conventional carrots (Fig. 3).

Previous results demonstrating the effect of production methods on bioelectrical properties (Walz 1996, Hoffmann 1997) could also be corroborated in this five year comparison: the organic carrots exhibited significantly lower P-values (p = 0,000), indicating better quality (Fig. 4).



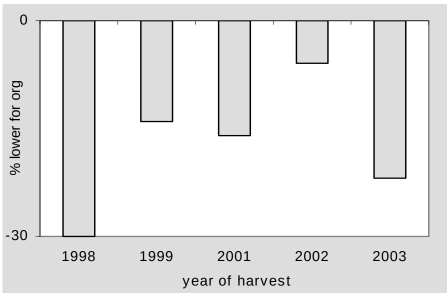


Fig. 3: Dry matter loss (p = 0, 027) **Fig. 4: P-values (p = 0,000)**

(* p=0,05; ** p=0,01; *** p=0,001)

The statistical evaluation of the results over the 5 year test period showed significant differences in favour of the organic variant concerning P-value determination, food preference tests and dry matter loss during decomposition and a tendency in the differentiation test. Since in the first year the test persons preferred the conventional variant, there was no significant result over the 5 years.

Although the method of single photon counting has only been applied with carrots of 1999, the results are mentioned here since the significantly better capacity to store biophotons in organic carrots further confirms their superior quality from a different angle (Lenzenweger 2000).

Conclusions

It could be demonstrated that carrots (var. *Tarvil*) grown in the Marchfeld (agricultural region near Vienna) revealed superior quality properties when grown on an organic farm as compared to conventional cultivation methods and that holistic methods are well qualified to differentiate between differently cultivated carrots on a significant level.

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LONG-TERM FIELD EXPERIMENTS

LONG-TERM ORGANIC CROP ROTATION EXPERIMENTS FOR CEREAL PRODUCTION – YIELD DEVELOPMENT AND DYNAMICS

Margrethe Askegaard (1), Jørgen E. Olesen (1), Ilse A. Rasmussen (2)

(1) Danish Institute of Agricultural Sciences, Dept. of Agroecology, Research Centre Foulum, PO-Box 50, DK-8830 Tjele, Denmark, +45 89 99 17 02, Margrethe.Askegaard@agrsci.dk, JorgenE.Olesen@agrsci.dk, www.agrsci.dk

(2) Danish Institute of Agricultural Sciences, Dept. of Integrated Pest Management, Research Centre Flakkebjerg, DK-4200 Slagelse, Denmark, +45 89 99 35 94, IlseA.Rasmussen@agrsci.dk

Key Words: green manure, catch crop, animal manure, clover buffer

Abstract

A crop rotation experiment was established in 1996/97 at three locations representing different soil types and climates. Three factors were tested: i) crop rotation with different proportions of N_2-fixing crops, ii) with and without a catch crop, and iii) with and without animal manure. A green manure crop increased yields in the following cereal crops, but at the rotational level, total yields were larger in crop rotations without a green manure crop. There were positive effects of animal manure and catch crops on yield. However, except for the coarse sandy soil, the yield effects of catch crops and animal manure decreased over time when a grass-clover green manure was included in the rotation. It appeared that the buffering effect of clover can counteract the positive yield effects of manure application and catch crop use. This shows the importance of assessing long-term effects in the evaluation of crop management measures.

Introduction/Problem

Crop rotations should be designed and managed to contribute to sustainable development of crop production. Under conditions of sufficient water supply, nitrogen (N) is often a yield-limiting factor on organic arable farms, and there may therefore be a trade-off between the inclusion of N_2-fixing green manure crops and cash crops in the rotation. Mixtures of N_2-fixing and non-N_2-fixing species are used for green manure, and differences in growing conditions may lead to very different rates of N_2-fixation. Catch crops can be included in the crop rotation to reduce N leaching losses and to supply N through fixation.

An organic crop rotation experiment was initiated in Denmark in 1997, and the effects of green manure, catch crop and manure application on yields, weeds and N-leaching were tested at three locations. The experiment has run for eight years (two 4-year courses), which allows an evaluation of trends in the different rotations and treatments.

Methodology

The crop rotation experiment was established at three locations representing different soil types and climates: a coarse sand at Jyndevad, a loamy sand at Foulum, and a sandy loam at Flakkebjerg. Average precipitation for the period 1961-90 was 964, 704 and 626 mm at Jyndevad, Foulum and Flakkebjerg, respectively (Olesen 1991). The soil properties of the topsoil for all sites are shown in Table 1.

The following experimental factors were included in a factorial design with two replicates and with all crops in the rotations represented every year (Olesen et al. 2000; 2002): i) crop rotation, with different proportions of N_2-fixing crops, ii) with (+CC) and without catch crop (-CC), and iii) with (+M) and without animal manure (-M) applied as slurry. Results are presented from two different 4-year crop rotations: rotation 2 (R2: spring barley undersown with grass-clover – grass-clover – winter cereal – pulse crop); and rotation 4 (R4, 1st course: spring oat – winter wheat – winter cereal – pulse crop, and R4, 2nd course: spring barley – pulse crop – winter cereal – spring oat). Cereal and pulse crops were harvested at maturity. All straw and grass-clover production was incorporated or left on the soil. The +M treatments received anaerobically stored slurry at rates where the NH_4-N application corresponded to 40% of the N demand of the specific rotation according to a Danish national standard (Anonymous 1997). The N demands of grass-clover, peas/barley and lupin/barley were set to nil.

Table 1. Soil texture, content of organic C and total N, and pH in the top 25 cm soil at the three experimental sites in autumn 1996 prior to the start of the experiment. pH is taken as pH($CaCl_2$)+0.5. Soil minerals, organic C and total N are measured in per cent of dry soil (Olesen et al. 2000).

Location	Clay	Silt	Fine sand	Coarse sand	Organic C	Total N	pH
	< 2 μm	2-20 μm	20-200 μm	200-2000 μm			
Jyndevad	4.5	2.4	18.0	73.1	1.17	0.085	6.1
Foulum	8.8	13.3	47.0	27.2	2.29	0.175	6.5
Flakkebjerg	15.5	12.4	47.4	22.9	1.01	0.107	7.4

Results and brief discussion

There were limited problems with pests, diseases, and annual weeds, and increasing problems with perennial weeds during the two courses. The average cereal yields of the manured crop rotations exceeded the yield level of Danish organic farms by 15-35%. Figure 1 shows the development of the average grain and seed yields for R2 and R4. The substitution of lupin for pea in 2001 explains the yield drop at Jyndevad due to a severe attack of grey mould (*Botrytis cinera*) on the lupins at this location. The high yield in R2 in 1998 at Foulum was probably due to optimal weather in the region that year. However, in R4 there was not a similar effect. The low yield in R4 in 2001 at Flakkebjerg was due to crop failure in oat. The yields were highest at Foulum and lowest at Jyndevad.

The yield in R2 at Flakkebjerg increased during the 1st course due to the progressive improvement of soil fertility from an initially low level (Schjønning *et al.* 2004). The grass-clover green manure crop in R2 increased the harvest yields by 10-15% compared with R4 without green manure. The lower yield variation between years in R2 compared with R4 indicates a stabilising effect of the grass-clover green manure crop (Figure 1). However, the benefits from the green manure could not compensate for the average yield reduction caused by leaving 25% of the rotation out of production. As a rotational mean, including zero yield in the green manure crop, R2 yielded 14-18% less than R4.

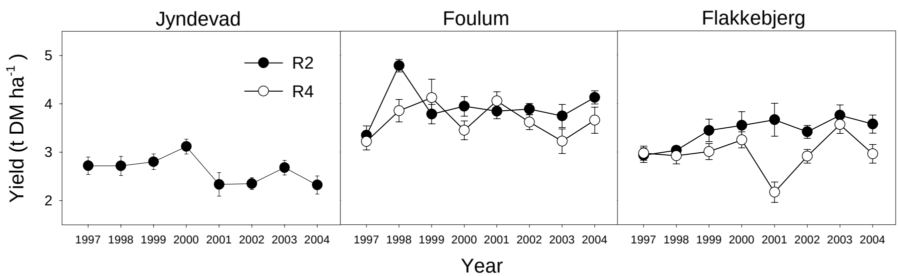


Figure 1. Annual dry matter (t DM ha^{-1}) in crop rotation 2 (R2) and 4 (R4) as an average of grain and pulses, with and without catch crops and with and without manure (n=24 in R2 and 32 in R4).

The use of catch crops in R2 increased yields in the first course at all locations, the most at Jyndevad and the least at Flakkebjerg (Table 2). This difference between locations was probably due to large nitrate leaching losses from the sandy soil (Askegaard et al., 2005). In the second course of R2, the use of catch crops caused a yield decrease in the winter wheat following the grass-clover crop at Foulum and Flakkebjerg. However, at Flakkebjerg this yield decrease was nearly matched by a yield increase in the spring barley crop. Thus, as an average of R2, there was only a small effect of catch crop on yields. This result can probably be ascribed to a buffering effect of the clover in the grass-clover crop. The clover content of the grass-clover decreased with increasing grain yields of the spring barley, which was grown as cover crop (Figure 2). We also found that the winter wheat yield increased with increasing clover content in the grass-clover green manure at Foulum and Flakkebjerg (Figure 3). The wheat yields at Jyndevad were low and did not respond to increasing clover content in the grass-clover, probably due to large nitrate leaching losses during winter.

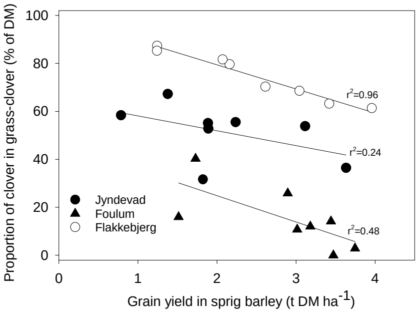
The catch crops in R4 were clover-based and contributed to the N supply through N_2-fixation. The ploughing-in of clover catch crops prior to spring cereals increased yields significantly in both the 1st and the 2nd course (Table 2). The negative effect of catch crops in the winter cereals in the 1st course of R4 derived from problems in the bi-cropping of winter cereals in a stand of clover. The method was changed in the 2nd course, which led to a positive effect of the catch crop on winter wheat yields. This effect derived from the catch crops grown two and three years prior to the winter wheat.

Yields increased significantly after manure application in both R2 and R4, but the effect decreased from the 1st to the 2nd course at Foulum and Flakkebjerg (data not shown). This was probably the result of the manure application affecting the proportion of clover in the grass-clover in R2 and the clover-dominated catch crops in R4 by reducing the development of the undersown clover crops. On the coarse sand at Jyndevad there was no such effect.

Table 2. Yield changes (t DM/ha) with the use of catch crops in the first and second course of rotations 2 and 4. Average of both manure levels.

Rotation	Course	Crop	Jyndevad	Foulum	Flakkebjerg
R2	1st course[1]	Spring barley	0.66	0.46	0.23
	(1998-2000)	Grass-clover	-	-	-
		Winter wheat[CC]	-0.09	0.03	0.11
		Pea/barley[CC]	0.04	-0.08	-0.15
		Average	0.15	0.10	0.05
	2nd course	Spring barley	0.23	0.03	0.25
	(2001-2004)	Grass-clover	-	-	-
		Winter cereal[CC]	-0.02	-0.14	-0.24
		Lupin/barley[CC]	-0.03	0.25	0.09
		Average	0.05	0.04	0.03
R4	1st course[1]	Spring oat[CC]		0.16	0.35
	(1998-2000)	Winter wheat[B]		-0.33	-0.07
		Winter cereal[B]		-1.15	-0.53
		Pea/barley[CC]		0.39	1.07
		Average		-0.23	0.21
	2nd course	Winter wheat[CC]		0.32	0.64
	(2001-2004)	Spring oat[CC]		1.23	0.85
		Spring barley[CC]		1.14	0.78
		Lupin/barley		-0.17	0.20
		Average		0.63	0.62

[CC]Undersown catch crops in the +CC treatments
[B] The winter cereals in the +CC treatment were drilled into rotary cultivated bands in a layer of clover.
[1]The first year '1997' is omitted due to lack of subcrop effects.



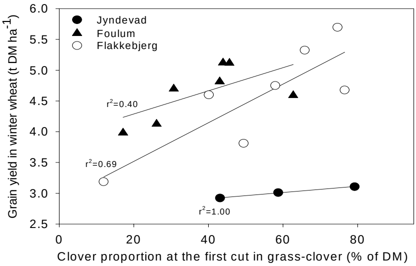


Figure 2. Proportion of clover in grass-clover (% of DM) in the first cut in 2000 depending on spring barley grain yield (t DM ha^{-1}) in each plot the previous year.

Figure 3. Average annual yields of winter wheat (1998-2004 at Foulum and Flakkebjerg, and 1998-2000 at Jyndevad) depending on the clover proportion in the first cut of the grass-clover in the previous year.

Conclusions

The yield effects of catch crops and manure changed from the first to the second course of the organic crop rotation experiment. This emphasises the importance of assessing long-term effects in the evaluation of crop management measures. The buffering effect of the clover-based green manure crop and catch crops depended on the soil type. This buffering effect can counteract positive yield effects of manure applications and catch crops.

The utilization of the grass-clover green manure could probably be improved by transferring N-containing biomass to fields in the crop rotation without N_2-fixing crops, especially on sandy soil where leaching losses are large.

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EFFECTS OF REDUCED TILLAGE, FERTILISATION AND BIODYNAMIC PREPARATIONS ON CROP YIELD, WEED INFESTATION AND THE OCCURRENCE OF TOXIGENIC FUSARIA

Alfred Berner [1], Robert Frei [1], Hans-Ulrich Dierauer [1], Susanne Vogelgsang [2], Hans-Rudolf Forrer [2], and Paul Mäder [1] *

(1) Research Institute of Organic Agriculture (FiBL), Ackerstrasse, CH-5070 Frick, Switzerland, Tel. +41 62 8657232, paul.maeder@fibl.ch, www.fibl.org

(2) Agroscope FAL Reckenholz, Reckenholzstrasse 191,CH-8046 Zurich, Switzerland, Tel. +41 1 3777229, susanne.vogelgsang@fal.admin.ch, www.reckenholz.ch

* corresponding author

Key Words: reduced tillage, mouldboard ploughing, manure compost, slurry, weed infestation, mycotoxins, organic farming

Abstract

In a recently started long-term field trial (2002-2011), located in Frick (1000 mm mean annual precipitation) near Basle (Switzerland), the effect of reduced tillage on crop yield, weed infestation, and occurrence of toxigenic fusaria was studied on a heavy soil (45% clay) in a crop rotation under organic farming conditions. Here, we present results of the first two experimental years (2003-2004), which are considered as the conversion period. Wheat yield was 16% higher ($p < 0.001$) in ploughed plots than in the plots with reduced tillage (chisel and rotary harrow). In the following year, sunflower yield was enhanced by 5% ($p = 0.06$) in reduced tilled plots. Reduced tilled plots manifested a higher weed infestation, in particular with *Convolvulus arvensis* and *Stellaria media.* With the exception of low levels of *Fusarium poae,* no toxigenic fusaria were detected in wheat grains possibly due to the exceptionally dry and hot summer 2003. The deoxynivalenol (DON) content was low in all treatments. While the DON content in wheat straw was increased after reduced tillage, it was decreased after application of biodynamic preparations ($p < 0.05$). Overall, we assume that even on heavy soils, reduced tillage systems may be applicable on organic farms, but with a considerably higher input of labour.

Introduction/Problem

Organic farming systems offer many benefits (Mäder *et al.*, 2002). However, these systems generally use mouldboard ploughing. Reduced tillage systems provide new opportunities, but were developed under conventional farming regimes involving the use of chemicals (Pekrun & Claupein, 1998). Problems with weeds (Zwerger, 1996; Hampl, 1999), slugs (Jourdan *et al.*, 1997) and a delay in soil nitrogen mineralisation in spring are difficult to solve under organic farming conditions. Furthermore, the occurrence of fusaria and the contamination of cereals with mycotoxins have frequently been associated with reduced tillage systems, especially in wheat following maize cultivation (e.g. Dill-Macky & Jones, 2000; Champeil *et al.*, 2004). In the present study, we are investigating whether the use of newly developed machines, in combination with an optimised fertilisation strategy and the use of biodynamic preparations will improve the sustainability of reduced tillage systems, without relying on synthetic inputs.

Methodology

In autumn 2002, we established in Frick (Switzerland) a field experiment comprising the following factors, each performed at two levels:

Soil tillage	Ploughing system (mouldboard plough followed by rotary harrow) *versus* reduced tillage system (chisel plough* followed by rotary harrow**).
Fertilisation	Slurry alone *versus* manure compost and slurry (both systems at a level of 1.4 LU).
Biodynamic preparations	With *versus* without biodynamic (bd) compost and field preparations (see http://www.sciencemag.org/cgi/content/full/296/5573/1694/DC1).

*) WeCo-Dyn-System of the company EcoDyn, Schwanau, Germany. **) Rotary harrow of the company Rau, Weilheim, Germany. LU = livestock units.

The three factors tillage, fertilisation and preparations were fully factorised. This resulted in eight treatments, each replicated four times. The 32 plots were arranged in a split-plot design. The plot size was 12 x 12 m, allowing the use of common-size farming equipment.

The clay soil at the experimental site contained in mean 2.2% organic carbon, 45% clay, and had a pH of 7.1 (n = 32). The mean annual precipitation was 1000 mm per year. Before the experiment started, the field site was uniformly planted with silage maize in 2002. In this paper, results of the first two experimental years, 2003-2004 are presented. Winter wheat (variety 'Titlis', 2002-2003), oat-clover intercrop (2003-2004) and sunflower (variety 'Sanluca' 2004) were cultivated. Wheat grains and straw were harvested and removed from the field. Undressed seeds were sawn. Weeds were controlled mechanically by a tractor-driven hoe in both main crops and also by hand in the sunflower crop.

Yields of the three crops were assessed in 8 x 8 m harvest plots. Weed infestation was assessed twice in the season. For this, the number of weed seedlings per capita was counted (sample area of 2 x 1 m^2/plot) or the percentage coverage of the soil surface was estimated (sample area of 64 m^2/plot). The incidence of *Fusarium* fungi in wheat grains was analysed using a seed health test on agar (Neergard, 1977): The number of seeds infected by *Fusarium* species (*Fusarium graminearum*, *F. culmorum*, *F. poae*, *F. langsethiae*, and *F. avenaceum*) as well as *Microdochium nivale* was counted. The content of the mycotoxin deoxynivalenol (DON) in harvested wheat grains and straw was measured by an ELISA (enzyme-linked immunosorbent assay) kit (RIDASCREEN®FAST DON, Art. No.: R5901, R-Biopharm AG, Darmstadt, Germany).

Data were analysed by an analysis of variance (ANOVA). Significance levels were: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$, and n.s. not significant.

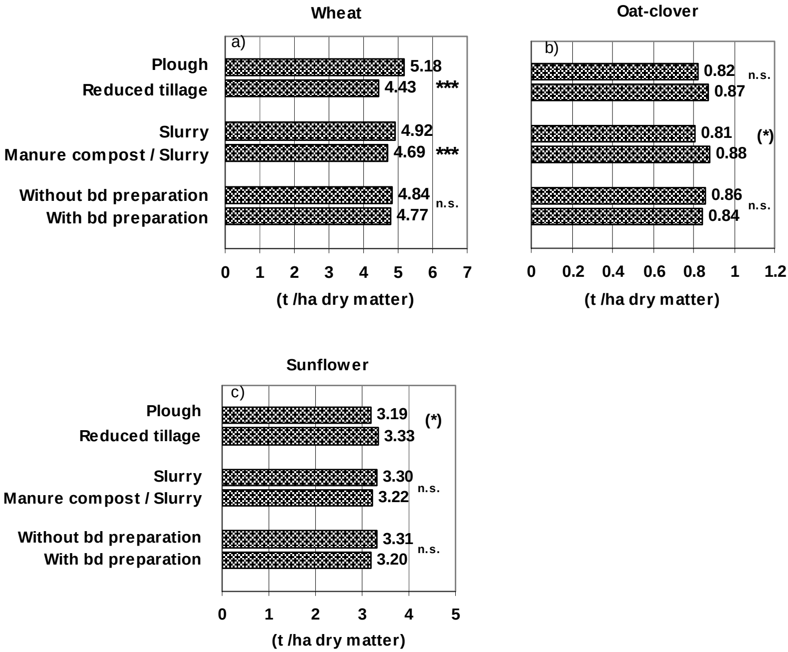

Fig. 1: Crop yield depending on different tillage, fertilisation, and biodynamic preparation treatments. a) wheat grain yield 2003, b) yield of oat-clover fodder intercrop 2003, c) sunflower grain yield 2004.

Results and discussion

Yield:

In the first year, grain yield of winter wheat in the reduced tillage plots was 16% lower compared with the yield in ploughed plots ($p < 0.001$; Fig. 1). In contrast, the yield of the intercrop oat-clover was not lower in the reduced tillage plots, and the sunflower yield in reduced tillage plots across all fertilisation and preparation levels was 5% higher ($p = 0.06$) than that in ploughed plots. This result was unexpected, because the formation of stable pores, leading to higher inherent soil fertility, usually takes time. Sunflowers may also have taken up mineralised nitrogen in late summer in reduced tillage plots. After a very dry summer in 2003, soils of the reduced tillage plots were chiselled down to 20 cm and subsequently sawn with the oat-clover mixture. This led to a substantially improved soil structure in the reduced tillage plots compared to the ploughed plots in the sunflower crop as observed by a subsequent spade diagnosis. Application of slurry resulted in a 5% higher wheat grain yield ($p < 0.001$) in comparison with manure compost, but did not affect sunflower yield. The biodynamic preparations had no effects on yield.

Weed infestation:

Weed infestation was relatively low in the first experimental year, but was higher in the second year. Total soil cover by weeds was 13% in the reduced tillage plots and 9% in the ploughed wheat plots across all fertilisation and preparation levels at flowering stage in 2003. Initially, *Convolvulus arvensis* was occurring in the trial; the level of infestation by this weed was low, but it is difficult to control in organic production systems. *Stellaria media* occurrence is the most differentiating weed towards soil tillage at this site. In spring 2004, 144 and two *S. media* seedlings m^{-2} were counted in reduced tillage and ploughed sunflower plots, respectively. *C. arvensis* was also more abundant in reduced tillage plots (4.5 compared with 2.4 seedlings m^{-2} in ploughed plots). When the sunflower plant height reached around 1 metre, soil cover rates were found to be higher in reduced tillage plots compared with ploughed plots (*S. media* 28.6% *vs.* 1.2%, *C. arvensis* 6.9 *vs.* 4.1%). The soil cover within the rows by all weeds present was 47% in reduced tillage plots and 20% in ploughed plots. Hand-weeding time for control of *C. arvensis* and *Cirsium arvense* in sunflowers was 27 hours 42 min ha^{-1} in reduced tillage plots and 15 hours 10 min ha^{-1} in ploughed plots. While sunflower yield was even slightly higher in reduced tillage plots, there is a great risk that these weeds might impede the crop's growth in the coming years. Due to extreme wetness after sunflower harvest, it was not possible to perform efficient weed control.

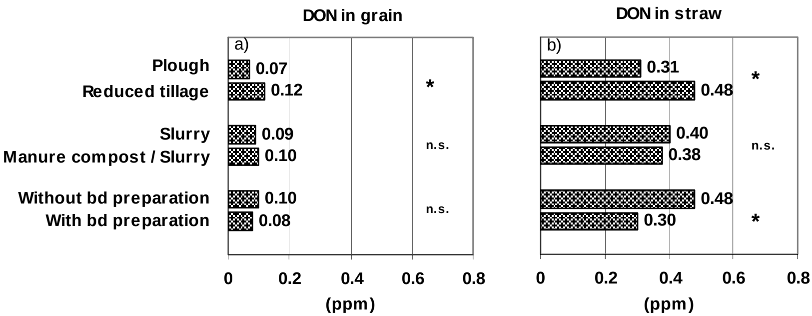

Fig. 2: Fusarium toxin DON (deoxynivalenol) content in wheat depending on different tillage, fertilisation, and biodynamic preparation treatments (2003). Overall DON levels were low. a) DON in wheat grains, b) DON in wheat straw.

Occurrence of fusaria and mycotoxins:

Although wheat was cultivated after silage maize, overall *Fusarium* infestation level was very low across all treatments investigated (data not shown), possibly due to the dry and hot summer in 2003. However, across all levels of fertilisation and application of biodynamic preparations, *F. poae was* detected in 1.2% of the wheat grain samples from both the ploughed plots and plots with reduced tillage. As expected from the very low infestation by *F. graminearum*, very little DON was measured from the wheat grains of all experimental treatments (all values below the calibration curve at 0.222 ppm) (Fig. 2). Despite the low overall amount, grains from ploughed plots contained on average significantly ($p < 0.05$) less DON compared with samples from reduced tillage plots. This result is in line with other studies (Teich & Hamilton, 1985; Dill-Macky & Jones, 2000) where remaining maize residues on the soil surface were associated with greater contamination by DON. For the straw samples, overall DON contents were considerably higher (range of 0.2-0.9 ppm) but still well below 1 ppm (Fig. 2). This is not surprising as higher amounts of DON in straw compared with those of grains are a common observation (Hecker *et al.*, 2004). Straw samples from plots receiving biodynamic preparations contained on average significantly ($p < 0.05$) less DON compared with samples from plots where no preparations were applied. In general though, these data need to be interpreted with caution as DON values from all grain samples and from individual straw samples were below the calibration curve, rendering them not entirely appropriate for statistical analysis.

Conclusions

In the conversion period from a ploughed to a reduced tillage system under organic farming conditions, yields decreased in the first year, but recovered in the second year. This can be interpreted as an adaptation of the soil processes to lower levels of mechanical disturbance. Although our results are based on two seasons only, we believe that reduced tillage might be applicable even on very heavy soils in organic farming, but with a considerably higher input of hand weeding compared with ploughing systems. However, in order to minimise the risk of infection by *Fusarium graminearum* and mycotoxin contamination, wheat after maize should be avoided and wheat varieties with a low susceptibility to Fusarium head blight should be chosen.

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INFLUENCE OF ORGANIC MANAGEMENT WITH DIFFERENT CROP ROTATIONS ON SELECTED PRODUCTIVITY PARAMETERS IN A LONG-TERM CANADIAN FIELD STUDY

M. Entz (1), J.W. Hoeppner, L. Wilson, M. Tenuta, K.C. Bamford and N. Holliday

(1) University of Manitoba, Winnipeg, Manitoba, Canada, R3T 2N2, m_entz@umanitoba.

Key Words: Crop yield, soil nutrient status, energy efficiency, mycorrhiza

Abstract

The Glenlea long-term rotation study, located near Winnipeg, is Canada's oldest conventional vs organic crop comparison study. Since 1992, three farming systems (grain only; grain with green manure crops; combined grain-forage rotation) were evaluated under two management systems (organic and conventional). Organic system ranked higher than conventional systems in energy efficiency and biodiversity while conventional system ranked higher in yield, weed management and soil nutrient status. However, significant farming system by management interactions were observed for many variables. The basis for these interactions was enhanced performance of organic production in the combined grain-forage system compared with the grain only system. Organic crop production is sustainable provided combined grain-forage rotations and livestock manure recycling are used.

Introduction/Problem

Organic farming is increasing in Canada. Currently, 1.4% of Canadian farmers grow organic crops on 391,000 ha of certified organic land. Despite this interest there is little information on long-term effects of organic management on crop and soil parameters. Long-term studies elsewhere have shown that organic crops yield similar to conventional crops depending on weather conditions (Lotter et al., 2003). Maeder et al. (2002) reported soil benefits from organic farming with minimal decrease in crop yields.

There are many questions about the consequences of eliminating traditional fertilizer and herbicide inputs in Canadian crop production. Previous long-term trials in Saskatchewan, Canada have shown that soils become very nutrient deficient (especially in available P) when inorganic fertilizer use is eliminated (Campbell et al., 1993). P deficiencies were greatest in rotations that contained hay but did not involve manure return to the land. Available soil P was found to be low in organically managed farm fields in western Canada (Entz et al., 2001).

A recent survey showed that Canadian organic farmers grow their crops using three main rotation types: 1) diversified grain-only rotations; 2) rotations that contain green manure crops; and 3) rotations that combine perennial forages and grain crops (Entz et al., 2001). The Glenlea study was established to compare organic and conventional crop production in these three rotation systems. Our hypothesis is that organic farming will be more successful in the combined grain-forage rotation and least successful in the grain-only rotation.

Methodology

The Glenlea study was established on approximately 10 ha near Winnipeg, Canada in 1992. The soil is an Osborne clay and annual precipitation is 500 mm; 30% of annual precipitation falls as snow. The experimental design is a randomized complete block with three replicates. Main plots consist of farming system: combined grain-forage system (wheat-alfalfa-alfalfa-flax); grain plus green manure crop (wheat-red clover-wheat-flax); and a grain only system (wheat-pulse-wheat-flax). Each main plot is conducted under conventional and organic management. Details of crop and soil management are given in a previous paper (Hoeppner et al., 2005). Briefly, organic and conventional systems had similar seeding dates and seeding rates. A minimum tillage regime (typical of the dryland prairies) is used in all systems. Organic systems required 1 to 2 additional tillage passes each year. The alfalfa is harvested for hay two or three times per year. Manure from the dairy is returned to one sub-subplot within the grain-forage rotation. Straw from grain crops is chopped and returned to the soil. Herbicides were used in all conventional plots; fungicides were used only in conventional wheat crops. Between 1992 and 2004, rotation phases were not included each year. In 2005, plots were split to allow the study to be "fully-phased" (that is, all phases of rotations appear each year); introducing a sub-subplot level into the experiment. Sub-subplots are 6 m wide and 25 m long. Measurements include crop yield, soil nutrient status (sampled autumn 2003), soil biology (mycorrhizae, nematodes), soil erodibility, ground beetles, weeds and other pests, energy consumption, and energy production.

Results and Discussion

Flax "test crops" appeared at the end of each 4-year rotation cycle. Flax yielded less in the organic than in the conventional system; however a rotation by system interaction (P=0.15 in 1995; P=0.19 in 1999 and P=0.001 in 2003) indicated that yield loss due to organic management was influenced by the farming system (grain only rotation > green manure-grain rotation > grain-forage rotation) (Table 1).

Table 1. Influence of farming system type on yield, weeds, soil nutrient status and energy efficiency in organic and conventional management, Glenlea long-term study, 1992-2003.

Rotation	System	Flax test crop yields (kg/ha)			Weed density/m^2			Available soil N (kg/ha)	Available soil P (kg/ha)	Mycorrhizal infection of flax roots (%)	Energy efficiency [1]
		1995	1999	2003	1995	1999	2003	2003		2003	1992-2003
WPWF[2,3]	Organic	930	558	276	46	189	1379	22	33	82	10.4
WPWF	Conventional	1798	1364	1167	33	532	2041	32	46	44	6.8
WClWF	Organic	1054	992	304	24	91	1735	31	37	-	-
WClWF	Conventional	1798	1736	677	37	128	2235	29	24	-	-
WAAF	Organic	1364	1364	849	24	40	594	37	11	61	11.9
WAAF	Conventional	1674	1426	1044	11	110	1338	81	24	44	7.4
Significance (P>F)											
Rotation (Rtn)	-	0.0300	0.0910	0.0003	0.0002	0.0030	0.0106	0.0024	0.0002	0.0388	<0.0001
System (Sys)	-	0.0014	<0.0001	<0.001	0.1899	0.0001	0.0713	0.0093	0.1899	<0.0001	0.0006
Rtn x Sys	-	0.1564	0.1984	<0.001	0.0153	0.0603	0.1764	0.0153	0.0153	0.0024	0.0102

[1] Assuming alfalfa production:meat production conversion factor of 9:1. Units of energy produced per unit energy consumed.
[2] W=wheat, P=pea, F=flax, A=alfalfa; Cl=red clover
[3]WPFW, grain-based rotation; WClWF, green manure rotation; WAAF, integrated rotation,

Averaged over the three cycles of the study, yield reduction due to organic management averaged 63% for the grain rotation, 46% for the green manure rotation and 14% for the integrated grain-forage rotation. Similar observations were made for wheat yields in years when wheat was common to all systems (data not shown). These observations show that farming system type was very important to the success of organic grain crop production, and that among farming systems, the integrated grain-forage system was most beneficial in maintaining grain yield of organically managed crops. Similar observations were reported by (Mahoney et al., 2004) An interaction between year and farming system also existed (data not shown). In the grain-only rotation, yield reduction due to the shift to organic management increased from 49% in 1995 to 77% in 2003. By contrast, yield reduction due to a shift to organic management in the combined grain-forage rotation was 19% in 1995 and 2003. This observation suggests that long-term grain yield sustainability (after 12 years in the present study) is much greater when grains are grown in rotation with forage crops than in grain monocultures.

Weed populations appeared to increase over the course of this study. Very high weed populations in 2003 were attributed to environmental conditions that were favourable to weed seedling recruitment. By the end of the third rotation cycle, total spring weed density in the rotation containing alfalfa was half that in the annual grain and green manure rotations (Table 1). Alfalfa's ability to suppress total weed population was similar under conventional and organic management. Alfalfa was particularly effective at suppressing green foxtail (*Setaria viridis* (L.) Beauv.), a major weed in 2003 (data not shown). Wild mustard (*Sinapsis arvensis* L.) populations, however, were higher in the alfalfa rotation than in the grain-only or green manure systems. The annual rotation was dominated by grassy weeds, particularly green foxtail. By the third rotation cycle, the green manure rotation had high levels of green foxtail, wild mustard, and red root pigweed (*Amaranthus retroflexus* L.). Red root pigweed was highest in the green manure rotation. Although there was no interaction between crop rotation and input management for total spring weed density, there were interactions in some cases for specific grass and broadleaved weed species. The most common interaction observed for the different weed species involved better weed control by alfalfa in organic management, indicating that crop rotation with alfalfa can be an important part of an organic weed control strategy. These results support Ominski et al. (1999), who observed that alfalfa provided excellent suppression of perennials and summer annual grassy weeds but only marginal suppression of summer annual broadleaved weeds.

Level of flax root colonization with mycorrhiza was significantly higher under organic vs. conventional management (Table 1). More colonization under organic management may be attributed to less available soil P in organic compared with conventional management (Table 1). Other Canadian prairie researchers have observed lower mycorrhizal colonization in fertilized than in unfertilized cropping systems (J. Clapperton, Agriculture and AgriFood Canada research centre, Lethbridge, Alberta, pers. comm.). Greater mycorrhizal colonization of flax grown in the grain-only rotation compared with the grain-alfalfa system (Table 1) may be due to differences in the weed flora. For example, the alfalfa-based system contained much higher populations of wild mustard, a non-mycorrhizal plant, while the grain system was dominated by green foxtail, a mycorrhizal plant.

Soils in the combined grain-forage system were found to have the highest soil-N concentrations of any system in this study (Table 1). On the other hand, level of available soil P was lowest in the grain-forage system. Results of a farm field survey in Manitoba support both of these observations (Entz et al., 2001). One of the subplots in the forage-grain system has received composted dairy manure (data not shown). Levels of available P in this manured soil is adequate (>25 kg/ha).

A complete energy audit was conducted for the grain-only and combined forage-grain rotations for the period 1992 to 2003 (Hoeppner et al., 2005). For the grain-only rotation, energy consumption averaged 2,019 MJ/ha/year in the organic system and 5,708 MJ/ha/year in the conventionally-managed system. Energy consumption in the forage-grain rotation averaged 1,844 MJ/ha/year for the organic system and 4,100 MJ/ha/year for the conventional system. Energy output was 20% lower in organic compared with conventional management. Energy use efficiency (assuming alfalfa conversion to beef was 9:1) was approximately 40% higher for organic than conventional systems (Table 1). Energy efficiency was 10% higher in the forage-grain rotation compared with the grain-only rotation.

Conclusions

Organic flax crops yielded significantly less than conventionally grown crops in all three test crop years. This trial showed that yield loss due to organic management could be reduced by using a combined grain-forage rotation. Weed populations increased over the 12 years of the study; however, increases in weed density under organic management were least in the combined forage-grain rotation. Soil nutrient status was strongly influenced by both system and rotation. Evidence for P deficiency in the combined grain-forage system was observed. It was concluded that adding manure is necessary for long-term maintenance of soil fertility in organic management when forage hay crops are included in the rotation. Higher mycorrhizal infection of organic compared to conventional crops was attributed to lower soil P availability in organic plots. Weed flora also played a role, with lower colonization coinciding with non-mycorrhizal weeds. Energy efficiency was much higher for organic compared with conventional systems, and the combined forage-grain system under organic management produced the highest energy efficiency. In conclusion, the organic system performed poorer than the conventional system in terms of crop yield (20 to 70% lower), available soil nutrients (30 to 50% lower) and weed control. However, the organic system performed better than the conventional system in terms of energy use efficiency (30 to 40% higher) and mycorrhizal colonization (30 to 50% higher). Organic systems that include forages and composted manure are very sustainable over the 12 years of this study.

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HOW ECONOMIC IS ORGANIC? RESULTS OF A LONG.TERM TRIAL AT BURGRAIN/LUCERNE, SWITZERLAND

Padruot M. Fried (1), Urs Zihlmann (1), Fredi Strasser (1), Ruedi Tschachtli (2), Helmut Ammann (3), David Dubois (1)

(1) Agroscope FAL Zurich-Reckenholz, POB, CH-8046 Zurich, Switzerland, 0041 44 377 7111, padruot.fried@fal.admin.ch, www.reckenholz.ch
(2) Landw. Bildungs- und Beratungszentrum LBBZ, CH-6170 Schüpfheim, Switzerland, 0041 41 980 3038, ruedi.tschachtli@edulu.ch
(3)Agroscope FAT Tänikon, POB, CH- 8356 Ettinghausen,Switzerland, 0041 52 365 1190, helmut.ammann@fat.admin.ch

Key Words: Organic Farming, Economics, Long-term Trial, Net Profit, Field Crops

Abstract

Long-term trials are necessary not only to judge agronomic and ecological indicators when studying organic farming, but also to analyze and describe economic parameters. From 1997-2002, an organic arable farming system (Bio) was compared with two Integrated farming systems (IP intensive and IP extensive) on 6 plots in a 6-year crop rotation at Burgrain near Lucerne, Switzerland. The 6 plots were subdivided into 3 subplots of 0.65 ha each. In the organic system, the input of fertilizer and pesticides was substantially reduced, which resulted in a yield reduction of 19% over all 4 arable crops and of 14% if the temporary leys are included. Nevertheless, the organic system showed an excellent net profit, mainly due to the higher prices paid to the farmers for the organic products. The influence of the direct governmental payments was less pronounced.

Introduction/Problem

Apart from ecological and social aspects, a sustainable agricultural system must also be economically viable. Many reports on the ecological advantages of organic farming are available today (e.g. Alföldi et al., 2002, FAO Report), but economic analyses are less frequent. In order to obtain clear answers for farmers, extension specialists and politicians concerning the profitableness of organic farming, we analyzed the data of our long-term trial at Burgrain/LU, which has been running since 1991.

Methodology

The trial is located in an experimental farm, at Burgrain/Lucerne, at 8:00 degrees E and 45:10 degrees N, 500m above sea level. The soil belongs to the group of cambisols (FAO classification) with 3.4% humus, 17-25% clay and a pH between 6.1 and 7.5. The average rainfall is 1100 mm, the average temperature 8.5 degrees Celsius; the whole farm has 40 ha of land, 23 ha are arable land.

Three arable farming systems differing in nutrient input and plant protection measures are compared. All systems are implemented by farmers and comply with the Swiss requirements of Integrated Production and the "ökologischer Leistungsnachweis" (proof of ecological performance linked to the governmental direct payments program). The program is described under www.blw.admin.ch (Direktzahlungsverordnung Art. 5ff) and sets minimal requirements for crop rotation, cover crops, ecological compensation areas, pesticide input and balanced nutrients on the farm. For animal well-being, two programs are also defined and are voluntary. The minimal requirements for organic farming (OF) are described in an ordinance, too, (www.blw.admin.ch, Bioverordnung), which is comparable to and compatible with the EU ordinance on OF.

The trial was conducted on 6 arable plots of ca. 2 ha each (Zihlmann and Tschachtli, 2004). The plots were cultivated with regular farm machinery. Yield and economical performance were quantified. Each plot was subdivided into three strips of 0.65 ha each. This permitted a direct comparison of the three systems within two 6-year crop rotations: IP intensive (an integrated, more intensive farming system aiming at high yields, which corresponds to an average cropping intensity of the region), IP extensive (an integrated, more extensive farming system), and Bio (until 1996 a low-input system similar to organic; since 1997, an organic farming system). In this paper, we present the results of one crop rotation, covering the 6 years from 1997-2002. This crop rotation included potatoes (followed by white mustard as catch crop) – winter wheat (followed by over-wintering clover grass) – grain maize – spring barley – two years of temporary lay.

Results and brief discussion

On the average, the number of pesticide applications per arable crop and year was 3.3 for IP intensive, 1.2 for IP extensive, and 0.6 for Bio. If the temporary lays are included in the calculation, the corresponding values are 2.7, 1.3 and 0.7, respectively. On the other hand, mechanical interventions were more frequent in the less intensive systems, mainly because of more manual, mechanical weed control. The number of interventions/year was 0.2, 1.1 and 1.6 for IP intensive, IP extensive and Bio, respectively.

The inputs of manure and pesticides differed in the three systems: IP extensive and Bio received 31% and 45% less nitrogen, respectively, compared to IP intensive (Fig. 1). Under Burgrain climatic conditions, lays are fertilized after each cut with 20-50m3 of liquid manure. Accordingly, the yields are very high.

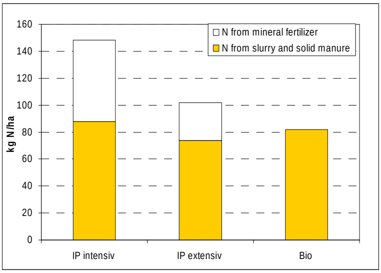
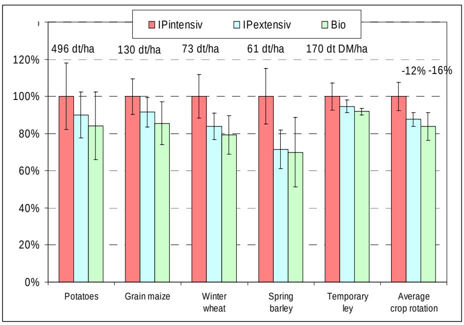


Fig. 1. Input of ammonium and nitrate N in kg/ha/year in 3 farming systems, IP intensive, IP extensive and Bio, 1997-2002

In the arable crops, average yields were 14% lower for IP extensive and 19% lower for Bio, respectively, compared to IP intensive. Heavy precipitation in this area favours fungal diseases and as expected, the highest yield losses were measured in the cereals, namely in spring and winter barley (up to 30%). With maize, potatoes and temporary lay, yield losses were less severe (Fig. 2). If the two temporary lays are included in the calculation as yearly crops with average hay prices, the total yield reduction of IP extensive and Bio, compared to IP intensive is 12 % and 16 %, respectively.



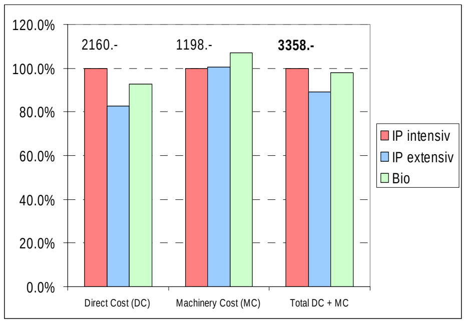


Fig. 2. Average yield of field crops and temporary lay, 1997-2002

Fig. 3. Average direct costs and machinery costs, 1997-2002

The indicator for profitability we use here is the net profit. It is defined as the profit after subtraction of direct costs and machinery costs. The direct costs include seeds, pesticides, mineral fertilizers, drying costs and insurance costs. The direct costs were 19% and 7% lower for IP extensive and Bio, respectively. In IP extensive, no fungicides in cereals were used, which reduced the direct costs to a large extent. For Bio, the higher price for seed had a significant effect on the result.

The machinery costs cover variable costs of machinery, rent of machines and work carried out by third parties. All direct payments by the government were included in the calculations. Both, direct costs and machinery costs, are shown in Fig. 3. The higher machinery costs of the OF procedure were due to the higher input in mechanical weed control and the costs for distribution of slurry.

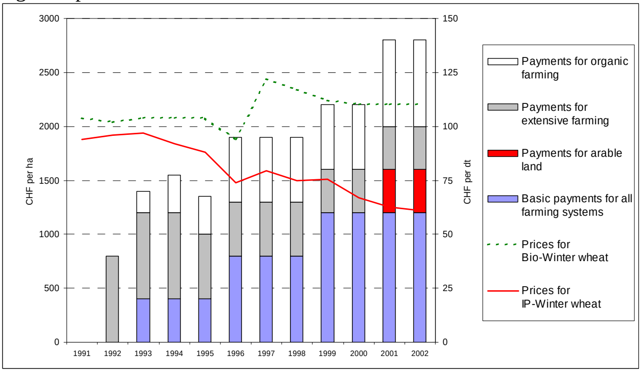


Fig. 4. Development of governmental direct payments (Y1) and of wheat prices (Y2), 1991-2002. (Extensive farming payments=no use of fungicides, insecticides and plant growth regulators allowed).

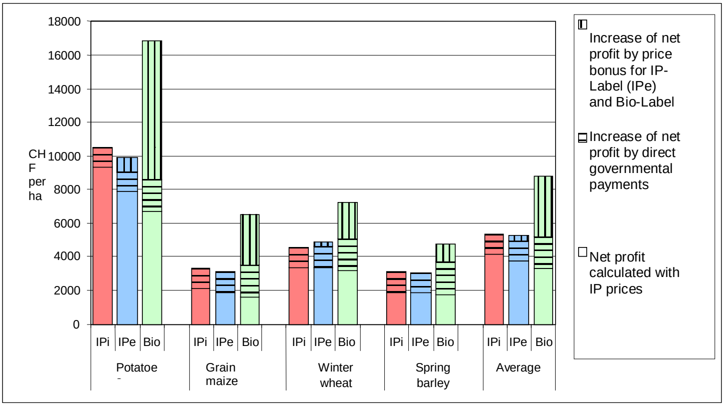


Fig. 5. Average net profit of the field crops after subtraction of direct costs and machinery costs, 1997-2002. (1.20 CHF = 1 USD)

Work input, on the average, was 0.1 and 16.8 hours/ha/year higher in IP extensive and Bio, respectively. The higher input in OF is mainly due to the necessary mechanical (manual) control of dock plants (*Rumex* sp.) in the temporary lays. Up to 47 additional working hours /ha/year were registered for this mechanical, manual work.

The development of prices for winter wheat in IP and Bio is shown in Fig. 4, together with the different government contributions (direct payments). While IP prices for wheat were reduced by 35% from 1991 to 2002, the price for organic wheat increased by 6% in the same period. Simultaneously, the contributions for all farms, but specifically for the organic farms, were increased.

As expected, the calculated theoretical net profit, on the assumption of IP prices for all crops, was highest for IP intensive; it showed a reduction of 7% for IP extensive and of 16% for Bio, respectively. (Fig. 5, “Average”). After addition of the direct governmental payments, the average net profit for the 3 procedures was almost equal. The picture changes dramatically if the price bonus for products with IP-Label (IP extensive for wheat and potatoes) and Bio-Label is taken into account: Bio’s average net profit was 65% (or 3475.- CHF/ha) higher than that of IP intensive. IP extensive reached 2% less than IP intensive. The largest net profits in Bio were obtained with the potato crop, followed by winter wheat, grain maize and spring barley (Fig. 5).

In terms of environmental impact, e.g. population and species counts of earthworms (Jossi et al., 2004/a) and ground beetles (Jossi et al., 2004/b), all the farming systems produced favourable values, though IP extensive and Bio often achieved somewhat better results. Higher than average values were measured for some soil parameters, e.g. soil microbiological activity in comparison to other farming areas in Switzerland (Oberholzer, 2004). More ecological parameters and details are published in Schriftenreihe 52 (see References below).

Conclusions

For the success of an organic farming system, the economic analysis of our long-term trial at Burgrain, Switzerland, clearly shows the importance of the prices paid to the farmers for their organic products. Yield losses can be rather high, but they are more than compensated for by the high market prices for organic products and the higher ecological direct payments by the Swiss government. Therefore, an economic analysis of the farm situation, taking local markets into account, should be made before, during and also after conversion to organic farming.

In addition, the whole farm situation must be carefully analyzed, because lower yields in organic plant production may necessitate a larger surface of grassland in mixed farms to produce the feed for the animals; in our case, this increase of surface was 9%. This would, in turn, slightly reduce the net profit of the arable crops.

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YIELD AND ROOT GROWTH IN A LONG-TERM TRIAL WITH BIODYNAMIC PREPARATIONS

W.A. Goldstein, W. Barber

Michael Fields Agricultural Institute, P.O. Box 990, East Troy, Wisconsin, 53120; Tel: 001-262-642-3303; wgoldstein@michaelfieldsaginst.org; www.michaelfieldsaginst.org

Key Words: Biodynamic preparations, root growth, yield balancing effect, long-term experiments

Abstract

Crop yields and root growth were studied in a 6-year trial comparing conventional, organic, and biodynamic methods of fertilization. Intense use of a set of biodynamic preparations, including a nettle-containing compound preparation, was found to have a balancing effect on the yields of maize and winter wheat. This effect may have been caused by greater root growth and improved root health. Biodynamic farmers use 'preparations' to improve soil and crop quality, including fermented herbs to inoculate manure and compost, and field sprays that are either made from cow manure and silica fermented in cow horns, or from special mixtures of cow manure with concentrated applications of herbs ('compound preparations') (Koepf et al. 1989). In several studies biodynamic preparations have had hormone-like effects on various crops (Stearn, 1976; Goldstein, 1979; Goldstein and Koepf, 1982; Fritz, et al., 1997) and they can increase root growth (Bachinger, 1996; Goldstein, 1986). In Germany the biodynamic sprays increased crop yields (cereals and vegetables) on years where yields were low (Raupp and Koenig, 1996). Very little research has been done on compound preparations. These materials are often utilized as compost 'starters' or as field sprays and various formulae exist for their production. Our objectives were to compare conventional, organic, and biodynamic systems of fertilization on the yields of crops, and to test a newly developed nettle-containing variant of the 'compound preparation' field spray commonly used in biodynamic management.

Methodology

An experiment was carried out for 6 years near Elkhorn, Wisconsin in a precipitation zone of approximately 720 mm/annum, on a McHenry silt loam (alfisol) that had been in continuous, conventional maize production. In 1993 a crop of oats and alfalfa was harvested in a checkerboard, and test plots for conventional, organic, and biodynamic systems were set out in 1994 on uniform, equally yielding parcels of soil in a randomized, complete block design with 4 replications. Average soil characteristics for pH, % organic matter, available P and K were 6.9, 2.43%, 18.5 ppm, and 110 ppm, respectively. The biodynamic plots were partitioned into subplots and five different biodynamic treatments were compared, including a check without compound preparations, and treatments including four different compound preparations. Of all the treatments used in the study, root growth was examined on only four treatments (conventional, organic, the biodynamic check which did not receive compound preparations (BD), and the treatment that included the new nettle-containing biodynamic compound preparation (BD+)). Plots were approximately 4 m x 7 m in size for the organic and conventional and 4 m x 3.5 m for the biodynamic subplots. The biodynamic check treatment (BD) differed from the organic only by receiving biodynamic preparations according to normal practice (Koepf, et al., 1989). This entailed application of biodynamic herbal preparations to compost piles and application of horn manure and horn silica to soils and crops, respectively. The BD+ treatment was the same as the BD treatment except that it received two extra applications of a compound preparation field spray made from a fermented mix of cow manure, stinging nettle (Urtica dioica L.) and the biodynamic herbal preparations. The mixture consisted of 40 kg of fresh cow manure, 1% by weight of nettle and one set of biodynamic preparations (yarrow (Achillea millefolium L.), chamomile (Matricaria chamomilla L), stinging nettle (Urtica dioica L.), oak bark (Quercus robur L.), dandelion (Taraxacum officinale L.), and valerian (Valeriana officinalis l.)). The nettle had been harvested when in flower and chopped to 2.5 centimeter long pieces. The mixture was allowed to compost in a wooden box inserted into the top 30 centimeters of a loamy topsoil with a loose fitting cover for at least ½ year before being used. The formula for this preparation had been developed at Michael Fields Agricultural Institute in laboratory trials involving bioassays with wheat seedlings grown in tap water and nutrient solutions according to Goldstein and Koepf (1982). In these studies the nettle containing preparation had shown both growth stimulating and regulating effects (Goldstein, unpublished data). Conventional management consisted of a maize-soybean rotation with annual applications of mineral fertilizer to corn (mostly 169-112-

112 kg of N, P, and K per hectare). Organic and biodynamic systems used a 6-year rotation: 1) maize; 2) oats + sweetclover; 3) sweetclover for seed; 4) winter wheat + grass & alfalfa; 5) grass + alfalfa hay; 6) grass + alfalfa hay, and was fertilized with 22 t/ha of composted sheep manure before maize was grown. Mechanical cultivation controlled weeds in all systems. All crops in each phase of the two rotations were grown each year. Monoliths were excavated around the crown of three plants from each plot, 3-times in 1998 and twice in 1999. Root length and necrosis were determined on individual nodes of washed roots using the line intersect method (Goldstein, 2000) or 'WinRhizo' computerized measuring system. Data from samplings for individual root nodes were summed (Goldstein, 2000) to estimate root length and dry matter production. Results were analyzed using regression and analysis of variance tools available from Statistical Analysis Systems, Cary, N. Carolina.

Results and Brief Discussion

Five years of data are available for wheat (1995-1999) and maize (1994-1998). In 1999, the maize crop was damaged badly by deer before harvest and yield data was not used. Yields of other crops will be reported elsewhere. *Yield of Wheat:* The BD+ system resulted in 403 to 605 kg /ha more grain than did the organic system. A negative linear relationship existed (Diagram 1).

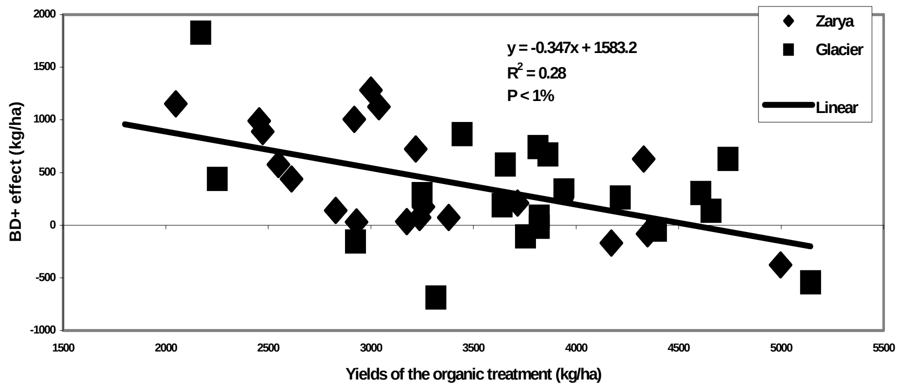

Diagram 1: The effects of the biodynamic treatment on the yields of winter wheat (2 varieties) relative to the organic treatment including data of replications (1995 – 1999).

When the organic plots yielded below 4.5 Mg/ha, the biodynamic + treatment had a positive effect on wheat yields. If the organic wheat yielded 2, 3, 4, 5 Mg/ha, the predicted yield increase from using the preparations was 0.89, 0.54, 0.12, and –0.15 Mg/ha, respectively. *Yield of Maize:* Five years of trials showed average yields of 5.58, 6.71, 6.77, and 7.15 Mg/ha of grain for the conventional, organic, BD, and BD+ treatments, respectively. Yields from the conventional plots lagged behind the organic and biodynamic plots throughout the experiment. As had been the case with wheat, the largest differences between organic and BD+ treatments occurred in those years where yields were low (Diagram 2).

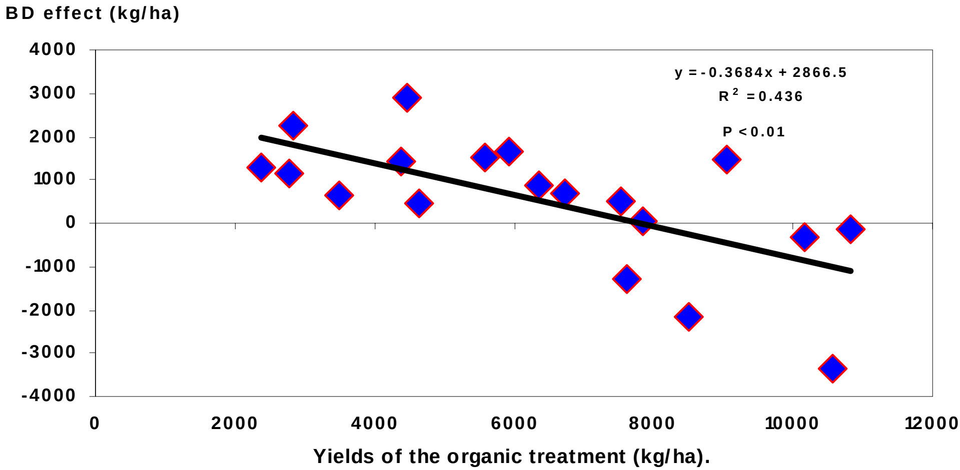

Diagram 2: Effects of the biodynamic and treatment relative to organic on the yields of maize (1994 – 1998).

These happened to be the first two years of the conversion period. When the organic plots yielded below 7.78 Mg/ha, the BD+ treatment had a positive effect on maize yields. A negative effect occurred when maize yields were higher than this. If the organic maize yielded 2.5, 5, 7.5, or 10 Mg/ha, the expected yield increase from using the preparations was predicated to be 1.95, 1.02, 0.1, or –0.82 Mg/ha, respectively.

Maize Roots: In 1998, the organic system had significantly less total root length than the conventional treatment. The two biodynamic treatments were intermediate for length. There were no significant differences in the length of healthy and diseased roots between treatments. The conventional and BD+ treatments produced significantly more root weight than the other two systems (Diagram 3). The organic treatment produced only 75% and 69% of the root weight achieved by the BD+ and conventional treatments, respectively. In 1999, maize grown in BD+ had significantly more total root length and healthy root length than did the organic and conventional treatments. Both of the biodynamic treatments had significantly more root weight than the organic and conventional treatments (Diagram 3).

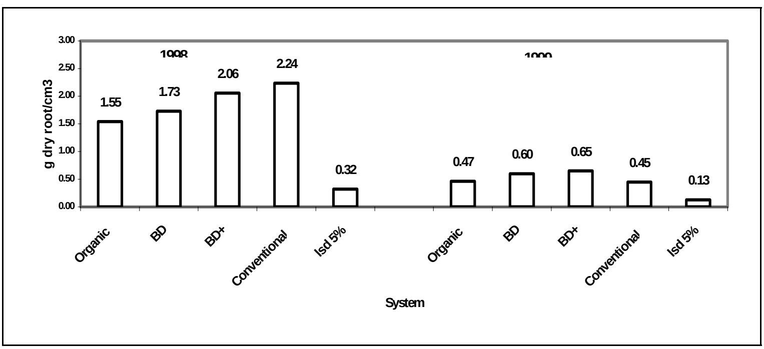

Diagram 3: Average root weight in 1997 and 1999 for maize grown in different farming systems

Conclusions

Our results show that the set of biodynamic preparations that were tested in BD+ had a yield stabilizing effect on wheat and maize. The kind of response as exemplified by the response slopes is practically identical for wheat and maize, indicating that the effect is of the same magnitude for both crops. Our results suggest that preparations increased root growth strongly in maize and that the magnitude of the effect was greatest with the biodynamic treatment that received the most preparations. This ‘yield-balancing’ effect could be important for reducing financial risk, and it may indirectly due to enhanced soil quality and rooting.

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COMPARISONS OF ORGANIC AND CONVENTIONAL MAIZE AND TOMATO CROPPING SYSTEMS FROM A LONG-TERM EXPERIMENT IN CALIFORNIA

Stephen Kaffka, Dennis Bryant, Ford Denison[1]

(1) Department of Plant Sciences, University of California, Davis, California, USA 95616-8515, srkaffka@ucdavis.edu, www.ltras.ucdavis.edu

Key words: organic farming, conventional farming, maize, tomatoes, long-term research

Abstract

Yield differences and trends, organic matter accumulation, and the loss of nutrients to deeper soil horizons are discussed using data from organic and conventional maize/tomato cropping systems from the Long Term Research on Agricultural Systems Project (LTRAS) at the University of California, Davis. Compared to the conventional system, higher and increasing yields of tomatoes were observed in organic systems, but lower yields of maize. Fruit quality, measured as soluble solids, was not significantly different. Soil organic matter increased in the organic system, but remained stable in the conventional one. More irrigation water was used in the organic system than in the conventional one due to higher rates of infiltration, but less winter runoff occurred during the rainy season for the same reason. There was no measurable loss of inorganic N (NO3, NH4) in soil to 3 m depth in either the conventional or organic system after ten years of farming.

Introduction

Gradual changes in soil properties that affect long-term productivity may be hard to detect. The Long-Term Research on Agricultural Systems project (LTRAS) at the University of California at Davis was designed to detect and estimate changes in crop productivity trends due to the effects of differing irrigation and fertilization practices as well as environmental changes related to management. It includes an organic cropping systems comparison in which maize and tomatoes are grown in rotation and compared to conventionally produced crops. Many assume that organic farming systems are sustainable, but there are few data available about the performance of organic systems over time, either farms or experimental systems (Kaffka and Koepf, 1987; Kaffka, 1985; Mäder et al., 2002). The LTRAS experiment was inspired by results from other locations like Rothamsted in England, which has demonstrated that short-term trends can be poor predictors of long-term sustainability (Johnston, 1994).

The primary objective of the LTRAS project is to understand the relationships between sustainability and external inputs in locations with Mediterranean to semi-arid climates where irrigation is essential for crop production. The 10 cropping systems in the LTRAS experiment differ mainly in how much irrigation water, nutrients (particularly nitrogen) and carbon are added. One system follows organic farming guidelines and several are biologically-based, relying on nitrogen-fixing legume cover crops for fertility. Sustainability is determined from long-term trends in yield, profitability, efficiency in the use of limited resources (such as water or energy), and environmental impact, such as leaching of nitrate or pesticides. Trends in key soil properties, such as organic matter, pH, and salinity, changes in weeds, pests, and diseases are monitored to see whether any of these are good predictors for long-term sustainability. This report focuses on results from comparisons between organically (OCT) and conventionally (CCT) farmed maize/tomato systems after 11 years of differing management.

Methods

Following uniformity cropping with sudan grass (Sorghum vulgare) in 1992 and 1993, ten different cropping systems were established using 0.4 ha plots (Denison et al., 2004). Each cropping system is replicated three times and both phases of the two-year systems are present in each year. Systems differ in the amount of irrigation received (rain fed or irrigated) and in the amounts of N and organic matter applied to the soil either as winter legume cover crops, fertilizer, or composted manure. Crop yields and total biomass are measured and analyzed for total N and C. Record keeping and sample archiving includes yearly plant samples from all cropping systems, and time zero and subsequent soils samples collected every few years. In year 10, six soil cores to 3 m in depth were collected from each plot and analyzed in eight segments for N and pesticides to compare losses from the differing systems. Plots are large enough to allow for the use of commercial scale farm equipment, and records are kept for machinery and labor requirements. Daily weather data are collected at the site and irrigation amounts applied are measured using flow meters located at each irrigated plot. Systems rather than single inputs are compared, so a valid comparison requires that each system be managed as carefully as possible to achieve its potential yields. For example, both systems are irrigated as needed and amounts are recorded using water meters, but conventional and organic systems receive different amounts of N and C depending on what is judged best for each system. Conventional maize tomato systems receive 235 kg N ha-1 yr-1, while OMT receive approximately 160 kg N ha-1 yr-1 as an annual winter legume cover crop and approximately 4.5 Mg ha-1 yr-1 (DW) composted poultry manure (250 kg N ha-1 yr-1) on average. Planting dates also differ due to the use of winter legume cover crops in winter in the organic system, but not in the conventional one. The systems studied are simplified compared to actual farms, however, and are chosen to include representative crops rather than more complex, changeable crop rotations. California farmers rarely follow fixed crop rotations, but organic farmers especially tend to have more complex rotations than the one studied at LTRAS. Because plots are smaller than most actual farm fields (0.4 ha) and because of simplified crop rotations, comparisons at LTRAS may not allow for representative assessment of many secondary agro-ecological characteristics like insect and weed problems compared to actual farms.

Results and Discussion

After 10 years of management, soil organic matter levels differ significantly between the conventional (CMT) and organic (OMT) maize/tomato systems. OMT plots had 90 Mg C ha^{-1} added over the period from crop residues, legume cover crops, and composted manure, while CMT systems had 52 Mg ha^{-1}, entirely from crop residues. Soil organic matter levels increased in the OMT system, but remained stable in the CMT one (Kong et al., in press). In a carefully conducted assessment of the role of soil microorganisms and mineral N, Burger and Jackson (2003) reported that potentially mineralizable N (PMN) was approximately twice as abundant in the organic system (tomato phase) as in the conventional one throughout most of the season, and supported a much larger active soil microbial biomass community. This microbial community rapidly absorbed mineral N compounds present, especially NO_3–N. Increased infiltration of surface-applied irrigation water due to greater organic matter levels and the cumulative effects of cover crop growth on infiltration resulted in larger amounts of water being used for irrigation in the OMT system compared to the CMT (6,860 m^3 ha^{-1} compared to 13,350 m^3 ha^{-1} in 2003). Results are partly an artifact of the size of the plots, which limits the length of the irrigation run, and likely would be different (comparable) using sprinkler or drip irrigation systems. For the same reason, and due to cover crops in the winter period, surface water runoff volume during winter was less in the organic than in the conventional system (W. Horwath, personal comm.). Based on analyses to date, there have been no significant differences in the loss of inorganic N (NO_3, NH_4) between organic and conventional maize/tomato systems observed to date based on the analyses of soil core samples taken to 3 m in depth after the tenth year of cropping (Fig. 1). Both systems seem to be environmentally benign so far with respect to this system property.

Average grain yields on a dry weight basis for CMT maize were 11,990 kg ha^{-1} yr^{-1}, while for OMT they were 7,250 kg ha^{-1} yr^{-1}. The coefficient of variation (CV) for inter-annual yield variation was 14.1 % for CCT and 26% for OCT. Lower grain yields result in part from different planting dates used between the conventional and organic system. To allow vetch/pea winter legume cover crops to produce sufficient biomass and fix enough N, they must grow until early April. After incorporation, there must be a 30-day period for decomposition to avoid damage from the seed corn maggot (*Delia platura)*, which is associated with incorporation of fresh organic matter. This results in an unavoidable delay in planting of 40 days or more compared to conventional maize crops and is a structural yield disadvantage associated with organic production in this region, at least until an acceptable organic method of controlling this insect is developed. There are sufficient heat units to mature the later-planted maize crop, but starting the crop later in the summer season results in reduced yields because there is less seasonal light interception and correspondingly less photosynthesis. Conventional and organic system maize yields by year are reported in fig. 2A. Temple et al, (1994) reported similar maize yields among conventional, intermediate and organic systems when planted at similar dates.

Results for fruit yields of tomato, the more profitable crop, were opposite those for grain yields. CMT tomato yields (fresh weight of harvested fruit) were 56 Mg ha^{-1} yr^{-1} while OMT yields were 63.3 Mg ha^{-1} yr^{-1}. In this case inter-annual variation in yield was less in the OMT system: 18% compared to 30.4% in the conventional system. Yields are apparently stable for conventional maize but may be declining in the organic system.. No yield trends are apparent for tomatoes (fig. 2B). Tomato fruit quality was compared at harvest over the period. Soluble solids are a standard measure of quality, and are used as the basis for payment to farmers. There were no significant differences between the cropping systems in soluble solids (Fig. 3).

Conclusions

Comparisons of organic and conventional maize/tomato systems after 11 years of contrasting management indicate that soil quality, measured as total and protected organic C, can be improved using organic systems with winter legume cover crops and external inputs of composted manure in a Mediterranean climate zone. Increases in soil organic C do not appear to have reached a limit (Kong et al., in press). Improving soil quality, so defined, did not increase tomato yields, suggesting that there was no yield benefit from further increasing organic matter above moderate levels. In contrast, there appears to be an unavoidable yield loss associated with delayed planting of organic maize. Sustainability in agriculture is a composite quality in which different measures of system performance can be included. In some of the biophysical measures of system performance, such as nutrient retention and loss and tomato yield and quality, the organic system has performed as well or better than the conventional one, but in others like maize yield and irrigation water use efficiency, not as well.

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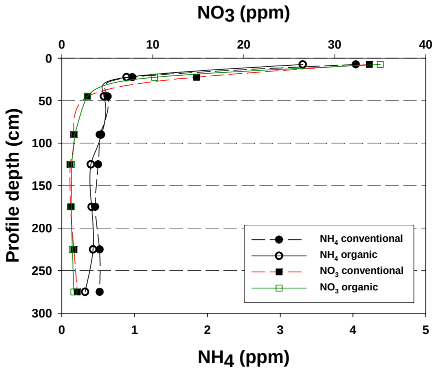

Fig. 1. NO_3 and NH_4 from CMT and OMT plots in fall 2003 collected from 0 to 300 cm deep in the soil profile. Values are the average of three soil cores.

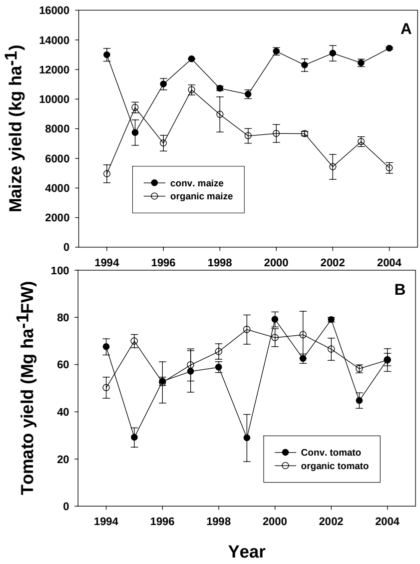

Fig. 2A,B. Maize and tomato yields (1994 to 2004) LTRAS

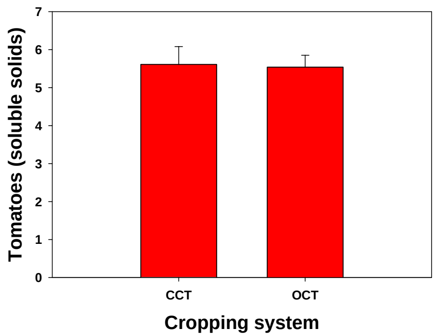

Fig. 3. Average soluble solids for the conventional (CCT) and organic (OCT) cropping systems (1994-2004)

LIFE CYCLE ASSESSMENT OF CONVENTIONAL AND ORGANIC FARMING IN THE DOC TRIAL

Thomas Nemecek, David Dubois, Lucie Gunst and Gérard Gaillard

Swiss Federal Research Station for Agroecology and Agriculture, CH-8046 Zurich, Switzerland, Contact: +41 1 377 72 54, Thomas.Nemecek@fal.admin.ch, www.reckenholz.ch

Key Words: Life Cycle Assessment, Eco-Efficiency, Organic Farming, Conventional Farming, Fertilisation Level

Abstract

The environmental impacts of the conventional and organic farming systems practised in the DOC trial (organic-**d**ynamic, **o**rganic and **c**onventional farming) have been assessed by the SALCA life cycle assessment method. Both organic farming systems were more favourable for the environment in all investigated impacts per area unit. When analysed per product unit, clear advantages of organic farming were found for ecotoxicity and the use of mineral resources, while energy use and eutrophication were similar to conventional farming. Reducing fertilisation by 50% led to lower or equal environmental impacts for all systems, depending on the impact category and the functional unit. The analysis of single crops revealed large differences that are partly counterbalanced by other crops in the crop rotation. The eco-efficiency of organic potato production in particular should be improved.

Introduction

The intensity of agricultural production increased dramatically during the twentieth century. The higher productivity is, however, to a large extent due to the intensive use of mineral fertilisers and synthetic pesticides with potentially adverse impacts on the environment. Organic production was one of the ways proposed to reduce negative environmental impacts of intensive farming. In order to compare the sustainability of organic farming to that of conventional farming, long-term studies are needed, since the transitional phase from conventional to organic production tends to be a long one. This paper evaluates the environmental impacts of different farming systems in a Swiss case study.

Methodology

Organic and conventional farming systems were compared since 1978 in the DOC trial in North-Western Switzerland (Mäder *et al*. 2002). Three farming systems are practised (Tab. 1): organic-**d**ynamic (D), **o**rganic (O) and **c**onventional farming with mixed fertilisation (mineral and organic, C). A conventional control with pure **m**ineral fertilisation (M) was also included. Three fertiliser levels were considered: standard fertilisation according to the recommendations (level 2), 50% of standard fertilisation (level 1) and no fertilisation (level 0). The system without fertilisation (D0) is often also called “N”.

Tab. 1: Overview of the farming systems in the DOC trial. The amounts of the nutrient elements N, P and K per ha and year are given in parentheses as “(kg total N/kg P/kg K)” for the period 1985-98.

Farming system	Organic-dynamic	Organic	Conventional/integrated	
Form of fertilisers	organic	Organic	mineral organic	mineral
Normal fertilisation (100%)	D2 (93/22/170)	O2 (86/25/131)	C2 (165/39/262)	M2 (125/39/249)
Half fertilisation (50%)	D1 (47/11/85)	O1 (43/13/65)	C1 (83/19/131)	
No fertilisation (0%)	D0 (0/0/0)			

The experiment was designed as a Latin square and consisted of crop rotations of seven years each, including the following crops: potato, winter wheat, beetroot, winter barley and clover/grass. In this study, the 14 years of the second and third crop rotation (1985-1998) were analysed. The crop rotations were identical for all farming systems. Comparisons of systems are possible along the rows and columns in Tab. 1.

A life cycle assessment (LCA) was performed by the SALCA method (Swiss Agricultural Life Cycle Assessment) according to Rossier & Gaillard (2004) and Gaillard *et al*. (2005), using the ecoinvent database (Frischknecht *et al*. 2004). The yields, quantities of fertilisers, pesticides and seed as well as the application dates were taken directly from the experimental records. The machine work processes were also taken from the experimental records, but for the purpose of the LCA calculation a mechanisation level typical in practice was assumed. Direct field emissions (ammonia, nitrate, nitrous oxide, nitrogen oxides, phosphorus and heavy metals) were estimated by emission models, partly using situation specific parameters. The analysis was carried out for the crop rotations as well as for individual crops. The following environmental impacts were analysed: use of non-renewable energy resources, global warming potential, ozone formation potential, eutrophication potential, acidification potential and aquatic and terrestrial ecotoxicity potentials, human toxicity potential, land occupation and use of the mineral resources P and K. By means of multivariate techniques (factor or principal component analysis) and correlation, the impacts – with the exception of land occupation, which requires separate consideration – were grouped into three categories (see Rossier & Gaillard 2004). From each of these groups, one representative impact (underlined) was chosen for a detailed analysis:

Group 1 / Resource management: <u>use of non-renewable energy resources</u>, global warming potential, ozone formation potential, mineral resources P and K,

Group 2 / Nutrient management: <u>eutrophication potential</u> and acidification potential,

Group 3 / Pollutant management: <u>terrestrial ecotoxicity</u>, aquatic ecotoxicity, and human toxicity.

Two functional units were considered, representing two main functions of agriculture:

Soil cultivation function: the functional unit is 1 cultivated hectare per year (ha*a) and the environmental goal is to reduce area intensity, i.e. to cultivate the area with minimal adverse environmental impacts.

Productive function, representing the production of food and feedstuff. This is measured as 1 kg dry matter of main products (without straw). The environmental goal is to increase eco-efficiency.

Results and discussion

Fig. 1 shows that the environmental impacts are lower per area unit in the organic systems D and O. This reflects the lower production intensity of organic agriculture, owing to the ban of mineral fertilisers and synthetic pesticides. The eco-efficiency (environmental impacts per kg product) of the organic system is better for toxicity, but not for energy use and eutrophication. Organic yields amounted on average to less than 80% of the conventional yields.

Energy use (characterised by the “cumulative energy demand” method according to Frischknecht *et al*. 2004) is dominated by the use of machinery (including fuel) and the production of mineral fertilisers. Mechanisation differs only slightly between the systems. The largest differences are therefore explained by the use of mineral fertilisers, nitrogen fertilisers having a particularly high energy demand. Consequently, the highest energy use was found in M2, followed by C2 and C1. The product-related energy use differs only slightly between the fertiliser levels 2 and 1, but is clearly higher in D0. There seems to be an optimal fertiliser level close to C1 and D2/O2, i.e. at about half of the nutrient quantities typically applied in conventional systems.

The *eutrophication potential* (characterised by the EDIP method according to Hauschild & Wenzel 1998) is dominated by nitrate leaching and ammonia losses. It decreases with reduced fertilisation and is lower for mineral compared to organic fertilisers, mainly due to higher ammonia losses from the latter.

The *terrestrial ecotoxicity potential* (characterised by the EDIP method according to Hauschild & Wenzel 1998) is clearly higher in the conventional systems C1, C2 and M2, which all received the same pesticide treatments. According to the assessment method applied, the toxicity is caused mainly by diquat, used for potato haulm destruction in one year, followed by the potato fungicide chlorothalonil and the herbicide metamitron (applied to beetroot). Copper applied in system O and partly in K and M did not have a significant effect on the terrestrial ecotoxicity potential, due to much lower ecotoxicity values according to Hauschild & Wenzel (1998).

Land occupation is largely dominated by agricultural production. Due to lower yields, organic systems occupy more land per product unit compared to conventional ones.

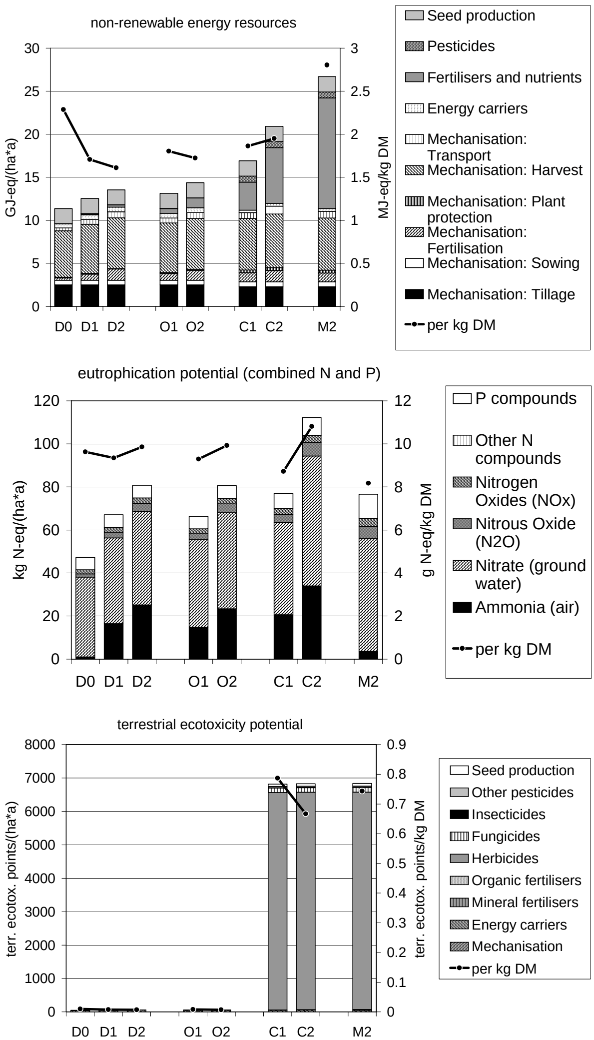

Fig. 1: Selected environmental impacts for the cropping systems in the DOC trial (years 1985-98). Columns represent impacts per cultivated ha and year, the dots and lines impacts per kg dry matter (DM) of harvested main products.

The comparison between organic (O2) and conventional farming (C2) for single crops shows a more differentiated picture (Fig. 2). Energy use is lower per area unit as well as per product unit for cereals and beetroot, whereas it is clearly higher for 1 kg of potatoes. The low potato yield in organic farming prevents eco-efficient production. Few differences were found for clover grass.

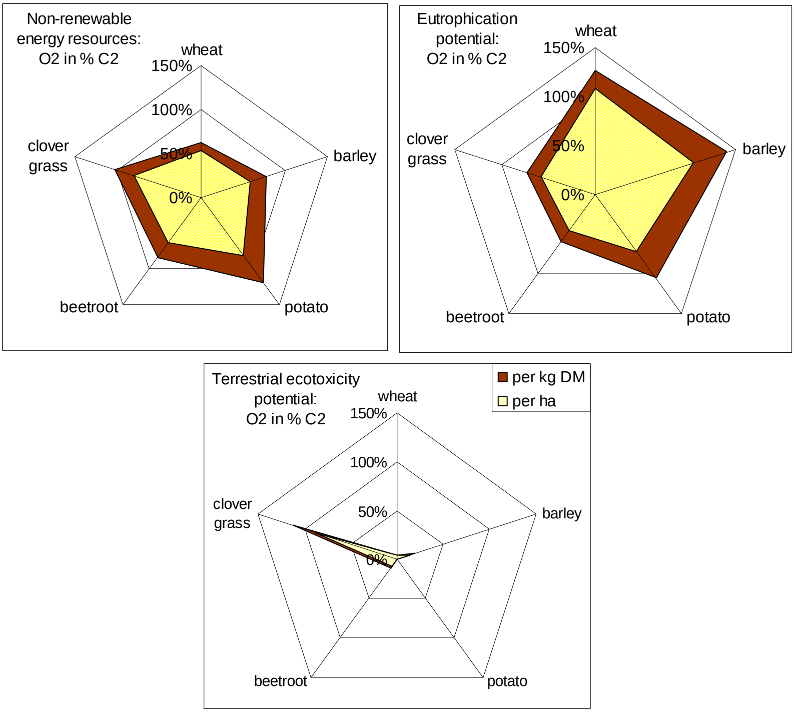

Fig. 2: Comparison of relative environmental impacts of organic and conventional farming (O2 in % of C2 = 100%) for five crops (years 1985-98).

The different manure spreading strategies in organic and conventional farming caused large differences in the eutrophication potentials. In organic farming, the slurry is spread mainly on arable crops, whereas in conventional farming slurry is applied predominantly to clover grass. This situation is typical for Swiss farms, most of them having some livestock production. This leads to higher values for wheat, barley and potatoes, whereas the nutrient losses are higher in the conventional clover grass. Note that clover grass has a high importance in the analysis, since it was grown during 5 years out of 14. Ecotoxicity is clearly lower for all organic arable crops. Since no pesticides were applied to clover grass, no differences were found.

Conclusions

The indisputable advantage of organic farming lies in the better pollutant management leading to lower ecotoxicity potentials. Conversion from conventional to organic farming can lead to agricultural production with fewer negative environmental impacts per area unit and equal or higher eco-efficiency. However, if individual products from organic farming are considered, the associated environmental impacts may be lower, equal or even higher per product unit. This is especially the case for organic potatoes. Great optimisation potential also exists within the different farming systems, especially in improved fertilisation management.

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LONG-TERM ORGANIC CROP ROTATION EXPERIMENTS FOR CEREAL PRODUCTION – PERENNIAL WEED CONTROL AND NITROGEN LEACHING

Ilse A. Rasmussen (1), Margrethe Askegaard (2), Jørgen E. Olesen (2)

(1) Danish Institute of Agricultural Sciences, Department of Integrated Pest Management, Research Centre Flakkebjerg, DK-4200 Slagelse, Denmark, +45 89 99 35 94, IlseA.Rasmussen@agrsci.dk, www.agrsci.org
(2) Danish Institute of Agricultural Sciences, Department of Agroecology, Research Centre Foulum, PO-Box 50, DK-8830 Tjele, Denmark, +45 89 99 17 02, Margrethe.Askegaard@agrsci.dk , JorgenE.Olesen@agrsci.dk

Key Words: Elymus repens, Cirsium arvense, catch crops, summer fallow, grass-clover green manure, yield

Abstract

In long-term organic crop rotation experiments for cereal production, stubble cultivation to control perennial weeds increased nitrogen leaching compared to catch crops grown after harvest. Stubble cultivation contributed to the control of *Elymus repens* on a sandy soil, but not to the control of *Cirsium arvense* on a loamy soil. Manure application had a tendency to decrease *E. repens* density in one rotation at the sandy soil. Grass-clover green manure decreased *C. arvense* in the succeeding crops. Despite high infestations of perennial weeds, yields were at the same level with as without stubble cultivation. The results point to an important dilemma in organic farming: should the farmer control perennial weeds in the stubble at the expense of losing nitrogen by leaching? Or should catch crops be grown that preserve nitrogen, but allow *E. repens* to proliferate?

Introduction/Problem

In arable organic farming, there are many conflicting effects of management decisions leading to dilemmas. An example is the control of perennial weeds. In Denmark, perennial weeds such as *Elymus repens* L. Gould and *Cirsium arvense* L. are traditionally controlled by stubble cultivation in the autumn after harvest of a cereal or pulse crop. When the weed no longer reappears after stubble cultivation, or when soil or weather conditions prohibit the cultivations, the field is ploughed either in late autumn/early winter on heavier soils or in spring prior to sowing of spring crops on lighter soils. Carrying out cultivation during autumn prohibits growing a catch crop. Since autumn and winter is the time of excess precipitation, cultivation may lead to higher risks of nutrient leaching. Contrary to this, when a catch crop is grown, nutrients are retained within the topsoil by being incorporated in the biomass of the catch crop. If the catch crop is a leguminous species, N_2-fixation can further increase the N supply for the next crop. Thus catch crops will both reduce N leaching and increase yields of the following crops. Thus mechanical control of perennial weeds may have negative effects for the N supply in the crop rotation. Results of a Danish crop rotation experiment with and without catch crops were used to analyze treatment effects on the development of perennial weeds and the N leaching at two sites.

Methodology

A crop rotation experiment was initiated in 1996/97 at three sites in Denmark, but only data from two sites are used in this paper (Table 1). The crop rotations represent three systems with different proportions of cereals and nitrogen fixing crops in a four-year rotation (Table 2). The crop rotations were tested with four different combinations of catch crops and manure (Table 2) (Olesen et al., 2000, 2002). 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 N demands for grass-clover, pea/barley and lupin or lupin/barley were set to zero. The target rates for application are shown in Table 2. All cereal and pulse crops were harvested at maturity. 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. The crops were irrigated at one site (Jyndevad).

Table 1. Soil texture, content of organic C and total N, and pH in the top 25 cm of the soil at the three sites in autumn 1996 prior to the onset of the experiment and mean annual precipitation. pH is taken as pH (CaCl2)+0.5. Soil minerals, organic C and total N were measured in percent of dry soil (Olesen et al., 2000).

Site	Clay	Silt	Fine sand	Coarse sand	Organic	Total	pH	Precipitation
	< 2 μm	2-20 μm	20-200 μm	200-2000 μm	C	N		mm
Jyndevad	4.5	2.4	18.0	73.1	1.17	0.085	6.1	964
Flakkebjerg	15.5	12.4	47.4	22.9	1.01	0.107	7.4	626

Weed harrowing and row hoeing were used to control annual weeds. A reduced effort was used in the treatments with catch crops. Perennial weeds were primarily controlled by stubble cultivation in autumn after cereal and pulse crops without catch crops. For *E. repens* this was done when a threshold of 5 shoots m^{-2} was reached in the plot, which happened in 25-100% of the –CC plots at Jyndevad from 1998 to 2002. Most years, stubble cultivation was carried out by shallow ploughing (10-15 cm) in order to loosen the rhizomes, followed by repeated stubble harrowings alternating with rotavations, 2-8 treatments in all. In 2001, the *E. repens* infestation in the +CC treatment of the pulse crops at Jyndevad was so severe that half of the plots were stubble cultivated. The rhizomes brought to the soil surface in these plots were removed manually. *C. arvense* plants were pulled out in all plots at the time of budding, which coincided with anthesis of the cereals. At Flakkebjerg in 2000 to 2002, winter wheat was row hoed in the –CC treatments to control *C. arvense*. The decision whether to carry out stubble cultivation against *C. arvense* was made from visual evaluation of the infestation. One to four stubble cultivations were carried out with a stubble harrow with goosefoot shears, so wide that the whole area was cut through, at increasing depths from 5 to 15 cm in 36-100% of the -CC plots at Flakkebjerg from 1999 to 2002. No stubble cultivations were carried out in 2003 at either location.

Table 2. The crop rotations were carried out with the treatments: without catch crops (-CC), with catch crops (+CC) in combination with the treatments: without manure (-M) and with manure (+M). It is indicated in which crops catch crops are undersown (+CC), and the target rates of NH_4-N (kg ha^{-1}) applied in slurry is shown for the +M treatments.":" indicates undersown ley, "/" indicates intercropping.

	Rotation 1 (R1)	+CC	+M	Rotation 2 (R2)	+CC	+M	Rotation 4 (R4)	+CC	+M
First course 1997-2000	Spring barley:ley		50	Spring barley:ley		50	Oats	+	40
	Grass-clover			Grass clover			Winter wheat	+	70
	Spring wheat	+	50	Winter wheat	+	50	Winter cereal	+	70
	Lupin	+		Pea/barley	+		Pea/barley	+	
Second course 2001-2004	Spring barley:ley		50	Spring barley:ley		50	Winter wheat	+	50
	Grass-clover			Grass-clover			Oats	+	50
	Oats	+	30	Winter cereal	+	50	Spring barley	+	50
	Pea/barley	+		Lupin/barley	+		Lupin/barley		
Sites	Jyndevad			Jyndevad Flakkebjerg			Flakkebjerg		

+CC: + = catch crops in +CC treatments   +M: 30-70 = kg ammonium-N/ha in +M treatments

Nitrate leaching was measured using ceramic suction cells installed at 0.8 m depth at Jyndevad and at 1.0 m depth at Flakkebjerg in selected plots. Above-ground shoots of *C. arvense* were counted and weighed (fresh weight) in the whole plot at the time of anthesis of the cereals. Shoots of *E. repens* that extended above the crop were counted in five 0.1 m^2 areas two weeks after anthesis.

Results and brief discussion

The nitrate leaching losses were largest at Jyndevad and least at Flakkebjerg ($p<0.001$) (Table 3). Catch crops reduced nitrate leaching in both rotations at Jyndevad. The same tendency was seen in rotation 2 at Flakkebjerg ($p=0.09$). At Jyndevad, in six combinations of crop and year, stubble cultivation for control of *E. repens* was carried out in one of the two –CC/+M replicates only, due to differences in infestation with couch grass. This allowed for a comparison of nitrate leaching between +CC plots, –CC plots without stubble cultivation and –CC with stubble cultivation. Stubble cultivation after pulses (lupin and pea/barley) in the –CC plots doubled the nitrate leaching compared with no harrowing. After cereals there was no effect of stubble cultivation on nitrate leaching (Askegaard et al. 2005).

Table 3. Effect of crop rotation and catch crop on nitrate leaching (kg NO3-N ha-1 yr-1) at the two experimental sites. Values with the same letter within a row are not significantly different (P<0.05) (Askegaard et al. 2005).

Site	Rotation 1				Rotation 2				Rotation 4			
	– CC		+ CC		– CC		+ CC		– CC		+ CC	
Jyndevad	106	a	56	b	104	a	65	b				
Flakkebjerg					35	a	26	a	29	a	28	a

At Jyndevad, the *E. repens* infestation developed into a problem during the first few years. Stubble cultivations decreased *E. repens* density in the –CC treatments (Table 4). Application of manure decreased the *E. repens* density in rotation 2 (Table 4). In spite of the high level of *E. repens* infestations in the +CC treatments at Jyndevad, the mean of cereal and pulse yields where higher in the +CC than in the –CC treatments, probably because of an improved nutrient supply. ^

Table 4. Mean density of shoots of *E. repens*, no m^{-2}, with and without catch crops and manure in the two crop rotations for the two courses at Jyndevad. In course 1, 1997 is not included in the mean since the effects of catch crop, stubble cultivation and manure had not appeared yet.

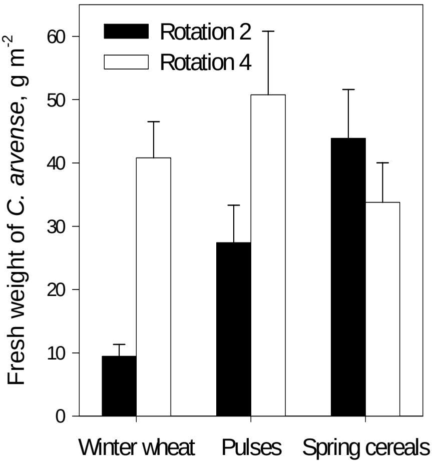
Rotation	Course	-CC	+CC	-M	+M
1	1 (98-00)	7.7	5.8	9.5	4.0
	2 (01-04)	9.8	34.8	21.2	23.4
2	1 (98-00)	6.5	14.9	14.6	6.8
	2 (01-04)	9.2	34.9	28.6	15.5

At Flakkebjerg, there was lower infestation of *C. arvense* in rotation 2 than in rotation 4, with least biomass in the crop the year after grass-clover (Fig. 1). There was no significant difference between the biomass of *C. arvense* in the –CC and +CC treatments (Fig. 2), in spite of the fact that stubble cultivations and row hoeing were carried out in the –CC and not in the +CC treatments. The reason most likely is that the nutrients retained in the topsoil by the catch crops benefited the crops, which became more competitive against the weeds. There was no significant difference in nitrate leaching between the catch crop treatments at Flakkebjerg, but a yield increase in the +CC treatment in rotation 4 (data not shown). Yields of spring cereals were consistently increased after catch crops (data not shown).

Conclusions

At sites with light soils and excess precipitation in autumn, stubble cultivations will most likely contribute to nitrogen leaching compared with growing catch crops in the same season. With stubble cultivations, the following crop will be deprived of some important nutrition, and probably be less competitive against the weeds compared with the situation with catch crops. This is also indicated by the fact that manure applications in some cases reduced *E. repens* density. Our experiments show that although stubble cultivations reduce the *E. repens* infestation compared to the use of catch crops, the expected increase in the yield of the following crop may not be large enough to counter the negative effect of the nutrient loss.

The efficacy of direct control on perennial weeds in the succeeding crop interacts with nutrient leaching so that the yield effects may differ from what is expected. Experiments aimed solely at revealing efficacy of direct control measures may fail to describe the relationship between different treatments, which are very important in organic farming. Our results emphasize that long-term experiments are important for evaluating the effect of different measures.



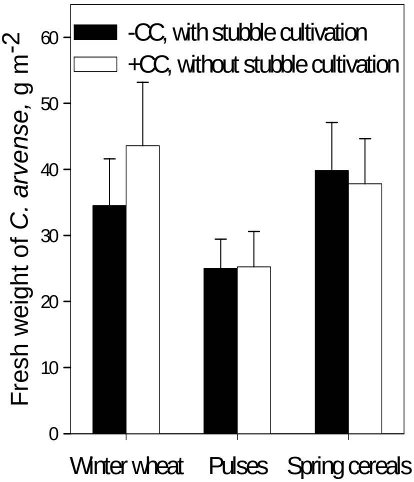


Figure 1. Fresh weight m^{-2} of *C. arvense* in different crops at Flakkebjerg in rotation 2 and rotation 4, mean of 1999-2003, catch crop and manure treatments. Bars indicate standard errors.

Figure 2. Fresh weight m^{-2} of *C. arvense* in different crops at Flakkebjerg without (-CC) or with (+CC) catch crops, mean of 1999-2003, rotations and manure treatments. Bars indicate standard errors.

Acknowledgements

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NUTRIENT TURNOVER AND LOSSES DURING COMPOSTING OF FARMYARD MANURE - RESULTS OF OUTDOOR EXPERIMENTS OVER 11 YEARS

Joachim Raupp, Meike Oltmanns

Institute for Biodynamic Research, Brandschneise 5, D-64295 Darmstadt, Germany, +49-6155-8421-19, raupp@ibdf.de, www.ibdf.de

Key words: Heap, nitrogen, potassium, covering, phosphorus, ammonia, nitrate, temperature, ash content

Abstract

This paper tries to quantify losses of dry matter and nutrients and to look for parameters relevant to the risk of losses. We used data from 14 outdoor experiments carried out in 11 years with cattle manure. Nitrogen (N) rich manures seem to be predestined to have high dry matter and N losses during composting. In cases of high temperatures in the thermophilic stage we also observed high dry matter losses, but not necessarily high N losses. This may be a hint that an intensive decomposition of organic matter is combined with a strong heat development. However, temperature level was independent from the original N content. K losses were not correlated with any of the investigated parameters, not even with water content. Composted manure was about 60% of the original dry matter (calculated by increase of ash content). However, nutrient losses were much lower. Compared to the original contents, approx. 33% N and 39 or 17% K (based on ash contents) have been lost during the entire period of up to 223 days.

Introduction

The reduction of nutrient losses during composting of farmyard manure or other organic materials to a tolerable, unavoidable extent makes sense for reasons of both agriculture (recycling of nutrients and organic matter) and environment (conservation of natural resources). It is impossible to push losses down to almost zero, as composting is a complex system of biological (mainly microbiological) processes, and each metabolic system, a microbe as well as a manure heap, is an open system which exchanges substances and energy with its environment. To reduce losses requires to know first, in which factors and processes losses originate, and how the relevant parameters can be influenced. This can be studied either in closed systems under controlled laboratory conditions or in outdoor experiments under practical conditions.

In this paper we used data from 11 years of outdoor experiments. We try to quantify losses of dry matter, nitrogen, potassium and phosphorus under such conditions, and we look for relevant parameters to predict the risk of losses. Finally, measures shall be discussed that can be taken against losses.

Methodology

In order to have composted manure for our long-term trials, since 1989 in each year between July and September, cattle manure has been stacked on heaps next to our experimental fields (590 mm precipitation per year, 9.5°C annual mean temperature). The manure was taken from organic or conventional farms with a deep-litter stable or a sloping floor straw yard system. Each heap was at least 2 tons fresh weight. The heaps were covered with straw from the beginning. After the thermophilic stage the heaps were covered with a plastic film to protect the material against precipitation. The composting procedure was basically the same in all years and series. The manure was composted until its application, partly in autumn (September or October) to winter crops, partly in spring (March) to spring crops. In each of the composting series (starting in summer, ending in next spring) at least 2 samples have been taken from the fresh manure and from each of the 1-2 heaps of composted manure in autumn and in spring to analyse dry matter (DM), ash, total nitrogen (N), ammonia (NH_4^+), nitrate (NO_3^-), potassium (K) and phosphorus (P). N, P and K contents have been calculated based on ash content in the material, supposing that this parameter is almost constant over time and therefore reliable to quantify the turnover process. Furthermore, total ash content was regarded as a suitable reference parameter, as the heaps have not been turned during composting (Raupp, 2002). Temperature in the centre of the heaps was measured repeatedly over the entire period.

Results are presented in two groups of composting series, altogether 14 experiments in 11 years between 1989 and 2003. No data could be used from 1991, 1992, 1996, 2001, because either no temperature data had been measured or the composting period was only some weeks long and, thus, not comparable to the other years. In 1998, 2000 and 2003 two series with different fresh manures have been set up. The first group of series consists of the years 1989-98, when the composting series fitted the described two-periods scheme: start in summer, first application in autum, second application in next spring. In 2000 the crop rotation of our long-term trial was changed with the consequence that from 2000 to 2003 only summer crops were cultivated. In these years the composting series built a second group that only comprises one period: starting in autumn and ending with manure application in next spring.

Where appropriate, analyses of variance were calculated using the programme PLABSTAT (H.F. Utz, Univ. of Hohenheim, Germany) setting the factor manure type (sampling date) as fixed and the factors year and heap as random. Dry matter loss has been calculated as amount of composted manure in percent of fresh manure with the term (1 : DM-dec) * 100. In this term DM-dec is the dry matter decrease calculated by its reciprocal phenomenon, i.e. the ash content increase expressed by ash content of compost (% DM) divided by ash content of fresh manure (% DM). Correlation coefficients *r* were calculated between the parameters DM, total N, P, K, temperature, DM loss, K loss, N loss and C:N.

Results and brief discussion

The temperature course in manure heaps usually is regarded as a simple indicator of the currently ongoing processes (Gray & Biddlestone, 1981). In our experiments two different temperature levels in the heaps could be distinguished (for reasons of limited space no figures are presented). We observed years with hot composting at a maximum of 60-70 °C (in 6 series), whereas in other years temperatures remained at a medium level below a maximum of 60, in some years even below 50 °C (in 4 series). The temperature course basically followed the well known pattern with a mesophilic stage at the beginning, a subsequent thermophilic stage and then a second mesophilic, cooling down stage.

Table 1: Contents of fresh and composted farmyard manure depending on time; mean values of 8 composting series in 7 years between 1989 and 1998; K = potassium, P = phosphorus; values with different letters are statistically different; $p < 0.05$)

	Fresh manure (in summer)	Composted manure in autumn (66days)	Composted manure in next spring (223 days)
Dry matter (% fresh matter)	23.8 b	25.2 c	21.6 a
Ash (% dry matter)	23.1 a	33.8 b	38.8 c
Compost in % fresh manure	100	67.2	58.8
Total N (% ash)	113.5 c	86.4 b	76.6 a
NH_4-N (mg g^{-1} ash)	20.00 b	1.94 a	1.05 a
NO_3-N (mg 100 g^{-1} ash)	11.8 a	66.6 b	300.6 c
K (mg g^{-1} ash)	138 c	112 b	84 a
P (mg g^{-1} ash)	25.8 a	37.5 b	25.3 a

Whereas dry matter content of the manures showed no clear reaction to composting, the ash content of the materials increased definitely over time, because of organic matter decay (Table 1 and 2). The first group of series showed that a large reduction to 67% of the original material already happened during the first period from summer to autumn (66 days on average of all series; Table 1). In spring after 223 days (on average) the rotted manure was 59% of the original material. We also observed a similar size of mass reduction in the second group of series (Table 2), where 60% of the fresh manure was left after 173 days. Comparing dry matter decomposition and temperature levels it can be stated that the period with the more intense decay also showed the higher temperature. N and K losses (based on ash contents) during the entire period were 32% and 39%, respectively, of the original contents. In the second group of series 33% of N, but only 17% of K have been lost (Table 2). A similar order of magnitude~~,~~ even higher N losses in many cases, is reported from other investigations. For example, in controlled experiments with sheep manure N losses of 46% were found (Thomsen, 2000). P content remained fairly constant all the time. This proves that phosphorus (like ash content) can be considered as a suitable reference parameter for turnover rates and nutrient losses, as e.g. Petersen *et al.* (1998) recommended.

As expected NH_4-N decreased and NO_3-N increased during composting. In many cases nitrate was not at all detectable in fresh manure. As no ^{15}N-labelled materials were used, the fate of NH_4-N and NO_3-N during composting (nitrification, NH_3 losses, assimilation in biomass) is unclear.

Table 2: Contents of fresh and composted farmyard manure; mean values of 6 composting series in 4 years between 1999 and 2003; K = potassium, P = phosphorus; values with different letters are statistically different; $p < 0.05$)

	Fresh manure (in autumn)	Composted manure (in next spring, 173 days)
Dry matter (% fresh matter)	25.0 a	30.2 b
Ash (% dry matter)	16.5 a	27.9 b
Compost in % fresh manure	100	60.2
Total N (% ash)	128.1 b	85.5 a
NH_4-N (mg g^{-1} ash)	1526 b	111 a
NO_3-N (mg 100 g^{-1} ash)	6.8 a	118.7 b
K (mg g^{-1} ash)	118 b	98 a
P (mg g^{-1} ash)	29.3	27.6

Correlation coefficients have been calculated for selected parameters (Table 3), in order to evaluate possible relations, although it has to be taken into account that a correlation coefficient may give a hint that two facts occur at the same time, but it is no simple indication of a causal connection. In most cases N rich manures had also high P contents, whereas K content was independent from N and P. The N or P rich fresh manures had also high dry matter losses during composting. In cases of high N contents in the fresh manure high N losses have also been observed. No other parameter correlated with N losses. High dry matter losses also occurred in cases of high temperature in the thermophilic stage. This may be a hint that an intensive decomposition of organic matter is combined with an intensive heat development. However, temperature level was independent from the original N content. Hot composting seems to not necessarily be the consequence of a high N supply in the original material. High temperatures were also not correlated with the original humidity (dry matter content), and the original P and K contents. This is surprising, as soil microorganisms react markedly to P availability in soils. Correlation coefficients of C:N ratio give no further information that has not already be gained from the parameter total N.

K losses were not correlated with any of the investigated parameters, not even with water content. It could be assumed that a wet fresh manure will lead to more seepage combined with K losses. However, in our experiments the range of water content in the fresh manures probably was not large enough to play a role.

Table 3: Correlation coefficients *r* between parameters of fresh manure (total nitrogen = N_t, dry matter = DM, phosphorus = P, potassium = K), the maximum temperature in the thermophilic stage (T-max), dry matter losses (DM-l), potassium and nitrogen losses (K-l and N-l) at the end of the composting period and C:N ratio at the beginning; n = 13, $p < 0.05$*, $p < 0.01$**

	N_t	DM	P	K	T-max	DM-l	K-l	N-l
DM	-0.467							
P	0.688**	-0.412						
K	0.137	0.42	0.226					
T-max	-0.216	0.219	0.399	0.519				
DM-l	0.730**	-0.351	0.681*	0.319	0.778**			
K-l	0.195	-0.322	-0.113	-0.093	0.177	0.313		
N-l	0.646*	-0.353	0.055	-0.107	-0.615	0.31	0.215	
C:N	-0.946**	0.422	-0.588*	-0.295	0.215	-0.823**	-0.254	-0.624*

Conclusions

Among all investigated parameters, only the original N content was correlated with N losses. This parameter, if any, seems to be suitable to predict the risk of N losses. Therefore, to balance the C:N ratio is sometimes recommended. Gray and Biddlestone (1981) consider a C:N ratio of 30:1 to 35:1 to be optimal. However, these values may only be used as a rough target, as N losses depend upon further circumstances. Moreover, the type of C-rich material used as bedding has an influence on the amount of N losses (Kirchmann, 1985).

The relatively low K losses achieved in our experiments are probably due to the rainproof covering on the heaps by plastic film after the thermophilic stage.

Further experiments should aim at clarifying which factors and interactions are responsible for the temperature level. Although not being significant in our experiments, temperature level seems to have an influence on N turnover.

Acknowledgement

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INTERPRETING SOIL ORGANIC MATTER CHARACTERISTICS IN ORGANIC FARMING SYSTEMS

Michelle M. Wander, Emily E. Marriott, Yun Wang

University of Illinois, 1102 S. Goodwin Ave, Urbana IL, 61801, 217-333-9471, mwander@uiuc.edu
University of Illinois, 1102 S. Goodwin Ave, Urbana IL, 61801, emarriot@students.uiuc.edu
University of Illinois, 1102 S. Goodwin Ave, Urbana IL, 61801, yunwang@uiuc.edu

Key Words: Organic Farming, biologically based fertility, particulate organic matter, labile N

Abstract

Soil organic matter (SOM) fraction characteristics need to be developed as indices that can be related to specific soil functions. The general effects of organic management on promising indices of SOM status (POM and a rapid measure of base hydrolyzable N) were determined by comparing the characteristics of organic and conventionally managed soils obtained from nine long-term trials in North America. In addition, a more detailed study was conducted of POM and of hydrolyzable N fractions (including amino-acids, amino sugars) at a site where use of organic practices failed to increase SOM. In the multi-site comparison, legume- and manure-based organic systems performed equally well in their ability to increase the quantity of SOM as well as enrich the proportion of particulate organic matter, where POM was assessed using a variety of methods. The quantity of C and N in the coarse fraction, loose light fraction, and aggregate occluded fraction were similar in soils from legume and manure-based systems. The amount of POM-N recovered using a variety of methods was equal to the amount of N recovered by base hydrolysis and was more that twice that required to support a full crop of maize. Base hydrolyzable N was no more sensitive to management than was total N. We were able to differentiate between the manure- and legume based organic systems by assessing the quality of the aggregate occluded POM fraction (< 2.0 g cm-1); this fraction was most humified and contained a greater amount of plant available N in the manured soils. In a related study of an aberant organic site, where SOM levels remained low and maize yields lagged in the legume based system, the only SOM attribute that differed among the three systems was amino acid N contents. Contents were least in the conventional and greatest in the manure based organic system. Whole soil and POM C/N ratios were quite low and were accompanied by extremely high amino sugar levels. Fraction characteristics suggest an imbalance in soil C and N reserves and that disease, rather than N insufficiency, may be limiting yield. This, and possibly C priming by surplus N, may constrain organic matter accumulation. Through using multiple measure of labile SOM, and considering C and N together, we begin to use SOM diagnostically. Disproportional responses in labile fractions can identify resource limitations or surpluses within a system.

Introduction/Problem

The vagueness of organic guidelines may stem from the fact that our understanding of biologically based fertility is quite limited (Wander, 2004). Our practical knowledge has progressed little since 1943 when, in "The Living Soil", Lady Eve Balfour outlined the principles of organic fertility and what was then called humus farming (Balfour, 1975). She claimed that "humus benefits the soil in three ways: mechanically, as a plant food, and by fundamentally modifying the soil bionomics". This conception of organic fertility persists and explains why special emphasis is given to the characteristics of soil organic matter (SOM) and points to the need to tailor measures to assess it's multiple benefits. Organic matter fraction characteristics need to be developed for diagnostic use. Numerous studies have documented differences between organic and conventional soils in SOM and microbial properties (Pullerman, 2003, Shannon, 2002). However, few measures of SOM have found their way into practical use. Indices of SOM status need to be related to plant nutrition, soil tilth, and disease suppression.

Methodology

Soils were obtained from the plow depth of nine long-term farming systems trials (table 1) that included manure- and legume-based organic, and conventional farming systems.

Table 1. Long-term farming system trials in the U.S., Rotation and Fertility Treatments

Trial	Trt‡	Crop rotation§	Fertility source
Field Crops Organic Transition Experiment, Wooster Ohio (FCTE)	M	*c-sb-o-h	raw strawpack beef manure and poultry compost
	C	*c-sb	synthetic fertilizer
Farming Systems Project, Beltsville Maryland (FSP)	M	c/r-*sb-w/v or cc	raw broiler litter
	C	c-*sb-w/sb	synthetic fertilizer
Farming Systems Trial, Kutztown, PA (FST)	M	w/rc/a-rc/a-*c/r-r/*sb-cs/w	aged cattle manure
	L	v/*c-c/r-*sb/w-w/v	hairy vetch cover crop
	C	*c-c-*sb	synthetic fertilizer
Living Field Lab, Hickory Corners MI (LFL)	M	*c/cc-c/ar-*sb-w/rc	dairy manure-oak leaf compost
	C	*c-c-sb-w	synthetic fertilizer
Long Term Ecological Research, Hickory Corners MI (LTER)	L	*c-sb-w/rc	red clover cover crop
	C	*c-sb-w	synthetic fertilizer
Long Term Research on Agricultural Systems, Davis CA (LTRAS)	M	v/p/*c-v/p/t	composted poultry litter
	C	*c-t	synthetic fertilizer
Muscatine Island Research and Demonstration Farm, Fruitland, IA (MIRD)	M	r/hv-*pp	poultry manure compost
	C	r-*pp	synthetic fertilizer
Neely-Kinyon Long-Term Agroecological Research, Greenfield IL (N-K)	M	*c-sb-o/a and *c-sb-o/a-a	composted swine manure
	C	*c-sb	synthetic fertilizer
Wisconsin Integrated Cropping Systems Trial, Arlington, WI (WICTS)	M	*c-o/a-a	dairy manure compost
	L	*c-*sb-w/rc	red clover cover crop
	C	*c-*sb	synthetic fertilizer

‡M, manure-based organic farming system; L, legume-based organic farming system; C, conventional farming system relying on inorganic fertilizers.
§Asteriks indicate crop entry points that were sampled. c, corn; sb, soybean; w, wheat; o, oats; h, hay; rc, red clover; a, alfalfa; r, rye; cs, corn silage; v, vetch; cc, crimson clover; ar, annual ryegrass; p, pea; t, tomato; pp, pepper.

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Composite soil samples of multiple cores were obtained from the surface depth, ≈ 0 to 25 cm, of the nine long-term trials during the spring of 2002 and/or 2003. Air-dried samples were ground to pass a 2-mm sieve after organic residues greater than 2 mm were removed by hand. Any carbonates were destroyed before SOC analysis. Particulate organic matter in the coarse fraction (CF > 53 µm) was collected on polyester mesh fabric after 20-g soil samples were dispersed in 5% Na hexametaphosphate. Plant available N in whole soils was assed using the Illinois Soil N Test (Khan et al., 2001) which liberates base-hydrolyzable N (BHN). In an effort to resolve differences in the fertility status of the organic systems, POM was subdivided using a sequential scheme to obtain the loose, light fraction (LLF <1.6 g cm^{-3}); occluded fraction (OF >1.6 g cm^{-3} <2.0 g cm^{-3} after dispersion); and coarse heavy fraction (CHF material remaining > 53 µm). Whole soil and POM fractions were analyzed for C and N by combustion-based elemental analysis. Additionally, the N supply capacity of POM fractions was assessed by determination of the BHN in each fraction.

In a separate study, samples were collected from the Wisconsin Integrated Cropping Systems Trial located in Lakeland WI. The treatments were similar to those applied in the WICTS trial established in Arlington WI. Particulate organic matter was isolated as the CF (POM> 53 µm). Soil N supply was assessed by using the diffusion techniques of Mulvaney et al. (2001). Briefly: total hydrolyzable N was measured by Kjeldahl digestion of the hydrolysate and diffusion of the digest with NaOH; diffusion was performed with MgO to determine hydrolyzable NH4-N; (hNH4-N + amino sugar)–N was recovered by diffusion with NaOH, after which amino acid–N was liberated by ninhydrin oxidation at pH <1.8 and then recovered by diffusion with NaOH.

Results and brief discussion

The thesis research of Emily Marriott investigated soils from long-term trials and showed that on average, use of organic management practices increased C sequestration by 0.4 t C ha-1 yr-1 in both legume and manure based systems. Surprisingly, the CF-C, -N, and BHN concentrations were similar in soils from manure- and legume-based organic systems (Fig 1). The same was true of the amount of N recovered in POM and BHN, which are reputed to be measures of plant available N (Fig 1). Over all, organic management enriched CF-C and -N concentrations in soil by nearly 30% relative to conventional controls; this level of enrichment was 2 to 3 times greater than were increases in BHN or whole soil C or N. The amount of BHN in soil was less responsive to management than CF-C or -N, and was highly correlated with SOC and TN. Soil BHN was also correlated with climatic and textural characteristics; this indicates this fraction includes biologically recalcitrant components. By assessing the quality of aggregate occluded POM (OF) we were able to differentiate among the two types of organic systems. The greater ability of manure-based organic systems to accumulate plant-available N was suggested by the OF's relatively low C/N ratios and its greater abundance of BHN (Fig 2). The close relationship between the quality of residues added to soils and the LLF was demonstrated by elevated fraction C/N ratios in the conventionally managed soils, which is consistent with plant based inputs. Input quality was also apparent in the 50% enrichment of the LLF's BHN content in the organic soils.

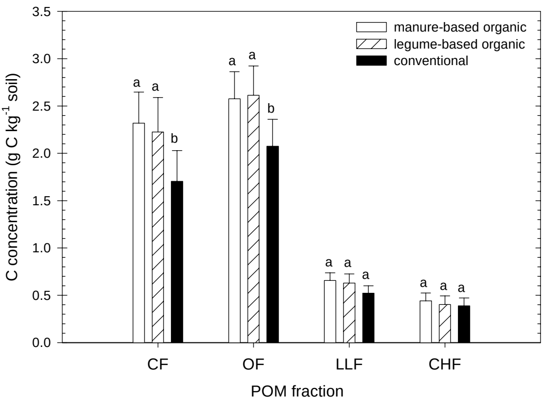

Fig. 1. Carbon concentrations in coarse (CF); occluded (OF); loose, light (LLF); and coarse, heavy (CHF) particulate organic matter (POM) fractions in manure-based organic, legume-based organic, and conventional farming systems at 9 long-term trials in the U.S. Different letters within a fraction indicate significant differences (*P* < 0.05). Error bars represent 1 standard error of the mean

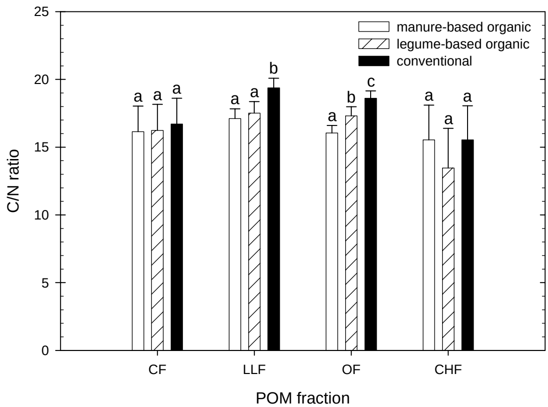

Fig. 2. Carbon to N ratios in coarse (CF); occluded (OF); loose, light (LLF); and coarse, heavy (CHF) particulate organic matter (POM) fractions in manure-based organic, legume-based organic, and conventional farming systems at 9 long-term trials in the U.S. Different letters within a fraction indicate significant differences ($P < 0.05$). Error bars represent 1 standard error of the mean.

The thesis research of Yun Wang, conducted on the Lakeland WICTS trial, investigated an aberrant site, where organic systems failed to accumulate SOC but did accumulate amino acid-N (Fig 3). The legume-based system failed to support maize yields equal to those achieved in manured plots. Both the concentration (1.3 g POM-C/kg soil) and proportion (≈7.5% of total C) of POM-C were low and did not vary among farming system. Failure to accumulate POM under organic management is rare; rapid POM decomposition rates might be related to high levels of available N. This was suggested by very high levels of hydrolysable-, amino acid- and amino sugar-N. A past history of manure-application may account for excessive levels of labile N. Positive yield response to manure application at that site may be due to disease suppression rather than N insufficiency.

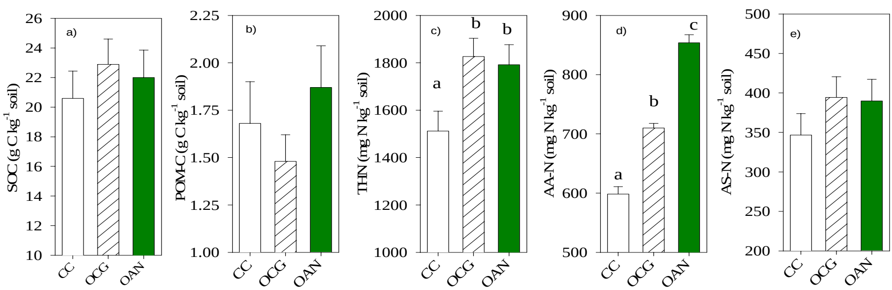

Fig. 3. Total SOC (a), Particulate organic matter-C (b), total hydrolyzable N (c), amino acid N (d), and amino sugar N, in soils (0-40cm) from conventional-, organic-cash grain or legume-based organic, and manure-based organic farming systems.

Conclusions

Results from these two studies suggest that POM fractionation characteristics are powerful integrators of system characteristics and demonstrate that different approaches to SOM characterization can amplify or obscure important differences in the fertility status of soils under different management strategies. It appears possible to make direct links between POM status and soil N supply as well as with soil physical and biological condition. However, it is not reasonable to expect that one measure of POM will adequately describe its multiple contributions to soil health; instead, efforts should be made to develop a shared strategy for measurement selection and interpretation

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ANIMAL HUSBANDRY AND WELFARE – NON-RUMINANTS

MOBILE AND STATIONARY SYSTEMS FOR ORGANIC PIGS – ANIMAL BEHAVIOUS IN OUTDOOR PENS

Christel Benfalk (1), Kristina Lindgren (1), Cecilia Lindahl (1), Margareta Rundgren (2)

(1) JTI – Swedish Institute of Agricultural and Environmental Engineering, P.O.Box 7033, SE-750 07, Uppsala, Sweden, +46 18 30 33 96, Christel.Benfalk@jti.slu.se, www.jti.slu.se, Kristina.Lindgren@jti.slu.se, Cecilia.Lindahl@jti.slu.se
(2) Swedish University of Agricultural Sciences, Dep. Animal Nutrition and Management, P.O. Box 7024, SE-750 07, Uppsala, Sweden, +46 18 67 20 57, Margareta.Rundgren@huv.slu.se, www.slu.se

Key Words: Fattening pigs, Defecating behaviour, Urinating behaviour, Excretion hotspots

Abstract

The production of organic pork in Sweden has increased. For several years, however, demand has been greater than production. An important factor contributing to the limited production is a lack of knowledge and experience of outdoor pig systems, since they are uncommon in Sweden. This study compared the behaviour of fattening pigs in two different organic production systems, with the main focus on excretory behaviour. In both the mobile and the stationary system there was an uneven distribution of manure and urine in the pens. In the mobile system, the hotspots were in the hut area and in part of the drinking area, while in the stationary system, the concrete pad as well as the wallowing area and the first section of the transportation area seemed to be the hotspots. Furthermore, the pigs avoided defecating around the feeding troughs and lying area in the mobile system. A more uniform distribution of nutrients can possibly be obtained by manipulating the excretory behaviour of the pigs, e.g. by regularly shifting the positions of the feeders and huts.

Introduction/Problem

Organic livestock farming, based on the production guidelines, has set itself the goal of establishing environmentally friendly production, sustaining animals in good health, realising high animal welfare standards, and producing products of high quality. In Sweden, the demand for organic pork has been greater than production for several years. An important factor attributing to the limited production is a lack of knowledge and practical experience, since outdoor pig systems are uncommon in Sweden (Alarik, 1999). In outdoor pen systems, the urine and faeces from the pigs are left directly on the ground, which with limited grass cover in the pen may lead to major nitrate losses during autumn and winter. Several studies have shown that pigs avoid defecating close to the lying area, feeding place, and the drinkers (Olsen *et al*., 2001; Stolba & Wood-Gush, 1989; Baxter, 1982). However, nutrient “hotspots” in the pen may be created, due to the excretory behaviour of outdoor pigs (Watson et al., 1998). Through daily allocation of new land, it is possible to influence the urination and defecation pattern (Andresen, 2000). Eriksen and Kristensen (2001) concluded that sows’ excretory behaviour is affected by large amounts of feed, as it causes more excreta to be deposited in the feeding area. The results of Eriksen and Kristensen (2001) were based on investigations of manure mapping through soil samples, while Andresen (2000) used behavioural studies of urination and defecation. This study is a part of a larger project with the overall objective of identifying and recommending strategies that simultaneously provide a good animal environment, resource-efficient nutrient management, and a good working environment for pigs when producing pork in outdoor systems. The aim of this study was to compare the behaviour of fattening pigs, with the main focus on excretory behaviour, in two organic pig production systems.

Methodology

Two Swedish commercial farms with fattening pigs were studied, a mobile versus a stationary system, during 2002 and 2003 (May - November). In the mobile system the pigs were kept on arable land and had access to huts made of straw and tarpaulins. Each pen contained a hut, feeding troughs, water and wallowing facilities, and a grazing area. The pigs were transferred to a different plot of arable land every year. Each hut had a total area of 26 m^2 and the laying area for each pig was approx. 0.7 m^2. The group size of each pen was between 20 and 50 pigs.
In the stationary system, the pigs were kept in a barn with access to an outdoor area. The feeding trough,

water facilities, and resting area with straw litter were located in the barn and each pen was 65 m^2. The group size of each pen was 40 pigs. The outdoor area started with a concrete pad of 39 m^2 per group, which opened onto a long, narrow grazing area where the wallowing facilities were located. In each system, 5 groups of pigs were studied, for a total of 780 pigs. The pigs were studied at two different ages, approximately 15 and 20 weeks. Each observation day was 8 hours long and chosen according to the pigs' period of activity, with 4 hours in the morning and 4 hours in the afternoon. The pens were divided into four sub-areas, corresponding to which activity the pigs performed in each area. The pens in the mobile system were divided into feeding area, hut area, drinking area, and grazing area. The wallowing area was placed either in the feeding or drinking area, depending on the pen design. The pens in the stationary system were divided into concrete pad area, wallowing area, transportation area, and grazing area.
Continuous recordings were made for defecating, urinating, drinking and wallowing. Each defecation and urination was also positioned on a map of the pen, where the different sub-areas were outlined. For eating, standing/walking, rooting, lying, grazing, and spending time in barn/hut, observations were made every 5 minutes. In the stationary system, eating and drinking behaviours were not registered because they were performed inside the barn. This also applies to defecating and urinating behaviour in the barn. After each observation day, manure mapping of the whole pen was done. The amount of manure was estimated on a scale 0-5, where 0 stands for no manure while 5 means that the ground was completely covered with manure. The data were analysed by PROC MIXED according to SAS (SAS Institute Inc., 1996). The model statement included year, system, age, and sub-area within system as general fixed effects. Random variables were group within year and type of system.

Results and discussion

It was shown that general behavioural differences existed between the systems in the proportion of wallowing, rooting, lying (outdoors) and spending time in the barn/hut (figure 1). In the stationary system pigs spent more time inside the barn ($p<0.001$), which is partly due to the fact that feed and water were provided in the barn. In the mobile system the pigs had to go out of the hut to eat and drink.

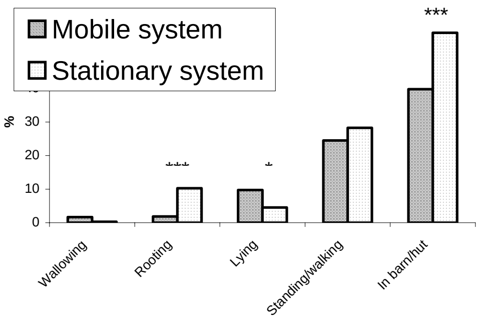

Figure 1. Proportions of general behaviour between systems (percent of total number of observations).

A significantly higher proportion of rooting ($p<0.001$) and a significantly lower proportion of lying ($p<0.05$) were seen in the stationary system. The proportion of rooting behaviour in the stationary system is in the same range as in a study by Andresen and Redbo (1999). The soil type was sandy loam. However, in the mobile system the level of rooting was very low compared to other studies (Stolba & Wood-Gush, 1989; Petersen, 1994; Andresen & Redbo, 1999). This was probably due to the fact that the soil type was clay, which became very hard during dry seasons. In the mobile system, pigs were observed to root around such places as the wallowing area and water facilities, where it was easier to root. The behaviour of drinking was studied only in the mobile system; the pigs drank mainly after feeding, before entering the grazing area, and when they returned from the grazing area. The pigs drank on average 6.8 times per observation day, and no differences were shown between year or age. There were no disparities in general behaviour between the different ages except for rooting, which was performed more often when the pigs were 20 weeks compared with 15 weeks old ($p<0.001$).

In the mobile system, the pigs normally did not defecate in the hut. Pigs attempt to urinate and defecate far away from their resting area (Baxter, 1984; Stolba & Wood-Gush, 1989). The pigs defecate and urinate when they left the hut on their way to the feeding area (figure 2). Therefore, the highest concentration of faeces and urine was observed between the hut and the feeding trough. Both the behavioural observations and the manure maps show that the pigs did not discharge their faeces in the areas around the feeding trough or the water facilities. Pigs prefer to keep the feeding area free from faeces (Olsen et al., 2001). However, other studies have discussed the fact that a high level of N in soil close to feeders is probably caused by the large amounts of both feed and faeces deposited in this area (Eriksen & Kristensen (2001). The pigs did defecate and urinate on their way to and from the grazing area. When the pigs defecated or urinated in the grazing area, they had no noticeable preferences for where they discharged their faeces and urine.

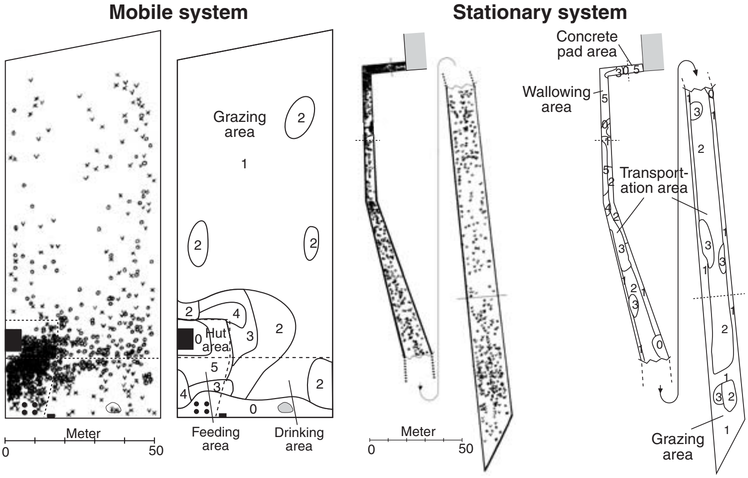

Figure 2. Manure map for one day of the behaviour study (left) and manure mapping (right) for one day, from the 0-5 scale, for one representative group. ○ = manure, x = urine from male pigs, v = urine from female pigs

In the stationary system, when the pigs went outdoors they defecated and urinated on their way to the grazing area (figure 2). The manure maps showed that the outdoor areas closest to the barn (the concrete pad, the wallowing area and the first section of the transportation area) had the heaviest manure loads, while in the rest of the outdoor area (secondary section of the transportation area and the grazing area), the manure was more evenly distributed.

Table 1. The average concentration of faeces and urine in each sub-area (number of defecations or urinations/10 m^2 and 10 pigs).

System	Area	Conc. manure	Conc. urine
Mobile	Feeding	0.22	0.35
	Drinking	0.31	0.39
	Hut	0.44	0.54
	Grazing	0.07	0.04
Stationary	Concrete	0.75	0.83
	Wallowing	0.94	0.81
	Transportation	0.20	0.10
	Grazing	0.18	0.19

In the systems investigated, both the pen and sub-areas within each pen differed in size. The number of pigs in each pen also differed both between systems and among pens within a system. By expressing the data as the number of defecations or urinations/10 m^2 and 10 pigs, the results obtained between sub-areas or pens within a system are comparable. It is to be noted that number of defecations/urinations is not proportional to the amount of faeces/urine, because the discharges are not equal in weight, for example due to differences in maintenance ration of fodder, especially between systems. The average concentration of faeces in each sub-area was significantly higher in the stationary system than in the mobile system ($p<0.05$) (table 1). Within the stationary system, the concentration of faeces and urine was significantly higher in the concrete and wallowing area than in the transportation and grazing area ($p<0.001$). The concentration of manure and urine on the concrete pad and in the wallowing area in the stationary system was higher compared to the hut area in the mobile system ($p<0.05$). These sub-areas, irrespective of system, were comparable due to their proximity to the resting areas (in the barn and in the hut). Also, the average size of these sub-areas was comparable. Olsen et al. (2001) stated that most outdoor urinations and defecations were placed in the wallow. We found that there were pigs defecating and urinating in the wallow but not in such high levels as reported by Olsen et al. (2001), although the wallowing area was exposed to high levels of faeces and urine in the stationary system.

Conclusions

In both the mobile and the stationary system, it was concluded that there was an uneven distribution of manure and urine in the pens. In the mobile system, the hotspots were in the hut area and in part of the drinking area ,while in the stationary system, the concrete pad as well as the wallowing area and the first section of the transportation area were the hotspots. Also, the pigs avoided defecating around the feeding trough and in the hut in the mobile system. The concentration of defecations and urinations was higher in the hotspot areas in the stationary system than in the mobile system. A more uniform distribution of nutrients should be obtained by manipulating the excretory behaviour of the pigs. This can be done by regularly shifting the position of the feeders and the huts, but also by having a longer distance between these facilities. In the mobile system, it is easier to fulfil the mentioned requirements, as the whole system is mobile in its construction.

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MOBILE AND STATIONARY SYSTEMS FOR ORGANIC PIGS – WORKING ENVIRONMENT

Qiuqing Geng, Anna Torén

JTI – Swedish Institute of Agricultural and Environmental Engineering, P.O. Box 7033, SE – 750 07, Uppsala, Sweden, Tel. +46 18 30 33 00, qiuqing.geng@jti.slu.se, www.jti.slu.se

Key Words: Ergonomic load, farmer, outdoor pig system, risk for accident, work environment screening tool

Abstract

This paper presents parts of the results from a work whose objectives were to investigate how well two organic growing-fattening pig systems fulfil the basic goal of having a safe and healthy working environment and to identify areas where there is a need for development. The work is one component of a large project that aimed to identify strategies for simultaneously reaching a good animal environment, a resource-efficient nutrient management, and a good working environment in outdoor pig systems. The Work Environment Screening Tool in agriculture (WEST-agriculture) was used in the study. The screening of the work environment was carried out in the two systems during different seasons. The results showed that during foddering and watering the risk for accidents and ergonomic load could be much higher in the mobile system than in the stationary system. Some proposals for the improvement of the working environment are discussed in order to obtain valuable information for agricultural advisory services and farmers working in different outdoor pig systems.

Introduction

Outdoor pig systems for organic pork production have increased during the last decade (Andresen 2000). In Sweden, there are two common types of outdoor systems. One is the mobile system, where the pigs have access to large areas with pasture. Huts for shelter and the feeding places are mobile and moved with the pigs to new areas. Another is the stationary system, with stationary barns and an outdoor area including pasture, which is restricted to the area that can be connected to the barn. Until now, only a few studies have been carried out concerning the working environment in organic farming as compared to non-organic farming. Lundqvist (2000) performed a mail-in survey among experienced people in organic farming in Sweden. In his survey, the positive aspects were the absence of pesticides or fertilisers, the positive response from the surrounding of being the "good example", and the positive challenge of getting a good harvest in organic production. Among the negative aspects, increased workload was the most common answer. The objective of this paper was to investigate how well the two systems fulfil the basic goal of having a safe and healthy working environment and to identify areas for further development.

Methodology

A method named WEST-agriculture (Torén *et al.* 2004) was utilised in the study. The method is a modified version of WEST (Work Environment Screening Tool, Karling & Brohammer 2002). With this method, six factors screened were risk of accidents, ergonomic load, psychosocial factors, noise, chemical health hazards, and the physical work environment. For each factor, there is a model for the exposure-response relationship for the factor and a method to translate this relationship into health effects. The model is based on the statistics for the economic activity where the screening is to be performed (number of people employed in the sector, number of accidents and diseases, sick leave, death-rate, individuals disabled, etc). Then the costs for these injuries and accidents are calculated, for the company, the individual, and society. The health effects are expressed as SEK per thousand working hours (SEK/1000 h). Each work situation gives positive or negative contributions to the factor of interest. A representation of the working environment is thereby obtained that clearly shows which factors give negative or positive contributions. In the WEST-agriculture the screening of accidents is based on the data from the economic activity agriculture. The screening of ergonomic load, psychosocial factors, noise and vibrations, chemical health hazards and physical work environment are based on the statistics from the economic activity manufacturing industry.

The screening was carried out on six outdoor pig farms, three with mobile and the other three with a stationary system. The screening of noise was performed in two of the farms, one with each system.

The work with pigs was categorised into three main tasks for the screening:

- work involved in turning pigs out to the outdoor area in the spring (setting up fences, handling of huts), bedding and cleaning of stall, etc.;
- daily work in feeding, watering, and management of the mud baths;
- preparation for sending the pigs to slaughter (weighing and loading for transport).

All work included in the three tasks was observed during two different seasons. A detailed interview was performed with each farmer. The interview involved questions concerning demand and control of the work, together with the economic and psychosocial support from the surroundings. The working time during the tasks was measured at two of the farms. For the other four farms the farmer was asked to estimate the time consumed by each task. Furthermore, the working time during the outdoor period was used as a weighting factor in order to compare the risk for accidents and ergonomic load at the farms. This means that for each task, the time was multiplied by the WEST – points obtained, and then summarised into total cost for each farmer during the outdoor period (SEK per outdoor period).

Results and brief discussion

The results from screening of the risk of accidents for the three work tasks are shown in Figure 1. The results showed that the risks for accidents were much higher during feeding, watering, and managing the mud-baths on two farms with the mobile system (M1 and M2) than on the other farms. The reason for this was that the daily work with feeding and watering was performed manually in the field. From Figure 2, it can be seen that these two farms had higher risks for overexertion of body parts, accident with vehicles, falls on the same level, and injury by animal. On farm M3, the task of feeding was carried out with semi-automation once per two or three days. On other farms with stationary system, the feeding and watering were performed with automatically controlled equipment.

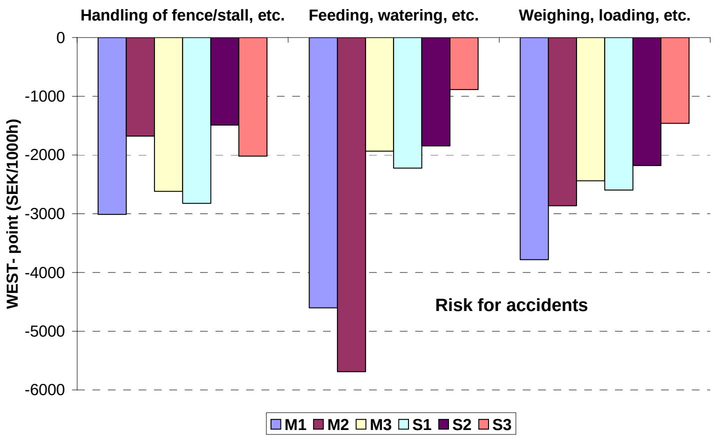

Figure 1. Risk for accidents for the three work tasks. M1, M2, M3 = farms with mobile system, S1, S2, S3 = farms with stationary system.

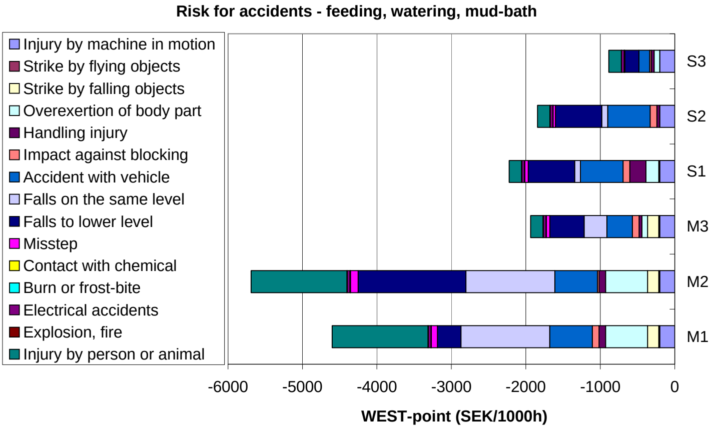

Figure 2. Main events resulting in the risk for accidents during feeding, watering and handling of mud baths on the farms.

The ergonomic load in the mobile system was up to 10 times greater than in the stationary system for the farmers who worked manually with feeding and watering (Figure 3). However, for the farm with the semi-automatic feeding (M3) the ergonomic load was at the same level as in the stationary system. Therefore, semi-automatic feeding is strongly recommended for the improvement of the working environment in the mobile system. Figure 3 also shows that a big ergonomic load occurred during handling of fence/stall in S3 because an additional manual task of setting up the fence was imposed on the farm. During weighing, the ergonomic load in M2 was higher than on the other farms. The weighing of pigs was performed inside a small wagon on the field, causing difficulties in getting the pigs into the scale. Also, the farmer had to move the heavy scale with a pig inside after weighing, causing large ergonomic load. An improvement of the wagon for weighing and transporting pigs is expected.

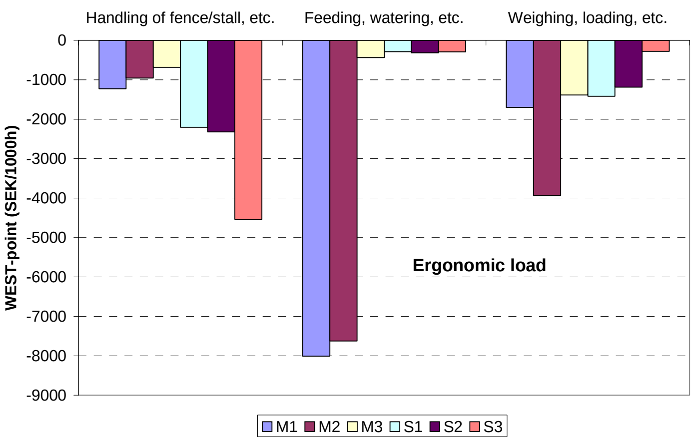

Figure 3. Ergonomic load for performing the three tasks.

All of the farms were judged with positive WEST-points for psychosocial factors (1000 - 4500 SEK/1000 h) and physical work environment (40 - 80 SEK/1000 h). WEST points for noise (-60 SEK/1000 h) and chemical factors were low (-5 SEK/1000 h). There were no differences between the systems concerning the psychosocial factors, noise, chemical health hazards, or physical work environment.

Furthermore, Figure 4 indicates that a farmer who worked in the mobile system was exposed to a risk for accidents corresponding to an economic annual cost of 400 - 1700 SEK/outdoor period. For the stationary system, the farmers were exposed to a risk for accidents corresponding to 200 - 600 SEK/outdoor period. The annual cost related to the ergonomic load could be up to 1800 SEK/outdoor period in the mobile system.

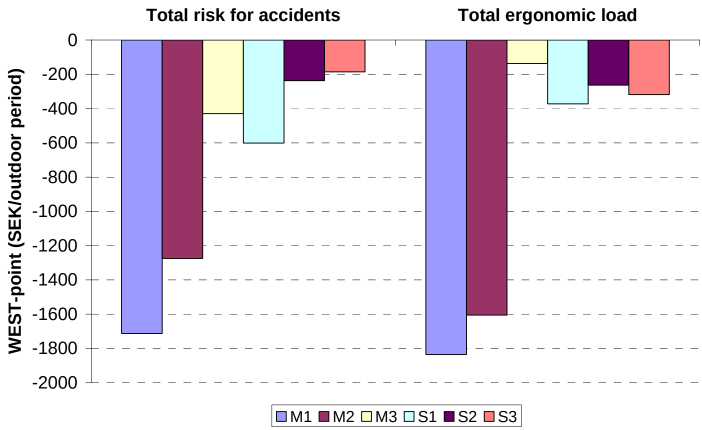

Figure 4. Total risk for accidents and ergonomic load after weighing the WEST-point with the time consumed for the tasks during outdoor period.

Conclusions

The risk for accidents and ergonomic load can be much higher in the mobile system than in the stationary system when the feeding and watering are performed manually. This does not fulfil the goal of having a safe and healthy working environment in outdoor mobile system for organic pigs. The semi-automatic feeding in the mobile system would be proposed for improving the working environment. No differences could be found between the systems concerning the psychosocial factors, noise, chemical health hazards, or physical work environment.

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FULL OR PARTIAL OUTDOOR REARING OF SLAUGHTER PIGS – EFFECTS ON PERFORMANCE, CARCASS QUALITY AND NUTRIENT LOAD

John E. Hermansen, Jørgen Eriksen & Karin Strudsholm

Danish Institute of Agricultural Sciences, Department of Agroecology, Research Centre Foulum, PO Box 50, DK-8830 Tjele, Tel. +45 8999 1236, E-mail John.Hermansen@agrsci.dk, Homepage: http://www.agrsci.org/jpm

Key Words: grazing, N-leaching, production strategy

Abstract

An experiment with slaughter pigs from weaning to slaughter including five treatments and five replicates was carried out at the Danish organic experimental station, Rugballegård. Treatments included full or partial outdoor rearing of the pigs, and the replicates covered the seasonal effects. Pigs fed *ad libitum* indoors had a significantly lower feed consumption (5 MJ ME /kg gain), a lower lean percentage (2.3% points), and a higher backfat depth (1.1 mm, $P < 0.05$) than pigs fed *ad libitum* outdoors. Compared with outdoor pigs fed *ad libitum*, restricted feeding outdoors resulted in a significantly lower daily gain (107 g), a lower feed consumption (6.3 MJ ME/kg gain), higher lean percentage (2.1% points), and a reduced backfat (1.8 mm) ($P < 0.001$). The content of soil nitrogen was considerably higher than for the soil outside the paddocks. Despite a considerable variation within the paddocks, N was distributed throughout the paddock. The present investigation highlights the fact that outdoor rearing of organic finishers may be a competitive option even in a temperate climate and all year round.

Introduction

In many countries, including Denmark, organic pork production takes place in barns where the pigs have free access to a limited outdoor area. However, such housing is often very expensive and it may be questioned whether pigs reared under such conditions comply with consumer expectations of organic farming.

Alternatively, slaughter pigs can be reared outdoors. However, data on production results obtained from outdoor rearing are limited. In addition, in relation to the deposition of manure in the outdoor paddocks, outdoor rearing may have drawbacks such as an increased risk of nitrate leaching. Strategies that combine indoor and outdoor rearing may be preferable from an overall perspective.

The purposes of this investigation were to quantify differences in performance and carcass quality traits of pigs reared outdoors or indoors, and to highlight the risk of N-leaching from grass paddocks in such systems.

Methodology

The experimental design comprised five rearing strategies in five replicates using a group size of ten pigs that were balanced in terms of live weight and sex. Upon weaning at age 7-8 weeks (approx. 19 kg live weight) piglets born in an outdoor system were distributed over the five rearing strategies as follows:

1. Piglets were moved indoors at weaning and fed *ad libitum* until slaughter.
2. Piglets stayed on pasture and were fed restrictively with concentrates until 40 kg live weight, followed by *ad libitum* feeding in an indoor pen.
3. Piglets stayed on pasture and were fed restrictively with concentrates until 80 kg live weight, followed by *ad libitum* feeding in an indoor pen.
4. Piglets stayed on pasture until slaughter and were fed restrictively during the whole period.
5. As treatment 4, but the growers were fed *ad libitum* until slaughter.

The first replicate started in January 2002 and the fifth and last replicate was completed in April 2003, so that the seasonal variation was covered by the design.

In the field each experimental unit (group of ten pigs) was allocated to a ‘new’ piece of land, differing in size according to the expected nutrient load from the pigs. The stocking rate in the field was calculated to cause a level of excretion of 280 kg N per hectare. To ensure a good distribution of the manure and thereby the environmental load from the pigs on the pasture, the huts, troughs and water supply were moved on a regular basis.

All pigs were individually weighed at weaning, at transfer, and at slaughter. Soil samples where collected and grass cover evaluated each time pigs were transferred from the field to housing or slaughterhouse. Grid points were established for every 5x5 m in the 10 m wide paddocks and similarly points were established outside the paddocks for every 5 m as a reference. At each point soil samples were collected to 40 cm by pooling 8 soil cores. A total of 948 soil samples have been analysed for content of mineral N, exchangeable K and extractable P to determine the level and the distribution of nutrients within the paddocks.

Results

The content of soil nitrogen was considerably higher than for the soil outside the paddocks. Despite considerable variation within the paddocks, increased N levels were found throughout the paddock (Figure 1). Generally, it was difficult to maintain a grass cover in the paddocks. The nitrogen use efficiency in the paddocks (feed N input relative to animal N output) decreased the longer pigs were kept on the pasture. Thus, N in piglets kept outside until 40 kg accounted for 38% of feed N input, whereas N in piglets on pasture until slaughter accounted for only 30% of feed N input.

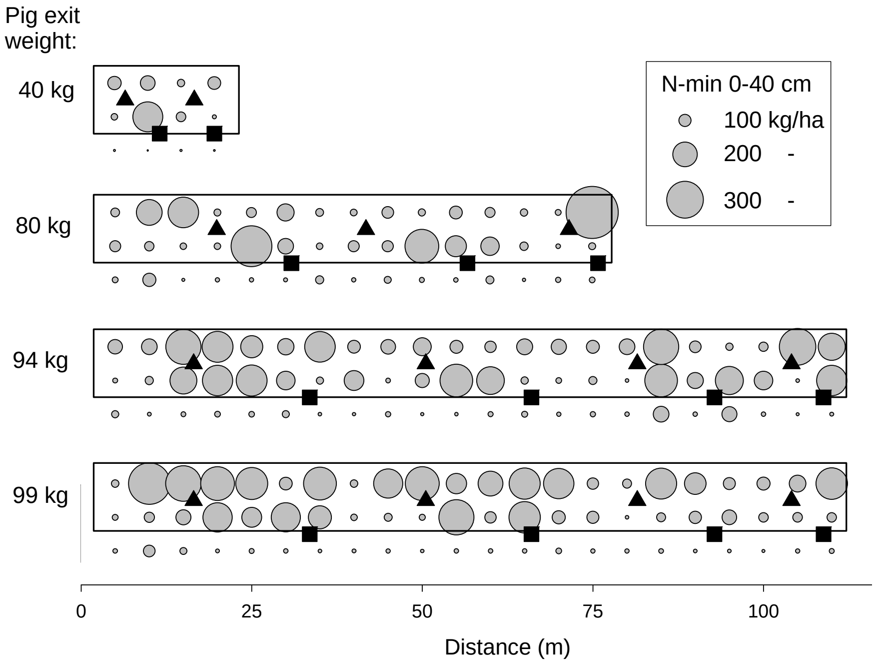

Fig.1. Bubble plot of inorganic soil nitrogen (0-40 cm) in and outside the four paddocks in replicate 4 of the experiment on growing pigs. Each paddock contained one hut (▲) and one feeding trough (■) that were moved every four weeks (from right to left). All positions throughout the experiment have been shown.

Performance traits of the pigs achieved in the five rearing strategies are given in Table 1.

The daily gain and age at slaughter were significantly affected by the weight/age at transfer indoors. The length of the pasture period with restricted feeding seemed directly related to a decrease in the overall daily gain in treatments IA, I40A, I80A and OR. However, the feed conversion rate was not significantly different among these treatments. Restrictively fed pigs had a higher age at slaughter (17 days), a lower daily gain (133 g), and an improved feed conversion rate (-6.3 MJ ME/kg gain). Compared to the indoor-reared pigs (IA) the outdoor-reared pigs (OA) had a small numerically lower daily gain and a higher age at slaughter, while the feed conversion was significantly poorer (13.4%).

Pigs that were transferred at a live weight of 40 kg to indoor facilities with free access to feed compensated almost completely in overall daily gain before slaughter, while pigs transferred at 80 kg live weight only compensated a little.

The pigs reared on pasture had a significantly higher intake of roughage compared with indoor pigs. Although they had the possibility to graze and root, pigs reared outdoors with free access to concentrates consumed 85% more roughage than indoor pigs. This indicates a synergy between foraging and access to a variety of feeds in an enriched environment, as discussed by Andresen (2000).

Table 1. Performance traits achieved in five rearing strategies compared at the same live weight at slaughter; Least square means, SEM and *P* values for significance of differences between treatments.

Treatment	Indoor *ad lib* (IA)	Transfer to barn at 40 kg (I40A)	Transfer to barn at 80 kg (I80A)	Outdoor restricted (OR)	Outdoor *ad lib* (OA)	SEM	*P* value
Age at slaughter, days 1)	156 ^{a}	161 ^{a}	170 ^{b}	177 ^{b}	160 ^{a}	2.2	< 0.0001
Daily gain, g/day 1)	767 ^{a}	728 ^{a}	672 ^{b}	634 ^{b}	737 ^{a}	14	< 0.0001
Concentrate, kg per kg gain	2.81 ^{a}	3.03 ^{ab}	2.95 ^{ab}	2.64 ^{a}	3.15 ^{b}	0.12	< 0.05
Roughage, kg per kg gain	0.21 ^{a}	0.23 ^{a}	0.43 ^{b}	0.46 ^{b}	0.39 ^{b}	0.06	< 0.05
Feed conversion, MJ ME/kg gain	37.3 ^{a}	40.2 ^{ab}	39.9 ^{ab}	36.0 ^{a}	42.3 ^{b}	1.7	< 0.05

Different letters within each row indicates a significant difference (P < 0.05)

1) Adjusted to a final live weight of 97 kg

The carcass characteristics are given in Table 2.

Table 2. Carcass characteristics of pigs as a result of five rearing strategies; Least square means, SEM and P values for significance of differences between treatments.

Treatment	Indoor *ad lib* (IA)	Transfer to barn at 40 kg (I40A)	Transfer to barn at 80 kg (I80A)	Outdoor restricted (OR)	Outdoor *ad lib* (OA)	SEM	*P* value
Lean in total carcass, %	57.5 ^{a}	57.6 ^{a}	60.4 ^{b}	61.9 ^{c}	59.8 ^{b}	0.39	< 0.0001
Backfat depth, mm	17.6 ^{a}	18.4 ^{ab}	15.9 ^{d}	14.7 ^{e}	16.5 ^{ac}	0.51	< 0.001
Lean in central piece, %	61.9 ^{a}	61.4 ^{a}	65.4 ^{d}	67.3 ^{e}	64.2 ^{d}	0.57	< 0.0001

Different letters within a row indicate a significant difference (P < 0.05)

Rearing strategy had a significant effect on carcass traits (Table 2). Pigs reared outdoors throughout their life or until 80 kg live weight had a significantly higher meat content than pigs reared indoors. Backfat depth showed the opposite results. There were no significant differences in the lean percentage between I80A and OA pigs.

The effects on lean percentage and backfat corresponds to findings by Guy et al. (2002) and Stern et al. (2001). Gustafson & Stern (2003) and Gentry et al. (2002), however, found no such difference between indoor and outdoor pigs during the summer. An explanation could be that pigs on pasture use more energy during cold periods to maintain body temperature than indoor pigs with access to an outdoor pen.

Conclusion

The recorded differences in carcass characteristics in the present investigation resulting from the different rearing strategies can be very important in organic production. In some situations, such as in Danish organic production, the price achieved for a slaughter pig depends very much on whether the carcass fulfils certain quality threshold values, i.e. a minimum lean percentage and a maximum depth of backfat. The effect of this can turn out to be more important for the financial return in pig production than the achieved weight gain and cost of the feed. The present investigation highlights the fact that outdoor rearing of organic finishers may be a competitive option even in a temperate climate and all year round.

A risk of nitrogen leaching commensurate with stocking rate is inevitable. It is important to focus on a lowering of the level of dietary N to increase N use efficiency in outdoor slaughter pig production. However it was demonstrated that carefully planned movements of huts and feeding troughs made it possible to have an acceptable distribution of the nutrient load.

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MOBILE AND STATIONARY SYSTEMS FOR PIGS – NUTRIENT EXCRETION, DISTRIBUTION ON OUTDOOR AREAS AND ENVIROMENTAL IMPACT

Eva Salomon, Christel Benfalk, Cecilia Lindahl & Kristina Lindgren

Swedish Institute of Agricultural and Environmental Engineering, P.O. Box 7033, SE-750 07 Uppsala, Sweden, Tel. +46 18 30 33 00, eva.salomon@jti.slu.se, christel.benfalk@jti.slu.se, cecilia.lindahl@jti.slu.se, kristina.lindgren@jti.slu.se, www.jti.slu.se

Key words: Organic fattening pigs, nitrogen, phosphorus, potassium, copper and zinc in manure

Abstract

The objectives of this study were to quantify fluxes and balances of N, P, K, Cu and Zn in two organic fattening pig outdoor systems, to quantify the load of nutrients in different sub-areas through behavioural studies of defecation and urination and to make an environmental risk assessment. The study forms part of a larger project with the aim of identifying a joint strategy. The outdoor area balance was calculated for N, P, K, Cu and Zn. Total calculated amounts of N, P, K, Cu and Zn in manure were distributed between outdoor sub-areas according to ratios determined in behavioural studies of defecation and urination and by manure mapping. Some proposals for improving the nutrient management and decreasing the negative environmental impact in different outdoor systems are discussed.

Introduction/Problem

Outdoor pig production is gaining interest because it has benefits in terms of animal welfare and low costs of buildings and equipment (Andresen, 2000). A balance between animals, the amounts of nutrients excreted by them and the area for spreading manure is a helpful strategy to avoid nutrient losses (De Clercq *et al.*, 2001) and harmful amounts of copper (Cu) and zinc (Zn) being added to the soil (Öborn, 2001). The limiting animal density in Sweden is based on an average manure application of 22 kg phosphorus (P) per hectare. Element (nutrient) balances based on the differences between nutrients imported to and exported from a system provide a tool for assessing the environmental impact (Öborn *et al.*, 2004). Even with moderate animal densities, the excretory behaviour of pigs may create high nutrient loads locally in outdoor areas (Watson *et al.*, 1998). This variability needs to be considered in relation to the value of nutrient budgets for outdoor pig production systems. The present study forms part of a larger project concerning production of organic pork with the overall objective of identifying and recommending strategies that simultaneously provide a good animal environment, resource-efficient nutrient management and a good working environment. The objectives of this study were to: quantify fluxes and balances of nitrogen (N), P, potassium (K), Cu and Zn in two organic fattening pig outdoor systems; quantify the load of N, P, K, Cu and Zn in different sub-areas through behavioural studies of defecation and urination and manure mapping; and to carry out an environmental risk assessment.

Methodology

The mobile system was represented by a commercial organic pig farm on clay soil with production of about 700 fattening pigs per year. The farm had its own sows and bred its own piglets. The sows and their weaners were moved to the outdoor area when the weaners were about 2 weeks old. After weaning the sows were removed to another outdoor area. Each group of about 40 pigs had access to a rectangular outdoor area which included grazing area, wallowing area, huts for shelter, feeding and drinking places. Only one pig group per year used the outdoor area. The pigs used the clover/grass ley in a four year crop rotation on the arable land. The pig groups studied used outdoor areas where pigs had never been before. The stationary system was represented by a commercial organic pig farm on a sandy loam soil with production of about 800 fattening pigs per year. The farm brought in piglets. Each group of about 40 pigs had access to a long and narrow outdoor area. In a stationary barn the pigs had access to feed, drinking water and a resting place with straw litter. Outside the barn was a concrete pad and beyond that the outdoor area on arable land, including wallowing and grazing areas. The outdoor area was used by two pig groups per year. One pig group was outdoors during the whole fattening period, while the other pig group was outdoors for half the fattening period. The pig groups studied here were outdoors during the whole fattening period. The pigs used a clover-grass ley in a two-year crop rotation. Element flows to and from the outdoor area were monitored during the fattening pig period. The outdoor area balance was calculated for N, P, K, Cu and Zn for a fattening pig group (see equation 1). The difference between kg nutrient input and kg nutrient output was kg nutrient in faeces and urine (Damgaard Poulsen, 1998). Four groups of pigs for each system were included (Table 1).

Outdoor area balance = Inflows to the outdoor area – Outflows to the outdoor area= Feed (purchased and home-produced) + piglets – pigs (Eq. 1)

The amounts of feed and the pig weights were based on the farmers´ specifications. Feed components were analysed for their content of N, P, K, Cu and Zn. The content of N, P, K, Cu and Zn in pigs of different ages was taken from Fernández (1998) and Mahan & Newton (1995). In the stationary system, amounts of N, P, K, Cu and Zn in faeces and urine excreted indoors were estimated by weighing and analysing the straw litter bed from two groups. For the other two groups, the calculated average amounts of elements excreted indoors were used. The outdoor areas were divided into four sub-areas corresponding to the activity the pigs performed in each area (Table 1). Behavioural studies of urination and defecation occasions, complemented by manure mapping, were carried out for each sub-area. Using the number of defecations or urinations per 10 m^2 and 10 pigs, it was possible to calculate the proportion of manure or urine load on the sub-area. It was then possible to compare sub-areas independent of their size (Benfalk *et al*., 2005). The proportion of manure or urine load for each sub-area was used to calculate the proportion of the total amounts of N, P, K, Cu and Zn in faeces and urine that loaded the sub-area.

Table 1. Number of pigs and total pen area for pig groups included in the study

System	Mobile				Stationary			
Number of groups	1	2	3	4	1	2	3	4
Number of pigs	35	34	29	35	40	43	32	52
Total pen area (m^2)	6288	4540	3808	3899	4875	4683	3333	3013
Feeding area (^{m2})	300	456	501	461	-	-	-	-
Drinking area (m^2)	491	198	428	428	-	-	-	-
Hut area (m^2)	237	400	230	230	-	-	-	-
Grazing (m^2)	5261	3486	2648	2781	2573	2370	2095	1870
Concrete (m^2)	-	-	-	-	39	39	39	39
Wallowing (m^2)	-	-	-	-	282	191	162	160
Transportation (m^2)	-	-	-	-	1979	2083	1007	944

Results and brief discussion

The Swedish regulation of an average application of 22 kg P per hectare with manure was established in order to balance the removal of P with harvest from a field and avoid a surplus application of both N and P (Fagerberg *et al*., 1996; De Clercq *et al*., 2001). The density of pigs and corresponding amounts of P excreted on the outdoor area for a four-year rotation was on average below 22 kg P per hectare in the mobile system (Table 2). On average, the stationary system exceeded the maximum pig density over a 2-year crop rotation, although a proportion of the nutrients was excreted indoors (Table 3). A four-year rotation in the mobile system seemed to lead to a more balanced nutrient distribution between outdoor areas over time. This nutrient management is also positive for crop production. In both systems, the load of nutrients was on average below 22 kg P ha^{-1} on the sub-area defined as grazing area (Tables 4 and 5). In the mobile system, on average 76% of the total area was grazing area, compared with on average 57% in the stationary system. In both systems the main proportion of the outdoor area, with the largest proportion in the mobile system, had an acceptable nutrient load. In the mobile system, the feeding and hut sub-areas had a nutrient load 3 to 5 times higher than the maximum allowed with the current rotation schedule (Table 4). In the stationary system the concrete pad and wallowing sub-areas had especially high nutrient loads, corresponding to 30 to 100 times the maximum allowed, with the current rotation schedule (Table 5). These sub-areas were used for pigs every year. However, the faeces and urine on the concrete pad were collected and spread on other fields for crop production. The nutrient load on the soil at the wallowing area was unacceptable. The sub-areas with highest nutrient loads also received a Zn load which was higher than the permissible amount according to Swedish regulations (Steineck *et al*., 2000).

Table 2. Amounts (kg) of N, P, K, Cu and Zn in manure per pen and per hectare in the mobile system for each pig group

System	Mobile																			
Groups	1					2					3					4				
Elements	N	P	K	Cu	Zn	N	P	K	Cu	Zn	N	P	K	Cu	Zn	N	P	K	Cu	Zn
In	234	49	61	0.2	0.9	184	40	47	0.2	0.2	218	46	57	0.2	0.8	269	57	70	0.2	1.0
Out	107	21	8	0.0	0.1	101	20	8	0.1	0.1	89	18	7	0.0	0.1	108	21	8	0.0	0.1
In manure pen^{-1}	127	28	53	0.2	0.8	83	20	39	0.1	0.6	129	28	50	0.2	0.7	161	36	62	0.2	0.9
In manure ha^{-1}	202	45	84	0.3	1.3	183	44	86	0.4	1.4	339	74	131	0.5	2.0	413	92	159	0.6	2.4

Table 3. Amounts (kg) of N, P, K, Cu and Zn in manure per pen and per hectare in the stationary system for each pig group

System	Stationary																			
Groups	1					2					3					4				
Elements	N	P	K	Cu	Zn	N	P	K	Cu	Zn	N	P	K	Cu	Zn	N	P	K	Cu	Zn
In	255	62	74	0.3	1.1	297	72	87	0.3	1.3	192	46	55	0.2	0.8	325	76	88	0.3	1.2
Out	122	24	10	0.0	0.1	131	26	10	0.0	0.1	101	20	8	0.0	0.1	171	34	13	0.0	0.2
In manure total	133	38	64	0.3	1.0	166	46	77	0.3	1.2	91	26	47	0.2	0.7	154	42	75	0.3	1.1
In manure pen^{-1}*)	92	27	44	0.2	0.7	115	32	53	0.2	0.8	74	21	38	0.2	0.6	91	25	44	0.2	0.6
In manure ha^{-1}	189	55	90	0.4	1.4	246	68	113	0.4	1.7	222	63	114	0.6	1.8	302	83	146	0.7	2.0

*) Amounts defecated and urinated indoors in the litter bed were excluded. Estimated amounts for Groups 1 and 2 were on average 30% of the total amounts. Weighed and analysed amounts for Group 3 were 19% of the total amounts. The corresponding amounts for Group 4 were 41%.

Table 4. Amounts of N, P, K, Cu and Zn (kg ha^{-1}) in manure for each sub-area in the mobile system and for each pig group

System	Mobile																			
Groups	1					2					3					4				
Sub-areas	N	P	K	Cu	Zn	N	P	K	Cu	Zn	N	P	K	Cu	Zn	N	P	K	Cu	Zn
Feed	1889	433	762	3	13	847	160	465	1	4	524	95	227	0	2	1315	324	459	2	9
Drink	339	70	147	1	2	579	145	268	1	4	769	192	268	1	5	780	188	277	1	5
Hut	2114	462	882	3	13	648	189	262	2	6	2736	600	1056	4	16	2523	436	1111	3	10
Graze	7	2	3	0	0	20	7	6	0	0	27	6	10	0	0	33	9	11	0	0

On average, both systems had an acceptable pig density, which is one condition for decreasing the risk of negative environmental effects. Another condition is a rotation of the pigs on arable land. A four-year rotation was recommendable, while a two-year rotation built up nutrient surpluses over the years. However, a rotation cannot balance out the effects of excessive net inputs of water-soluble nutrients such as N and K in a single year. Nitrogen and K surpluses increase the risk of leaching (Eriksen & Kristensen, 2001). In the mobile system, a minor proportion of the outdoor area had too high a nutrient load. One way to even out hot-spots of faeces and urine and decrease the risk of nutrient losses could be to regularly give the pigs access to a new grazing area (Andresen, 2000). In the stationary system, a minor proportion of the outdoor area also had too high a nutrient load. The nutrient load on the wallowing area was especially serious, as this sub-area was used for pigs each year. The long and narrow outdoor area may have influenced the pigs' choice of excretion area and resulted in a more concentrated nutrient hot-spot. Possible solutions are an increased rotation time or a nutrient management technique for collecting the manure on the wallowing area and spreading it on other fields for crop production.

Table 5. Amounts of N, P, K, Cu and Zn (kg ha^{-1}) in manure for each sub-area in the stationary system and for each pig group.

S-areas=Sub-areas, Con=Concrete, Wal=Wallowing, Tra=transporting, Gra=Grazing.

System	Stationary																			
Groups	1					2					3					4				
S-areas	N	P	K	Cu	Zn	N	P	K	Cu	Zn	N	P	K	Cu	Zn	N	P	K	Cu	Zn
Con	12112	2700	6768	15	62	20391	5543	9608	34	137	241	19	173	0	0	3927	1025	1972	6	25
Wal	1198	421	482	3	12	1678	497	743	3	13	2859	698	1450	4	17	3738	1026	1817	6	25
Tra	37	13	15	0	0	14	5	5	0	0	78	28	28	0	1	131	46	51	0	1
Gra	20	7	9	0	0	8	2	4	0	0	91	26	41	0	1	44	10	24	0	0

Conclusions

The conditions for environmentally friendly outdoor pig production on arable land are a balanced animal density and at least a 4-year rotation of the pigs. In this study, the excretory behaviour of the pigs created sub-areas with high loads of nutrients. However, the excretory behaviour of the pigs was affected differently by the two systems studied and thus different solutions were required to make these systems more environmentally sustainable.

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ANIMAL HUSBANDRY AND WELFARE – RUMINANTS

CLOSING THE PLANT-ANIMAL LOOP: A PREREQUISITE FOR ORGANIC FARMING

Marina A. Bleken (1), Håvard Steinshamn (2), Erling Thuen (3) and Matthias Koesling (2)

(1) Department of Plant and Environmental Sciences, Norwegian University of Life Sciences, P.B.5003, Soil Science Building, N-1432 Aas, Norway, +47 64965612, marina.bleken@umb.no
(2) Norwegian Centre for Ecological Agriculture, N-6630 Tingvoll, Norway, +47 71532027, havard.steinshamn@norsok.no
(3) Department of Animal and Aquacultural Sciences, Norwegian University of Life Sciences, P.B.5003, N-1432 Aas, Norway, +47 649948037, erling.thuen@umb.no

Key Words: emission factor, life cycle analysis, N utilisation, agricultural system, nitrogen

Abstract

An analysis of a number of published surveys of dairy farms in Europe is used to exemplify the consequences of the use of external feed on nitrogen loss from organic animal productions. It is concluded that the present international regulations are not adequate to enforce the adoption of environmentally friendly and sustainable organic production systems, in harmonious balance between crop production and animal husbandry.

Introduction

Since their origin, organic farming movements have considered it fundamental to achieve production in good balance with the natural conditions of the farm (Balfour, 1943; Steiner, 1999). Imports of external resources that can boost production have been considered undesirable, based on the intuition that the agro-ecosystem will enter an unbalanced and unstable situation. This principle is reflected, e.g., in the ban of easily soluble fertilizers. This is in contrast with the predominating agricultural development in general, which increasingly relies on inputs of external resources as off-farm feed as well as on mineral fertilizers. Searching for techniques to mitigate the pollution of the environment brought about by intensive agriculture, special attention has been paid to the efficiency of nitrogen (**N**) and phosphorus within the single sectors of the farm. It has been suggested that supplementing grass with concentrated high-energy feed can improve protein retention and off-take in milk by dairy cattle, and thus the N efficiency of dairy production (Tamminga, 1992). This in turn is used as an argument for the use of concentrate supplements with high energy but low protein content that often must be imported and may lead to a further specialization of separate animal and crop farms. This affects the skills and economic conditions surrounding the organic enterprise, and it challenges organic farming: if specialization and use of off-farm feed improves the nutrient use efficiency on the farm, why not adopt them? And: is it more important to focus on the principle of local resources or on the organic purity of the feed used? These questions are the focus of the present study.

Methods

We use the N efficiency of cattle milk production in Europe as an example. Data were collected from published farm surveys and intensive studies of prototype farms (Bleken *et al*., 2004). Prerequisites for this analysis were: 1) a holistic approach, which includes all primary (plant) production necessary for the animals, and 2) the distinction between trophic levels. The products considered were net milk and livestock sale (**P**). The net purchased feed ($\mathbf{F_{off\text{-}farm}}$) was calculated by subtracting crop sale. Systems with net crop sale or where $F_{off\text{-}farm}$ accounted for more than 50% of the total feed were not considered. All fluxes are expressed in kg N ha^{-1}y^{-1}. It was assumed that the N surplus (**S**: total N input as fertilizer, biological fixation and atmospheric deposition minus P) represents the potential N emission to the environment in the long run. The emission factor $\mathbf{E_{farm}} = S_{farm} / P$ gives the amount of N (in kg kg^{-1}) that is dissipated from the farm system in order to produce 1 kg of N in milk + livestock (ca 200 kg milk, or 40 kg animal live weight). The total emission factor $\mathbf{E} = (S_{farm} + S_{off\text{-}farm}) / P$ included both the N dissipation on the farm and the N dissipation related to the production of purchased feed ($\mathbf{S_{off\text{-}farm}}$). This was calculated by assuming a constant N-efficiency: $F_{off\text{-}farm} / (S_{off\text{-}farm} + F_{off\text{-}farm})$. We also calculated how much N was used by the farm in order to yield one unit of N in forage and other crops: $\boldsymbol{\alpha}_{\mathbf{farm}}$ = (manure N + biological N fixation + atmospheric N deposition) / F_{farm}.

Results

The farm surveys included 7 organic or integrated farming systems and 14 conventional systems, and covered a wide range of environmental conditions (from Northern Italy to Southern Norway) and yield intensity (from 3000 to 13000 l milk $ha^{-1}y^{-1}$). One of the organic farm surveys was eliminated due to uncertainties about the biological N fixation. The results showed that the N-utilization on the farm decreases as the ratio of bought feed ($F_{off\text{-}farm}$) to farm crop production (F_{farm}) increases. Farms with large purchases of $F_{off\text{-}farm}$ relatively to F_{farm} used increasingly larger amounts of N to produce one unit of F_{farm} (α_{farm}, Figure 1A). Also, the N emission factor from the farm increased with feed imports (Figure 1B). If feed purchase improves the N utilization by the animals, this advantage was not reflected in a lower N emission factor E_{farm}, primarily due to lower N efficiency ($1/\alpha_{farm,}$) of the plant sector.

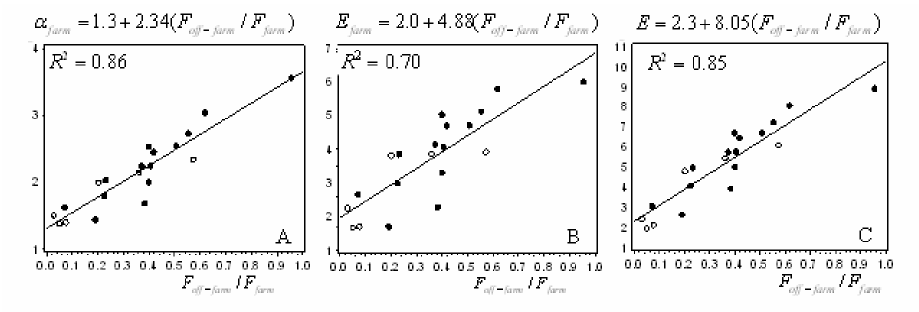

Figure 1. A: N units used by the farm to get a plant yield containing one N unit:
α_{farm} = (manure N + biological N fixation + atmospheric N deposition) / F_{farm},
B: N emission factor from the farm: $E_{farm} = S_{farm}$ / P, and
C: emission factor for the entire production E = (S_{farm} + S_{off_farm}) / P, versus the ratio of imported feed to plant production on the farm ($F_{off\text{-}farm}/F_{farm}$).
Open symbols: organic or integrated production. Closed symbols: conventional production. α_{farm}, E_{farm} , E and $F_{off\text{-}farm}/F_{farm}$ are in (kg N ha^{-1}) / (kg N ha^{-1}).

In spite of no use of chemical N fertilizer, additional manure N derived from feed imports was not effectively utilized by organic and integrated farms. This has two negative consequences: 1) directly on the global eutrophication of the environment, 2) indirectly by raising the need for more reactive N in order to produce $F_{off\text{-}farm}$. Taking the latter into consideration, we have estimated the total emission factor E = (S_{farm} + $S_{off\text{-}farm}$) /P. This is illustrated in Figure 1C assuming an average $E_{off\text{-}farm} = S_{off\text{-}farm} / F_{off\text{-}farm}$ based on nationwide surveys in Europe (see Bleken & Bakken, 1997): E increases from roughly 2 to 10 kg N per 200 kg of milk as $F_{off\text{-}farm}$ increases from nil to be equal to the farm's own plant production.

A closer inspection of the organic farming systems illustrates the significance of external feed, in amounts that are usually considered small or moderate, on N dissipation (Table 1). The share of external feed was low, on average ca 5% of the total ration, in the two surveys in Austria and in the Norwegian organic prototype farm. The Danish organic farms and the Welsh organic prototype had a larger use of external feed, 26 and 36% of the total ration respectively. Within this interval (5 – 36% of the total ration) the emission factor E increased by a factor of ca. 2.6. The total N surplus, including that occurring during the production of external feed, was estimated by multiplying the farm production (in kg N ha^{-1}) by the relevant E. It increased from 40 – 50 to 240 – 280 kg N y^{-1} per ha of dairy farm (Table 1).

Discussion

The present results show clearly that the use of imported feed relative to the farm's own plant production dramatically increases the N emission factor. It is surprising that feed imports play such an important role on the N emission factor, in spite of the large variation in ecological conditions considered (continental and maritime climates, latitude from 45° to 60° N, alpine and lowland regions). We had expected a difference between organic or integrated farms and conventional ones, but there were no statistically significant effects in this respect.

Table 1. Farm crop production and milk + meat produce (kg N ha^{-1} y^{-1}), total animal manure available at the farm, ratio of bought feed to total feed (kg N / kg N), N emission factor (E, kg N/kg N) and total farm surplus (kg N ha^{-1} y^{-1})

Source	kg N ha^{-1} y^{-1} Farm's production Crop	milk + meat	Total animal manure	Ratio bought feed/ total feed	E, kg/kg 1	2	Total farm N surplus kg N ha^{-1} y^{-1} 1	2
Norway, prototype	77	17	62	0.03	2.4	2.5	42	44
Austria, n = 40	88	20	72	0.05	2.0	2.7	39	54
Austria, n = 51	88	21	74	0.07	2.1	2.9	44	60
Germany, n = 6	84	22	79	0.17	4.8	3.9	106	86
Denmark, n = 14	108	32	124	0.26	5.5	5.2	175	166
Wales, prototype	117	40	144	0.36	6.1	6.9	244	276

E 1 = total emission factor E calculated specifically for the farm considered, and shown as a point in Figure 1C
E 2 = total emission factor E calculated from $F_{off\text{-}farm}/F_{farm}$ using the regression equation in Figure 1C
Total farm surplus, 1 and 2, is estimated by multiplying the farm production (meat/milk) by E 1 and E 2, respectively

It has been shown that high animal densities increase the N load to the environments (Halberg *et al*. 1995). However, as far as we know, the study by Bleken *et al*.(2004) was the first to calculate N emission per unit of production (E and E_{farm}) based on empirical data from many different environmental conditions and management practices. Here we have refined the analysis to show that the N efficiency of the soil-plant sector ($1/\alpha_{farm}$) clearly decreases as the ratio $F_{off\text{-}farm}/F_{farm}$ rises. At least in conventional farms this can partly be due to a lower efficiency of the chemical fertilizer. However, the most likely explanation for the reduced soil-plant efficiency on the organic as well as on the conventional farms is a lowered N efficiency of animal manure when this was available in amounts that exceeded those sustained by the farm's own plant production.

Obviously, if the farm's own feed production is poorly utilized by the animals, this can results in low N use efficiency at the farm level even without import of feed (Weller & Bowling, 2004). However, there is evidence that high milk yield per cow with good N utilization can be achieved by feeding the farm's own roughage with no or only small concentrate supplementation (Mogensen, 2004; Steinshamn *et al*., 2004). This is confirmed also by some of the surveys considered in this study, in a region (Austrian Alps) with a long experience in using pasture and the farm's own roughages. It has also been shown that organic dairy farming based on home-grown feed can be financially more attractive than organic dairy systems based on imported feed (Mogensen, 2004).

Excess manure contributes not only to N eutrophication, but also to several other environmental problems. On the other side, soils with large export of plant products and no return of animal manure can be depleted not only in N but also in several other minerals. Thus, it is reasonable to state that the increased N-pollution problem is only an example of several important reasons for adjusting animal rearing to the plant production of the farm.

A look at the regulations for organic agriculture indicates that the original aim that animal production be based on the farm's plant production is no longer perceived as fundamental, as long as the purchased feed is organically produced. The USDA standards as formulated in the National Organic Program have no restrictions (Organic Foods Production Act of 1990). The European Council allows feed import up to maximum 50% of the feed requirement on an energy basis, and the application of animal manure is limited to 170 kg N ha^{-1}, which indirectly limits the number of animals and the feed imports (EU Regulation No 2092/91 and supplementing regulations). However, this is a very high ceiling, and only three of the European surveys considered exceeded it. The present draft of the IFOAM's Basic Standards states that one of the principal aims of organic farming is "to create a harmonious balance between crop production and animal husbandry" (IFOAM, 2004). However, we have not been able to identify adequate rules to enforce this principle. The draft states that "The prevailing part (>50%) of the feed shall come from the farm unit itself ...". This is what conventional intensive Dutch farms used before they had to cut down the surplus due to new Dutch regulations (Aarts *et al*., 2000), and it is considerably more than is found in the surveys of organic farms in Europe (Table 1).

Fluctuations in feed quantity and quality due to weather conditions and animal welfare considerations may necessitate some feed purchase. A complete ban of feed import therefore is not desirable. On the other hand, unless a low ceiling is enforced through international regulations, there will be strong pressures on organic farms to adapt to production methods with large use of purchased concentrates. One of the reasons for this pressure will be the lack of expertises for the management of the herd based exclusively on the farm's own feed products, as well as for the cultivation and conservation of such feed. We tentatively suggest a ceiling of 5 - 10% of the annual ration on energy basis, which can be raised in years of exceptionally adverse weather conditions. Themes to be considered in a further discussion of such a ceiling include the ecological and environmental consequences of promoting specialized organic cereal cultivation for animal consumption in areas without livestock production, as well as yield insecurity due to annual variations.

Conclusions

Closing the plant-animal loop is a prerequisite for organic farming because it is an effective way of minimizing the N dissipation from dairy production, and legitimates organic dairy farming as more environmentally sound than farming based on imported feed and fertilizers.

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INVESTIGATIONS ON DAIRY WELFARE AND PERFORMANCE ON GERMAN ORGANIC FARMS

Bernhard Hörning (1), Christel Simantke (2), Erhard Aubel (2)

(1) University of Applied Sciences Eberswalde, Study Course Organic Agriculture & Marketing, Faculty of Landscape Management and Nature Conservation, Friedrich-Ebert-Str. 28, D-16225 Eberswalde, Germany, Tel. 0049-3334-657109, bhoerning@fh-eberswalde.de
(2) Beratung Artgerechte Tierhaltung (BAT), PF 1131, D-37313 Witzenhausen, Germany, simantke@bat-witzenhausen.de

Key Words: Organic dairy farming, milk production, welfare parameters, influencing factors

Abstract

An investigation was carried out on 74 organic dairy farms in Germany. Results were an average milk production of 5.960 kg, 223.000 somatic cell counts (SCC), 387 days calving interval, 23.5 % culling rate, 46 Euro annual veterinary costs per cow. Farmers were asked for disease incidences. Cows were scored for injuries and body condition. The results were combined with possible influencing factors (herd size, breed, region, farming association, housing system, housing factors, amounts of concentrates). The most frequent health problems were udder, fertility, and claw disorders. These subjective estimations of disease incidences by the farmers could be validated with herd recording data (SCC, calving interval, culling reasons). Overall rate of injuries was low. Body condition scoring revealed only few problems. Holstein-Friesians showed the highest milk production, but also more health problems and a higher culling rate. The straw yard systems seem to have advantages with regard to lameness, fertility, and injuries, but a higher risk for mastitis.

Introduction/Problem

Animal health and welfare are of growing importance in organic dairy production (e.g. Hörning 1998, Lund & Algers 2003, Nicholas *et al.* 2004, Vaarst *et al.* 2004). Winckler *et al.* (2003) proposed different indicators to be used for on-farm welfare assessments in cattle.

No information about the current state of dairy health and welfare on organic farms in Germany is available. Some data were collected ten years ago (Krutzinna *et al.* 1996). The aim of the project was therefore to provide up-to-date information.

Methodology

Information was collected during farm visits to 74 dairy farms in 2002/03. Farms were selected from a sample of 780 organic cattle farms that responded to a questionnaire. Selection criteria for farm visits were a representative distribution (according to the number of organic farms in the federal states), a minimum herd size of 10 cows, and participation in milk recording. The sample was then taken randomly from the farms that fulfilled these criteria.

Performance data were taken from the milk recording schemes of the last completed year (milk yield, somatic cell counts/geometric means, age of cows, culling reasons). Information about disease incidences, amounts of concentrates, veterinary costs and udder hygiene measures were based on interviews of the farmers because no veterinary health recording system exists in Germany. Disease incidence was classed as never, seldom, regular, or frequent.

645 dairy cows were scored for injuries. Size and severity of injuries were scored at different body parts according to a scheme developed by Wechsler *et al.* (1996). Injuries were recorded with three scores for type of changes (hairless patches, scabs, wounds), size of changes (< 2 cm, < 5 cm, > 5 cm), or swellings (slight, medium, severe) in different body areas (fetlock, carpal and hock joints, shoulder-blade, neck, dewlap, coxal and ischial tuberosity). Body condition was scored with a ten-point scale at eight body regions (583 cows).

Data were evaluated statistically with the SPSS package 12.0. Herd averages were used instead of individual cow results. Spearman rank correlations or Mann-Whitney-test were used for the non-normally distributed data. A GLM (Generalized Linear Model) procedure was used for multivariate analyses. The GLM allows for calculate metric and discrete variables at the same time. Whenever appropriate, breed (Holstein-Friesian, Simmental, Brown Swiss, rare breed), housing system (stanchion barn or loose housing), and organic association (Bioland, Demeter, Naturland, others) were included as fixed factors, and number of cows, milk yield, and amount of concentrates as covariates.

Results and brief discussion

Table 1 gives an overview of the recorded animal-related parameters and selected key features of the farms (possible influences on animal parameters). In the following, first univariate and then multivariate analyses will be discussed.

Table 1: Animal-related parameters and selected key features (possible influences) of farms investigated

			Animal-related parameters						
Selected key features	Farms (n)	Cows (n)	Concen-trates (100 kg/year)	Milk yield (kg)	Somatic cell count (1.000)	Calving interval (days)	Age of cows (years)	Culling rates (%)	Veterinary costs (€)
All farms	74	52.0	9.5	5957	223	387	6.0	23.5	45.8
1 – 29 cows	21	21.1a	7.2 a	5482a	198 a	391	6.3 a	23.8ab	50.3
30 – 59 cows	37	44.3b	9.4 b	6035b	233 b	386	6.0 ab	21.8a	42.1
≥ 60 cows	15	110.3c	12.5 c	6398b	231 b	385	5.8 b	27.0b	48.0
Bioland	49	48.6	9.9 a	6052a	227	390	6.0 a	24.4 a	48.7 a
Demeter	14	45.0	7.1 b	5232b	205	384	6.4 b	21.2 b	24.3 b
North/ West	20	50.1	10.2	6355a	243	396 a	5.7 a	28.6 a	52.4
East	5	141.8	13.2	6454	233	386	5.9	27.8	29.0
South	49	43.6	8.8	5743b	214	384 b	6.1 b	21.1 b	45.1
Holstein-Friesian	20	78.1a	11.9 a	6818a	220	396 a	6.0 a	29.1 a	42.7
Simmental	16	43.0b	9.1 b	5753b	198	378 b	5.5 b	20.3 b	29.0
Brown Swiss	14	46.2b	6.2 c	5668b	224	389 c	6.3 a	23.5 b	43.9
Stanchion barn	15	29.7a	7.1 a	5415a	221	392	6.3	22.3	43.1
Loose housing	59	57.6b	10.1 b	6094b	223	386	6.0	23.8	46.6

Different letters indicate significant differences within that part of the column ($p < 0.05$).

Means of milk yield were 5.957 kg (s.d. 1.135). Milk yield increased with increasing herd size and increasing amount of concentrates. Milk yield was higher in loose housing than in stanchion barns. Milk yield was higher in the northwest than in the southern part of Germany. Holstein-Friesian cows had a higher performance than Brown Swiss or Simmental cows. Farms belonging to the Bioland association had a higher milk yield than Demeter farms. Mean somatic cell counts amounted to 222.797 (s.d. 90.101). Smaller farms had a lower somatic cell count. No other influences were found. The average calving interval was 387.2 days (s.d. 23.0). Calving interval was longer in the northwest than in the southern part of Germany. Holstein-Friesian cows had a longer interval than Brown Swiss or Simmental cows. Cows were on average 6.0 years old (s.d. 1.0). Cows were older in smaller farms, in Demeter farms and in southern Germany. 23.5 % of the herd was culled per year (s.d. 8.93). Holstein-Friesian cows, bigger herds and farms in the Northwest showed higher culling rates. Veterinary costs amounted on average to 45.80 Euro per cow per year (s.d. 28.2). Demeter farms had lower veterinary costs.

Multivariate analyses with the GLM procedure revealed herd size and concentrates amount as significant influences on milk production (coefficient of determination $r^2 = 0.504$); breed had no influence. Veterinary costs were influenced by herd size and milk production level ($r^2 = 0.736$), but not by breed or region. No significant influences on somatic cell counts, calving interval, culling rates or age of cows could be found. Therefore, other influences seem to be effective, e.g. preventive hygiene measures for SCC.

Disease incidences mentioned as regular or frequent were 44.6% for udder health problems, 31.1 % for fertility, and 36.4 % for claw health problems. Fertility and claw problems were stated less often for Simmental (18.8 and 25.0 % respectively). Udder health problems were stated more often by farmers with loose housing systems (47.5 %), but fertility problems more often in stanchion barns (40.0 %).

Veterinary costs increased with increasing number of health problems given by the farmer (mastitis, infertility, claw disorders). Surprisingly, udder health problems and somatic cell counts were higher in farms that reported the use of more udder hygiene measures (e.g. cleaning towels, teat disinfection, frequency of servicing the milking equipment). One explanation could be that farmers do not take such meausures until health problems occur.

Somatic cell counts increased with increasing frequency of udder health problems, and calving interval increased with increasing fertility problems (Table 2). With increasing frequencies of udder health, fertility, or claw health problems, the culling percentages for the respective health problems also increased. These results could be interpreted as a validation of farmers' subjective estimations by objective herd record data.

Table 2: Objective herd record data in relation to subjective disease estimations by farmers

	Herd record data:						
	Somatic cell counts (1000)		Calving interval (days)		Culling reasons (% of the respective reason of all culling reasons)		
Disease incidence:	Udder diseases	Infertility	Udder diseases	Infertility	Udder diseases	Infertility	Claw health
Never	211	254	376	372	16.0	16.2	0
Seldom	217	218	385	388	11.6	16.4	8.0
Regularly	216	194	390	387	24.8	30.0	17.3
Frequently	259	216	408	398	40.4	34.8	14.0

The main culling reasons were udder health and infertility (Table 3). Holstein-Friesians had the highest percentage of mastitis as culling reason. Mastitis was also more frequent in straw yard systems than in cubicle houses or stanchion barns. However, infertility and claw health were mentioned less often for this housing system.

83.5 % of cows investigated showed skin alterations. Each cow had on average of 0.8 alterations. However, skin alterations were mostly moderate (more than 90 % hairless patches). The main body parts affected were hock and tarsal joints (146 and 131 cows). Injuries were found less often in straw yards than in stanchion barns or cubicle houses. Within both latter systems, an increase was found with decreasing amount of straw. Busato *et al.* (2000) found most injuries at hock joints in 152 Swiss organic dairy farms (mostly stanchion barns).

As in the study of Trachsel *et al.* (2000) on 152 Swiss organic farms, extreme values in body condition scoring were seldom found. However, BCS score was higher when dry cows were kept together with lactating cows. BCS scores were lowest in Holstein-Friesians.

Krutzinna *et al.* (1996) visited 268 organic dairy farms in West Germany (1993 – 1995). They found a milk yield of 4.953 kg, an average amount of concentrates of 580 kg per cow per year, somatic cell counts of 271.000, a calving interval of 385 days, and veterinary costs of 36.3 Euro. The lower cell counts in the present study could be a consequence of more restrictive legislation (max. of 400.000 cells allowed since 1998). Furthermore, Krutzinna *et al.* (1996) recorded fewer loose housing systems in their study (better hygienic conditions in the milking parlour).

Table 3: Culling reasons in relation to breed or housing system

Culling reasons	All farms	Breed			Housing system		
		Holstein-Friesian	Simmental	Brown Swiss	Cubicles	Straw yards	Stanchion barn
Breeding reasons	1.5	0.6	0	6.3	1.8	0.8	1.1
Age	10.9	6.8	10.3	14.7	9.8	5.4	18.8
Low performance	15.2	11.0	18.2	21.3	17.5	15.1	5.8
Infertility	21.9	20.9	16.1	24.1	25.6	9.3	24.2
Other diseases	2.7	3.4	1.4	0.3	1.7	8.3	0
Udder diseases	21.2	31.8	10.3	10.4	16.9	38.5	17.8
Milkability	4.5	5.0	7.7	1.8	3.3	8.8	4.5
Claw health	10.6	13.3	11.4	8.7	11.6	4.5	13.5
Others	11.8	7.1	24.3	13.5	12.2	9.3	14.0

Milk yield of all cows under milk control in Germany (3.6 million) in 2002 was 7.231 kg, SCC 191.000, calving interval 398 days, age of cows 4.8 years and culling rates 37.6 % (ADR 2003). It is questionable if the higher SCC counts found in this study compared with the literature values are caused by the organic farming method because Deneke and Fehlings (2001), for example, found in 203 Bavarian organic farms that recommendations for preventive udder health measures often were not followed.

Conclusions

Milk yield has increased in organic farms as in conventional farms during the last ten years in Germany. This could be explained by falling milk prices for organic milk. Veterinary costs increased with increasing milk production. Compared with data from the literature for all cows in Germany, organic cows investigated in this study had clearly lower milk production. They seem to have more mastitis, indicated by higher SCC, but fewer fertility problems and a longer life span. The latter parameters could be related to the lower milk production. Higher mastitis incidence seems not to be caused by organic farming per se but by management practices. Therefore, training and education measures seem useful to reduce health problems in organic farms.

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ORGANIC-CONVENTIONAL DAIRY SYSTEMS TRIAL IN NEW ZEALAND: FOUR YEARS' RESULTS

Terry Kelly[1*], Natalie Butcher[4], Kerry Harrington[1], Colin Holmes[2], Dave Horne[1], Peter Kemp[1], Alan Palmer[1], Alison Quinn[2], Nicola Shadbolt[3], Alan Thatcher[2]

1Institute of Natural Resources, Massey University, Palmerston North, New Zealand, http://inr.massey.ac.nz/

2Institute of Veterinary Animal and Biomedical Sciences, Massey University, Palmerston North, New Zealand

3Institute of Food Nutrition and Human Health, Massey University, Palmerston North, New Zealand

4Agricultural Services, Massey University, Palmerston North, New Zealand

* Corresponding author, Tel. 64 6 350-5517, E-mail t.c.kelly@massey.ac.nz

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Abstract

The Organic-Conventional Comparative Dairy Systems trial at Massey University began in August 2001, and the organic farmlet achieved certification in August 2003. The trial is unique because it is the only comparative grassland-based open grazing dairy study in the world. The organic and conventional systems are managed individually according to best practice, and both are intensively monitored for production, animal health, and environmental impacts. The systems remained similar for the first two years, but began to diverge in the third and fourth years. Production has been 10-20% lower on the organic farm, but environmental impacts appear to be less than on the conventional unit, and net incomes would be similar given a 20% price premium for the organic product. Animal health issues have been manageable on the organic farmlet, and not too dissimilar from the conventional farmlet. Full results after four years of the trial will be available and presented at the conference.

Introduction/Problem

Organic farming systems are usually considered to be lower producing, perhaps less profitable, but better for the environment. Better information based on rigorous science would help individual farmers make the decision to convert to organic production. The long-term aim of this research is to better understand organic dairy farming systems by investigating component interactions in these systems, and by determining how impacts and interactions change over time as organic systems mature, and compare these changes to those on a conventionally managed system with nearly identical resources.

Soil and land are the most valuable resources on a dairy farm aside from human capital. Farming organically places extra restrictions on the dairy farmer, requiring him/her to be even more aware of the soil resource. Previous research comparing conventional and organic dairy farms indicates that the management changes made by organic farmers can lead to both positive and negative changes to parameters that are used to indicate soil quality, depending to a large degree on inherent soil quality (Reganold *et al*, 1993; Macgregor 2002).

Key long-term objectives for the project are:

- develop farm and herd management systems that optimise performance over time;

- compare the impacts of organically and conventionally managed dairy systems on soil health (quality, flora and fauna) & water quality, pasture and forage crop productivity (quantity and quality), and animal production and health;

- identify management practices that improve the biological activity of soils, optimize clover content and best maintain biological N fixation, and best control mastitis and other health issues in organic milk production systems; and

- determine the stability and sustainability of high biodiversity organic dairy pastures, including the control of weeds.

Methodology

The Dairy Cattle Research Unit (DCRU) at Massey University in Palmerston North, New Zealand was split into two similar size farmlets, one conventionally managed (21.3ha) and the other organically managed (20.4ha), on 1 August 2001, at which time the organic farmlet began its organic conversion period. The DCRU was split in such a way that both farmlets were as similar as possible, including the herds. On 1 August 2003, the organic farmlet achieved its full AgriQuality (IFOAM accredited) organic certification.

The herd was split by breeding worth (BW) and production worth (PW), somatic cell count history, age and size to provide two herds as similar as possible. Both herds consisted of the same number of cows (44 Holstein Friesians) in the first year, with the expectation that cow numbers in the organic herd would decrease over time. Due to the slight difference in size, the stocking rate was actually slightly higher on the organic farmlet through the second year, but this was reversed deliberately in the third and fourth years, with the stocking rate higher on the conventional.

Although the organic farmlet has achieved full certification, the actual transition from conventional to organic production is continuing, with many of the biological systems taking longer than two years to make the adjustment from conventional management (Dabbert and Madden 1986). Thus, the whole farming system, and resulting profits, is still in transition.

Each of the two DCRU farmlets is managed individually according to “best practice” for its particular type of management system and environmental conditions. Thus, no attempt is made to try to do the same thing on one farm as is done on the other farm. For the organic farm, best practice is guided by the certifying agency (Agriquality) and by an organic farmer advisory group. Comparisons between the two systems are made through regular intensive monitoring, and full economic costing methods are used to determine the differences in cost of production under the two systems, and to influence management decision making.

Animal growth and health status for both herds are carefully monitored. There is considerable focus on preventative management on the organic unit, with extensive use of a range of homeopathic, herbal and other alternative treatments, tonics and drenches. This is further enhanced by carefully selected fertilizer inputs, based on herbage and soil analysis results, and focusing on a far wider range of trace elements and minerals than is standard practice on the conventional unit. Balancing trace element intake is also carefully considered for a wider range of elements than on the conventional unit and appropriate supplements are given to the organic herd, mainly in the form of fish proteinated chelates in the water trough, sprayed onto pasture or drenched orally. The parasite status of the organic calves is monitored closely throughout the period of maximum risk.

Regular monitoring of the mineral status of both herds is carried out and supplementation adjusted accordingly. Serum copper, selenium and magnesium have been analysed on a regular basis either for the purposes of routine monitoring or to check that changes to a supplementation regime were having the desired effect. Testing for other minerals is also carried out when circumstances indicate the possibility of inadequate intake. This additional testing includes analysis of serum for calcium, vitamin B12 and zinc, and liver biopsy samples for copper and vitamin B12.

The pasture composition of the organic and conventional farms has been surveyed twice yearly in October/November and again in May, except in 2002 when only the May survey was carried out. These surveys include herbage accumulation in all paddocks in each system, botanical composition in each season by point analysis of the pastures (including weeds) along permanent transects, and seasonal nutritive value of the pastures and other feed sources.

A range of soil properties and processes are being measured on both farmlets. Soil physical characteristics that are being monitored include; bulk density, infiltration rates, macroporosity, and aggregate stability. A range of indictors of soil micro- and macro-organism activity are also being measured including respiration rate, earthworm populations, microbial-C, total C, and degradation of cellulose strips.

Soil nitrogen dynamics are being studied in detail, with monitoring of nitrogen availability to pasture (total N, ammonium-N, nitrate-N and mineralisable-N), and nitrogen losses to the aquatic environment. Nitrogen leaching is measured using a network of suction cup samplers, and drainage is sampled as it enters surface water from pipe drain outlets. Soil chemistry monitoring includes inorganic and total organic forms of phosphorus, along with resin extractable, sodium bicarbonate extractable, sodium hydroxide extractable, and acid extractable fractions. A range of acidification indicators are monitored including pH in water and KCl, and pH buffering capacity. Cation exchange capacity and exchangeable cations are also measured.

Results and brief discussion

In general, the results of the first two years of the trial (2001-03), the conversion period for the organic farmlet, showed little difference in productivity, animal health, and soil and herbage quality between the two farms. The conventional and “in conversion” organic farms produced similar amounts of milksolids per cow and per hectare, and somatic cell counts were low for both herds. In the first season, milksolids per hectare were 959 and 993 and per cow were 436 and 451for the organic and conventional farms respectively. These compare favourably with the district average of 314 kgMS/cow that year. In the second season, with a very dry summer, milk production again was similar on both farmlets (723 kgMS/ha and 745 kgMS/ha respectively for conventional and organic). However, the cost per kg of milksolids produced was 23% higher on the organic farmlet, due mainly to the fact that it was a very dry summer and organic feed had to be brought in from off farm.

Animal health issues did not appear to differ significantly between the two units and there were no significant issues recorded on either unit during the first two seasons. Mastitis and somatic cell count data were analysed and reported by Lopez-Villalobos, *et al* (2003). The trial appears to indicate that the fish proteinated chelates are effective for a range of minerals. These products are a relatively inexpensive, easily administered but untested organic alternative to conventional mineral supplementation practices and the benefits of these products to all farmers are worthy of further investigation.

The third season (2003/04), the first in fully certified production, was characterised by average rainfall, but lower than average temperature and sunshine during Spring and Summer, with an extremely wet February. Overall, it was a very good dairy season. During this first season of full certification (01/07/03 – 30/06/04), the organic farmlet consistently grew less pasture than did the conventional farmlet, 11 tDM/ha on the organic farmlet compared to 13.5 tDM/ha on the conventional, so that less pasture was consumed and more supplements were fed on the organic farmlet. In particular, the conventional farmlet produced more pasture in early spring due to the application of urea fertiliser. The number of cows on the organic farmlet that season was lower than on the conventional side, 46 and 51 respectively. Because of these differences, milksolids production by the organic herd was lower both per cow (410 kgMS/cow vs. 457 kgMS/cow) and per hectare (925 kgMS/ha vs. 1094 kgMS/ha) than the conventional herd.

The 2004-05 season was characterised by a cool wet spring and early summer followed by a warm and dry late summer-autumn period, resulting in reduced pasture growth and milk production levels from the previous season. Stocking rates were down on both farmlets, with 43 cows and 48 cows respectively on the organic and conventional units. The dry autumn resulted in the organic herd and some of the conventional cows being dried off earlier than usual, contributing to the reduced production levels, particularly on the organic farm. Milk production on the organic farmlet was lower per cow (-14%) and per hectare (-20%) than on the conventional farmlet.

Both herds had similar body condition scores, and somatic cell counts were similar, though higher in both herds than in the two previous years. The organic herd had a higher incidence of *Staphylococcus aureus* infection in 2003/04 and 2004/05. Mastitis has been controlled in the conventional herd by the use of antibiotics and dry cow therapy, whereas homeopathic remedies were the frontline remedies for the organic herd. Other animal health indicators were also similar between the two herds. The organically reared calves have grown exceptionally well and tended to be slightly heavier and in better condition than their conventional counterparts. Parasite levels revealed no cause for concern at any stage. Similarly, the rising 2 year old heifers which have had a similar feeding regime have done well.

Soil monitoring up to autumn of the third season revealled no differences between the conventional and organically managed paddocks for ammonium-N, nitrate-N or mineralisable-N. The values for respiration rate, which is often viewed as a key indicator of micro-organism activity, were identical on the conventional and organically managed paddocks. Likewise, there is no difference in earthworm populations between the two systems. Preliminary results suggest that nitrate-N concentrations in drainage water are lower on the organically managed areas, but further monitoring is required to have confidence in this result. Some differences in soil nutrient status may be beginning to emerge between the systems – there is a hint that a gap in Olsen P, sulphate-S and potassium values may be developing between the conventionally and organically managed areas. These values are slightly greater under conventional management, presumably as a result of fertiliser inputs to this system.

The species composition of the pastures on the two farms has remained similar, except the white clover percentage on the organic farm has slightly increased relative to the conventional farm, but this is still a sub-optimal clover percentage for a dairy pasture. The most likely reason for the greater clover percentage on the organic farm is its lower pasture cover in spring.

There have been two approaches to increasing the clover percentage on the organic farm. First, grazing management objectives that include maintaining pasture masses in the 1500-2600 kg DM/ha range, particularly in spring, and grazing the poorer pastures hard (<1, 000kg DM/ha) in autumn. Second, the worst pastures on the organic farm are being renewed by cultivation and sown with a mix of perennial ryegrass, white clover, red clover, chicory and plantain. One half of a paddock was established in September 2004 and the other half was established in late February 2005 to compare establishment and weed ingress in spring and autumn.

Both farmlets are high producing units, and continually perform well above the district averages. Financial analysis reveals that with the exception of a very dry second season, both operate profitably. However, as a result of production per hectare differences, even though the absolute costs on the organic unit were less, the cost of milk production ($/kgMS) was 9%, 20%, and 16% greater for each of the first three seasons respectively – financial analysis for the fourth season of the trial will be available and presented at the conference.

Conclusions

It is still premature to draw any firm conclusions from this trial, since three plus years is quite a short time in the transition to a stable organically managed farming system. However, some preliminary indications are worth noting. Pasture production, and hence milk production, is less on the organic farmlet, most likely due to the inability to cost-effectively apply nitrogen fertilisers at critical periods in the spring. Mastitis, though more of a challenge on the organic farm, is manageable and has remained below tolerance levels; other animal health issues have not been a problem under organic management. The trial so far has demonstrated that organically rearing young stock is feasible, and in fact may be a very viable option for dairy farmers. Impacts on the environment in the form of nitrate-N contamination to ground and surface water may be less under organic management, but further monitoring is needed to be able to conclude this with any confidence. Finally, with a price premium for organic milk, the organic dairy system seems to be an economically viable option for dairy farmers.

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Use of Tanniferous Plants against Gastro-Intestinal Nematodes in Ruminants

Lüscher, A. (1), Häring, D.A. (1), Heckendorn, F. (2), Scharenberg, A. (3,4), Dohme, F. (3), Maurer, V. (2), Hertzberg, H. (2)

(1) Agroscope FAL Reckenholz, CH-8046 Zürich, Switzerland, andreas.luescher@fal.admin.ch
(2) Research Institute for Organic Farming (FiBL), CH-5070 Frick, hubertus.hertzberg@fibl.ch
(3) Agroscope Liebefeld-Posieux (ALP), CH-1725 Posieux, frigga.dohme@alp.admin.ch
(4) Institute of Animal Sciences, Swiss Federal Institute of Technology (ETH), CH-8092 Zurich

Abstract

On organic farms, infections of gastro-intestinal nematodes (GIN) in grazing cattle, sheep and goats can have a detrimental impact on animal health, and are therefore of substantial economic importance. The aim of our interdisciplinary project is to investigate the basic conditions for the implementation of a control strategy against GIN based on the use of tanniferous plants. The project combines research on plant growth and management, animal nutrition and parasitology. The first results, especially those from *Onobrychis viciifolia* (sainfoin), presented here are encouraging. *O. viciifolia* has a consistently high concentration of condensed tannins (CT) throughout the whole growing season. Thus, the optimal time for harvest can be determined in relation to agronomic properties such as fodder quality and yield and does not have to be related to a specific time period with high tannin concentration in the herbage. Despite its high CT content, the animals accepted *O. viciifolia* very well. Finally, the anti-parasitic properties of fresh CT-containing *O. viciifolia* were largely preserved in silage and hay leading to a substantial decrease in worm egg excretion in faeces. The present findings are promising for a potential integration of the CT-approach into the complementary control strategies against GIN in sheep.

Introduction

On organic farms, infections of GIN in grazing cattle, sheep and goats can have a negative impact on animal health, and so they are of substantial economic importance. Organic farmers are confronted with the problem of (i) reducing the infection pressure to an acceptable level and (ii) having largely to resign themselves to the use of conventional anthelmintic drugs in keeping with the organic farming guidelines. As complementary control strategies such as homeopathy or phytotherapy have not yet achieved satisfactory control of internal parasites, the control of endoparasites remains largely based on the use of anthelmintics. The present situation is incompatible with the philosophy of organic animal husbandry and necessitates the development of alternative forms of parasite control.

Recent studies on plants containing condensed tannins (CT) have shown anthelmintic effects, which have been attributed to their elevated CT content (Kahn & Diaz-Hernandez, 2000; Min & Hart, 2003). Effects have been found against adult parasites *in vivo* as well as against larval stages *in vitro*. The use of tanniferous plants as forage crops can thus potentially be incorporated into a combined control strategy against GIN.

Before we can recommend the implementation of tanniferous plants in an integrated control strategy against GIN, the basic mechanisms have to be understood and the system has to be adapted to local conditions. In a four-year interdisciplinary research project, the efficacy and practicability of a CT-based control strategy against GIN are tested under temperate climatic conditions in Switzerland. The single modules address the topics of plant growth and management, animal nutrition and parasitology.

Methodology

Plant growth and management

Aim and methods

Condensed tannins (CT) can have either beneficial or adverse effects on ruminants, depending on the concentration in which they are fed. Previous agronomic studies suggest that the optimal CT concentration is close to but below 5% DM (e.g. Aerts et al., 1999). Thus, we aimed to determine the optimal time for harvest with respect to tannin concentrations in three tanniferous plant species of the temperate regions for which positive effects on ruminants have been reported previously.

In an outdoor experiment *Onobrychis viciifolia* (sainfoin), *Lotus corniculatus* (birdsfoot trefoil) and *Cichorium intybus* (chicory) were sown in pots with a volume of 12 litres. The biomass allocation to leaves and stems, and the tannin concentration (Terrill et al., 1992) of the plants, were studied during the course of the vegetation period 2003 (from sowing until leaf senescence) in Zurich, Switzerland.

Results and discussion

Over the entire vegetation period, concentrations of CT in the species for any given tissue were in the following order: *O. viciifolia* > *L. corniculatus* > *C. intybus*. The tannin concentration in leaves was roughly three times higher than in stems in *O. viciifolia* and *L. corniculatus* and similarly low in both tissues in *C. intybus*. In all the species investigated, the tannin concentrations of stems were stable over time. In contrast, the tannin concentrations of leaves increased in *O. viciifolia* (from 5 to over 8 % DM; Fig. 1) and *L. corniculatus* (from 2 to 5 % DM) during the experiment. However, as plants grew older the proportion of leaves – where most tannins are located – decreased in harvestable biomass from 100, 80, 100% to 60, 35, 80% for *O. viciifolia* (Fig. 1), *L. corniculatus* and *C. intybus* respectively. With regard to the overall tannin concentration of harvestable biomass, the increasing concentration of CT in the leaves was almost exactly evened out by a dilution effect due to the increasing proportion of 'tannin poor' stems in the harvest. As a result of these two effects, the tannin concentration of the harvest was nearly constant during the growing season for all investigated species at about 6 % DM in *O. viciifolia* (Fig. 1), 2.5 % DM in *L. corniculatus* and <1 % DM in *C. intybus*.

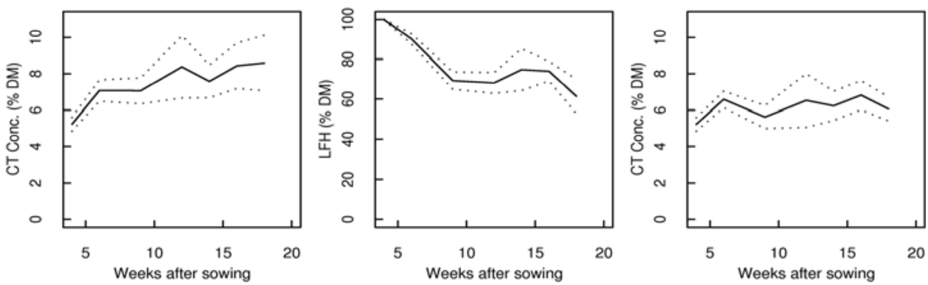

Figure 1: The concentrations of condensed tannins in leaves (CT Conc., left), the proportion of leaf fraction in harvestable biomass (LFH, middle) and the concentration of condensed tannins in harvestable biomass (CT Conc., right) during the experiment. All data from *Onobrychis viciifolia.* Shown are means and 95% confidence intervals of the mean.

In conclusion, as the CT concentration of harvestable biomass was found to be constant during the season, an optimal time for harvest can be determined in relation to agronomic properties such as fodder quality and yield. Of the investigated species, the tannin concentration in *O. viciifolia* seems most promising for the application against GIN.

Animal Nutrition

Aim and methods

High dietary concentrations of CT were related to low voluntary feed intake (Titus et al., 2000). Nevertheless, we aimed to find tanniferous plants that are well accepted by the animal, by assessing the palatability of three tanniferous plant species, each fed as dried or ensiled forage, and to compare it with a non-tannin containing grass/clover mixture.

The preference for each of the three CT-containing forage plants *(O. viciifolia, L. corniculatus, C. intybus)* was tested against a control mixture of ryegrass, white clover and red clover with three groups of adult wethers (n = 6). The study comprised two consecutive experiments: in the first experiment the forages were fed dried, and in the second experiment as silage. The respective CT-containing forage and the control forage were offered simultaneously in two separate boxes. In the first 10 days of each experiment, the diets contained 110 % of the maintenance energy requirement (ME (MJ) = 0.38 x LWˆ0.75 x 1.1) and were given in equal portions twice a day. During the second 10 days, the sheep received half of the experimental diets in the morning and low-quality hay in the evening. The total diets covered 155 % of the maintenance energy requirement. The palatability index (PI; Salem et al., 1994) was calculated 7.5 min (ensiled forage) and 15 min (dried forage) respectively after morning feeding. The CT content of the forages was analysed according to Terrill et al. (1992).

Results and discussion

On average, *O. viciifolia* (10 % DM) had the highest content of CT followed by *L. corniculatus* (3.3 % DM) and *C. intybus* (0.9 % DM). Averaged over all species, the CT content of dried forages (4.2 % DM) was slightly lower than that of silages (5.5 % DM).

Offered as dried forage, the preference of wethers for *O. viciifolia* (PI: 91.2 ± 23.9 %) and *C. intybus* (PI: 84.3 ± 23.0 %) was higher than for L. corniculatus (PI: 65.5 ± 21.8 %) during the first 10 days (Fig. 2), but none of the CT-containing forages achieved the PI of the control forage (100 %). During the second 10 days, the PIs of the CT-plants (*O. viciifolia*: 95.6 ± 2.9 %; *C. intybus*: 102.9 ± 13.5 %; *L. corniculatus*: 100.2 ± 13.1 %;) were in the same range as the control forage (100%).

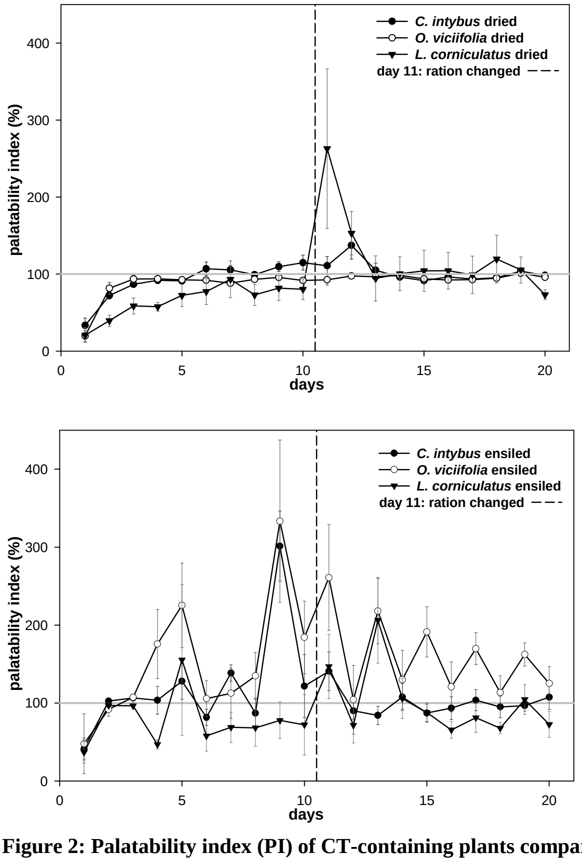

Figure 2: Palatability index (PI) of CT-containing plants compared to control forage (PI: 100 %) for dried (top) and ensiled (bottom) forages. Bars indicate standard errors.

Fed as ensiled forage, the PIs of *O. viciifolia* (151.9 ± 81.9 %) and of *C. intybus* (121.2 ± 69.0 %) were clearly higher than the PI of the control forage during the first 10 days (Fig. 2). In contrast, the preference for *L. corniculatus* (77.7 ± 33.3 %) was lower compared with the control forage. During the second 10 days, wethers clearly preferred *O. viciifolia* (159.6 ± 51.2 %) compared to the control forage while *C. intybus*

(100.6 ± 16.2 %) and *L. corniculatus* (101.0 ± 44.5 %) were in the same range as the control forage. Regarding the PI of *L. corniculatus*, wethers seemed to need a longer time to become accustomed to this feed.

In conclusion, the preferences of the wethers for the plants were not related to their content of CT. Despite its high content of CT, *O. viciifolia* was very well accepted by the animals and when ensiled, it was even preferred to the control forage.

Parasitology

Aim and methods

A reduction of GIN egg counts in faeces (FEC) was observed in several *in vivo* trials with CT using sheep and goats (Min & Hart, 2003). Recent studies focused onto whether these effects also hold true for conserved CT-containing plant material. Single and repeated administration of *O. viciifolia* hay to goats, naturally infected with GIN, has proven effective in reducing FEC (Paolini *et. al.* 2005). However, no information is available on whether this is also true for (i) ensiled CT-containing plants and (ii) other ruminant hosts like sheep. Thus, the present feeding trial aimed to assess the efficacy of ensiled forage of *O. viciifolia* against GIN in sheep.

Twenty-four lambs of the white alpine breed were artificially infected with a single dose of *Cooperia curticei* and *Haemonchus contortus* larvae. Twenty-eight days post infection lambs were allocated to 4 equal groups according to bodyweight and FEC. For 15 days the lambs were fed *ad libitum* with either *O. viciifolia* or corresponding isoproteic and isoenergetic control fodder without CT each as regular hay or silage respectively. FEC were performed twice a week. CT-concentrations of the fodder were measured according to Terrill *et al.* (1992).

Results and discussion

For *O. viciifolia* hay and silage the CT concentrations were 6.2 % DM and 4.1 % DM respectively. Compared to the control groups a marked reduction in FEC was observed in both *O. viciifolia* groups (Fig. 3). Within the 15-day feeding period, FEC decreased by 58 % when lambs were fed with *O. viciifolia* hay whereas FEC increased by 43 % when fed with the control hay (geometric means). For *O. viciifolia* silage, FEC was reduced by 37% whereas in the corresponding control group FEC increased by 16%.

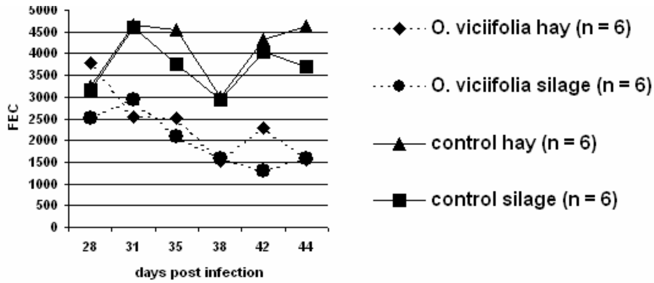

Figure 3: Geometric means of parasite egg counts in faeces (FEC) of lambs from 4 groups. Lambs were experimentally infected with H. contortus and C. curticei at day 0. Hay or silage was fed from day 29 to day 43 post infection.

In conclusion, the anti-parasitic properties of fresh CT-containing *O. viciifolia*, which were documented previously, are largely preserved in both silage and hay, leading to a substantial decrease in worm egg excretion in faeces. This implies that the ensuing pasture contamination with infective larvae will decrease considerably and reinfections will be reduced.

Conclusion

The present findings offer exciting opportunities for the practicability of the approach of feeding *O. viciifolia* against gastro-intestinal nematodes. Silage and hay are easily produced and the administration to sheep is neither linked to grazing nor to the vegetation period. Furthermore, as bioactivity is maintained after storage and transport of the conserved material, the production of *O. viciifolia* can be centralized.

Acknowledgements

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THE INCLUSION OF DIATOMACEOUS EARTH IN THE DIET OF GRAZING RUMINANTS AND ITS EFFECTS ON GATROINTESTINAL PARASITE BURDENS

Barbara McLean, David Frost, Eifion Evans, Aldwyn Clarke, Bernard Griffiths

ADAS Pwllpeiran, Cwmystwyth, Aberystwyth, Ceredigion, SY23 4AB, UK
Email: barbara.mclean@adas.co.uk, Internet: www.adaswales.co.uk

Key Words: Organic Farming, gastrointestinal parasites, sheep, cattle diatomaceous earth, Animal Production Systems (APS)

Abstract

Two studies were carried out to assess the efficacy of diatomaceous earth as an alternative to anthelmintics in grazing ruminants. Animals treated with anthelmintics and groups of untreated animals were included for comparison. Cattle and sheep which received the diatomaceous earth supplement had low Faecal Egg Counts (FEC) for the duration of the experimental period, similar to animals in the anthelmintic groups. Inclusion of diatomaceous earth in the diet of grazing ruminants may offer some benefits in controlling internal parasites.

Introduction

Organic systems seek to develop sustainable methods of production which balance output with high standards of animal welfare (Lampkin, 1990). Developing EU standards for organic livestock production have put downward pressure on the use of allopathic veterinary treatments (Keatinge, 1996), which in turn increases the urgency for the development of effective alternative strategies, if animal welfare is not to be comprised. In addition there is a need to substantiate popular claims for alternative treatments as to their efficacy and impact on animal welfare.

Heavy infestations of internal parasites in sheep result in poor performance of both ewe and lamb. Performance of young cattle is also affected by heavy parasite burdens. Under organic regulations, anthelmintics are permitted as a strategic dose in accordance with the farmer's overall strategy to reduce/eliminate the use of anthelmintics or where the farmer can show a need to drench i.e. faecal egg counts (FEC) of mobs or individuals are high and the animals are losing condition.

Alternative treatments to anthelmintics include diverse species grassland, nematode trapping fungi, mineral supplementation, herbal and homeopathic remedies. More recently the use of diatomaceous earth has also been advocated as an alternative treatment. Diatomaceous earth is the fossilised remains of diatom shells. After quarrying, crushing and milling, a fine light dust is obtained with certain abrasive properties and the ability to absorb lipids to about three times or more of the particle mass (Korunic, 1998). The action of diatomaceous earth on parasites is unclear but it has been suggested that the abrasive action of the powder pierces or scratches the outer protective layer of invertebrates including internal parasites, resulting in death by dehydration. However, diatomaceous earth is also rich in trace elements and it may be the enhanced nutritional status of the animals that has allowed them to cope with a parasite burden. However, to date only two papers have appeared in the scientific literature regarding the effect of diatomaceous earth on specific parasites and animal performance (Fernandez *et al*, 1999, Jordan, 1987) despite a plethora of popular press articles (Weehler, 1986, Sharabok, 1991, Macher, 1992, Cockrell, 1993, Wood, 1993). In addition a few state agriculture departments have also undertaken studies (Deutschlander, 1993, Osweiler & Carson, 1997). The results from all documented studies to date have been inconclusive with some studies reporting successful outcomes and others reporting little or no effect

Methodology

Two studies were carried out to assess the efficacy of diatomaceous earth as an alternative to anthelmintics in grazing ruminants. Study 1 was carried out with yearling Welsh Black Heifers. Study 2 was carried out with single rearing organic ewes.

Both studies were carried out under conditions of naturally acquired infections, with all heifers grazing the same pasture and all ewes and lambs grazing the same pasture. In both studies an anthelminitc treatment was included to replicate conventional farming practice in the UK. This treatment was administered regardless of FEC at the start of the trial.

In study 1, 18 yearling welsh black cattle were assigned to one of three treatment groups.

Group 1: a control group where no treatments were applied

Group 2: were treated with an anthelmintic drench prior to turn out

Group 3: received a daily supplement of diatomaceous earth (2% of daily DM intake).

The supplement of diatomaceous earth was mixed with rolled barley and fed every morning to the group. Groups 1 and 2 also received a similar ration of rolled barley. Cattle were turned out onto improved grass pastures which had previously been grazed by sheep during the late autumn and then stock free during winter and early spring. Faecal samples were taken and cattle were weighed prior to treatments being applied. Individuals were then randomly allocated to treatments so that each treatment was balanced for FEC and liveweight. Cattle were then weighed at weeks 4, 8 and 10. Faecal sample were taken from individuals on a weekly basis

In study 2, 45 single bearing pregnant ewes were allocated to one of three treatment groups.

Group1: A control group where no treatments were applied

Group2: All ewes were drenched prior to turning out with lamb on to grazing pasture

Group3: All ewes were given a daily supplement of Diatomaceous Earth post lambing

Faecal samples were taken prior to treatments being applied. Ewes were weighed and CS x weeks prior to lambing. Ewes were then randomly allocated to treatment groups, balanced for FEC and liveweight. The supplement of diatomaceous earth was mixed with rolled barley and fed every morning to the group. Groups 1 and 2 also received a similar ration of rolled barley. Ewes and lambs were turned out onto improved grass pastures which had not been grazed for at least three months.

Faecal samples were taken on a weekly basis for at least six weeks post lambing. Ewes were weighed and condition scored at four and eight weeks post lambing. Lambs were weighed at birth, four weeks, eight weeks and ten weeks of age.

In both studies, all liveweight data was analysed by ANOVA (Genstat, Lawes Agricultural Trust). All FEC data was Square root transformed prior to carrying out ANOVA. This transformation was performed to reduce the variation between animals in FEC. After statistical analysis FEC data was power transformed back to epg data.

Results and brief discussion

The physical performance results from study 1 are summarised in Table 1 below. In the cattle study (Study 1) there were no significant differences between treatment groups in terms of liveweight gain. There were significant differences in FEC (see Figure 1) however, with cattle in the control group (untreated) having significantly higher ($P<0.05$) FEC (404 epg) at week 7 compared to cattle in the drench group (137 epg). Cattle in the diatomaceous earth group had lower FEC (172 epg) in week 7 than cattle in the control group but this just missed significance.

Table 1: Physical performance of cattle in Study 1

	Control	Drench	Diatomaceous earth	SED	Significance
<u>Liveweight (kg)</u>					
Week 0	251.2	255.5	255.2	14.69	NS (P>0.05)
Week 4	256.0	257.0	250.0	12.60	NS (P>0.05)
Week 8	279.2	281.8	276.7	12.63	NS (P>0.05)
Week 10	289.8	283.8	280.5	10.05	NS (P>0.05)
Weekly liveweight gain	4.01	3.57	2.97	0.854	NS (P>0.05)
Daily liveweight gain	0.57	0.51	0.42	0.122	NS (P>0.05)

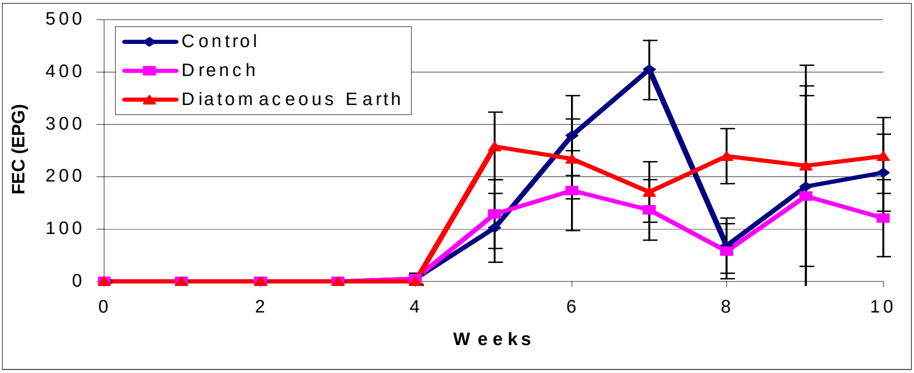


Figure 1: Effect of treatment on FEC of yearling cattle post turnout

Table 2: Effect of treatment on FEC of yearling cattle post-turnout

	CONTROL	DRENCH	DIATOMACEOUS EARTH	SED	Significance
WEEK 0	0	1	0	1.5	NS
WEEK 2	0	0	0	0.0	NS
WEEK 3	0	0	0	0.0	NS
WEEK 4	4	6	1	11.1	NS
WEEK 5	102	130	259	65.6	NS
WEEK 6	279	174	234	75.7	NS
WEEK 7	404[a]	137[b]	172[ab]	57.6	*
WEEK 8	69	58	240	52.3	NS
WEEK 9	182	164	222	192	NS
WEEK 10	207	121	240	73.0	NS

NS – Not significantly different
Values not sharing common superscripts differ significantly (P<0.05)

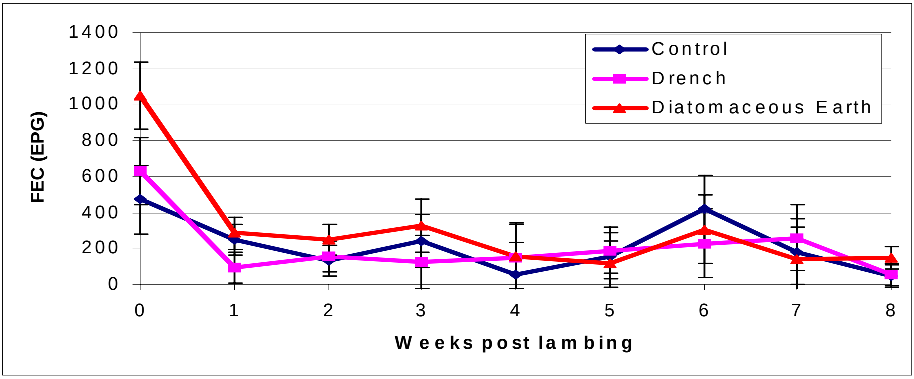
The physical performance results from study 2 are summarised in Table 3 below. In the sheep study (Study 2) ewes in the diatomaceous group had significantly heavier (P<0.05) liveweights than ewes in the drench group (51.6 *vs*. 45.9 kg respectively) at eight weeks post lambing. There were no differences between the diatomaceous earth group and the control group. By 10 weeks of age lambs from ewes receiving the diatomaceous earth treatment were significantly heavier (P<0.05) than lambs from ewes in the drench group (24.4 *vs*. 20.1 kg respectively). There were no significant difference in FEC between treatment groups prior to or post lambing (See Figure 2). There was however a trend for the ewes in the drench group to have lower FEC than the other two groups. It was noted that the group treated with anthelmintics, did not have 0epg after treatment. This may be due to two reasons, either treated ewes have populations of anthelmintic resistant parasites in their gastro-intestinal tract or the anthelmintic was not administered correctly. Follow-up studies on anthelmintic resistance is being followed up with this group of ewes.

Table 3: Physical performance of lambs in study 2

	Control	Drench	Diatomaceous earth	SED	Significance
Liveweight (kg)					
Birth	3.94	4.03	4.45	0.308	NS (P>0.05)
Week 4	11.0	11.1	12.8	1.484	NS (P>0.05)
Week 8	18.2	18.2	20.9	1.820	NS (P>0.05)
Shearing	21.1ab	20.1a	24.4b	1.997	* (P<0.05)

Values on the same row bearing different superscripts differ significantly

Figure 2: Effect of treatment on FEC of ewes post lambing



Conclusions

Inclusion of diatomaceous earth in the diet of grazing ruminants may offer some benefits in controlling internal parasites, however longer term studies are required to determine optimal quantities and duration of inclusion.

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HEAT-TREATED BLUE LUPIN AS PROTEIN SUPPLEMENT FOR HIGH YIELDING ORGANIC DAIRY COWS FED GRASS-CLOVER SILAGE AD LIBITUM

Lisbeth Mogensen (1), Peter Lund (2), Martin Riis Weisbjerg (3), Troels Kristensen (4), John Erik Hermansen (5)

(1) Danish Institute of Agricultural Sciences, Research Centre Foulum, DK-8830, Tjele, Denmark, +45 89991223, Lisbeth.Mogensen@agrsci.dk, www.agrsci.dk
(2) Danish Institute of Agricultural Sciences, Research Centre Foulum, DK-8830, Tjele, Denmark, +45 89991131, Peter.Lund@agrsci.dk, www.agrsci.dk
(3) Danish Institute of Agricultural Sciences, Research Centre Foulum, DK-8830, Tjele, Denmark, +45 89991181, Martin.Weisbjerg@agrsci.dk, www.agrsci.dk
(4) Danish Institute of Agricultural Sciences, Research Centre Foulum, DK-8830, Tjele, Denmark, +45 89991233, Troels.Kristensen@agrsci.dk, www.agrsci.dk
(5) Danish Institute of Agricultural Sciences, Research Centre Foulum, DK-8830, Tjele, Denmark, +45 89991236, John.Hermansen@agrsci.dk, www.agrsci.dk

Key Words: Feeding, Organic milk production, Protein supplement, Production experiment

Abstract

A screening of rumen and intestinally fistulated cows indicated that heat-treatment has the potential to improve the protein value of blue lupin. Heat-treatment can increase duodenal flow of rumen undegraded feed amino acid nitrogen (AAN) without hampering microbial AAN synthesis or intestinal digestibility and thereby increase metabolisable protein. Increased level of metabolisable protein is supposed to increase milk production. The effect on milk production of untreated *versus* heat-treated (toasted) blue lupin as supplement feed was examined in a production experiment including 60 dairy cows. The cows were fed grass-clover silage ad libitum and iso-energetic amounts of untreated lupin/cereals (UL), heat-treated lupin/cereals (HL) or cereals (C). Neither milk yield in kg, protein content, milk fat content nor energy corrected milk yield (ECM) was significantly affected by type of supplement. The ECM yields were 24.4, 25.6 and 24.7 kg ECM for treatments UL, HL and C, respectively.

Introduction

Organic milk production is very important in Denmark and constitutes 10% of the total milk production. Focus right now is on obtaining 100% organically grown feed, as this has been a requirement from the dominant dairies since the summer of 2001 and soon will be requested in all European Union countries for organically produced milk (EC regulation No 1804/1999). Further, focus is on increasing the proportion of home-grown feed as one of the basic principles in organic farming (IFOAM 2002). Crops that can be grown organically under Northern European conditions have typically been grass-clover for silage, and cereals for maturity and for whole crop silage (Mogensen 2004). With a feed ration based on these crops is it difficult to secure a sufficient level of metabolisable protein to cows in early lactation. Therefore, degradation of protein in the rumen should be restricted to what is necessary to maintain rumen NH_3 above the critical limit. A preliminary experiment determined the effect of heat-treatment on protein value of different organically grown protein supplements; blue lupin, soybeans, field beans, and peas (Lund *et al*. 2004). The results showed that heat-treatment had a positive effect on protein value, especially for blue lupin and soybeans. The objective of the present paper was to examine the effect of heat-treated *versus* untreated lupin on milk production. Blue lupins were chosen as protein source as they can be grown in Denmark – though experience of growing blue lupin organically is limited.

Methodology

A production experiment including 60 dairy cows was conducted on a private, organic dairy farm. The experiment ran for seven weeks. In the two-week pre-period all cows received the same type of supplement feed: a mixture of equal energy from the three experimental supplement feeds. The pre-period was followed by a five-week experimental period where the cows were fed one of the three experimental supplement feeds. The three experimental supplement feeds were untreated lupin/cereals (UL), heat-treated lupin/cereals (HL) or cereals (C).

The blue lupin was organically grown in Denmark. Part of the lupin was heat-treated (toasted) at 140°C for 90-120 seconds, part was untreated. Lupin was ground and pelleted together with ground barley. 2% molasses was added to secure pellet quality. The cereal mixture was fed rolled (unpelleted). Ingredients included and chemical composition of the experimental supplement feeds are shown in Table 1. Heat-treatment of the lupin resulted in a higher dry matter content, and therefore the composition of the pellet was changed to secure iso-protein content in untreated and heat-treated lupin/cereal pellet.

Table 1. Composition of experimental supplement feed

Treatment	UL	HL	C
Composition, % of weight			
Lupin, untreated	45		
Lupin, heat-treated		43	
Barley	53	55	20
Molasses	2	2	
Oats			23
Triticale			57
Chemical composition			
Dry matter (%)	84.5	87.2	85.5
Crude protein (% DM)	19.8	20.4	11.8

The cows were grouped according to parity and days in milk and divided randomly in three treatment groups. The experimental treatments were iso-energetic and based on the same net energy (4.5 Scandinavian Feed Unit (SFU) = 35.5 MJ) obtained daily from one of three types of supplement feed: 4.7 kg cereal mixture (C), 4.3 kg untreated lupin/barley (UL) or 4.3 kg heat-treated lupin/barley (HL). Grass-clover silage was fed ad libitum. Rations with supplement C and UL were expected to be deficient in metabolisable protein according to the Danish requirements.

Feed intake was measured daily. The intake of supplementary feed was recorded for the individual cow. Intake of roughage was recorded daily for all lactating cows in the herd. Cows within the experiment were assumed to have the same feed intake capacity (Strudsholm *et al*. 1999), and the roughage was divided equally among the total number of cows.

Milk yield was measured once during the pre-period and three times during the experimental period.

All cows were Danish Holstein. At the beginning of the experiment the cows were, on average, milked 143 days had an average daily milk yield of 26,2 kg ECM and weighed 579 kg.

The average daily milk yield per cow was calculated as a simple average of the three registrations during the experimental period. Effect of treatment on milk production was analysed using General Linear Model in SAS and the following model:

Yield = treatment (fixed effect) + parity (fixed effect) + treatment*parity + days in milk (covariate) + yield in the pre-period (covariate).

Results and discussion

Daily feed intake is shown in Table 2. The same feed intake of the ad libitum feed was assumed for all treatments, resulting in almost the same intake of net energy for all treatments. The content of crude protein in the total ration was 20% for the UL and HL, but 18% for C.

Table 2. Daily feed intake for the three treatments, kg DM and chemical content (g/kg DM).

Treatment	UL	HL	C
Ration, kg DM			
Lupin, untreated/cereal	3.6		
Lupin, heat-treated/cereal		3.8	
Cereal			4.0
Grass-clover silage	16.5	16.5	16.5
Total DM, kg	20.1	20.2	20.5
Ration composition (g/kg)			
Crude protein	198	199	182

Treatment	UL	HL	C
Sugar	32	32	29
Starch	85	87	131
Digestible cell walls	421	419	400
Fatty acids	20	20	19
Digestible protein	158	158	137
Amino acids absorbed in small intestine (AAT) [1)]	70	75	70
Protein balances in rumen (PBV) [2)]	70	64	51
Total net energy, MJ (SFU)	147 (18.6)	146 (18.5)	148 (18.7)

[1)] The protein value for intermediary protein synthesis in the animal is expressed as amino acids truly absorbed from the small intestine (AAT) (Madsen 1985)

[2)] The protein value for the micro organisms is the amount of degraded protein from the feed subtracted the amount of protein synthesized by the micro organisms on basis of the energy content of the feed (Madsen 1985)

As shown in Table 3 neither milk yield in kg nor milk concentration of fat and protein was significantly affected by type of supplement. Yield of energy corrected milk (ECM) was not significantly affected either.

Table 3. Milk production, LS means, SEM

Treatment	UL	HL	C	SEM	P
Milk yield, kg/day	24.6	25.9	24.5	0.6	0.14
Milk fat concentration, %	4.11	4.08	4.21	0.09	0.47
Milk protein concentration, %	3.26	3.25	3.27	0.02	0.66
Fat, kg/day	0.980	1.016	1.011	0.04	0.86
Protein, kg/day	0.787	0.832	0.769	0.02	0.12
Relative, %	100	106	98		
ECM, kg/day	24.4	25.6	24.7	0.6	0.23
Relative, %	100	105	101		

The preliminary experiment showed that heat-treatment of lupin seemed to have a positive effect on duodenal AAN flow, which was increased 50 gd^{-1}, when cows were fed 5 kg lupin per day either untreated or heat-treated (Lund *et al*. 2004). The increase in duodenal AAN flow was primarily due to a numerical increase in duodenal flow of undegraded feed AAN (162 *versus* 119 gd^{-1} for treated and untreated lupin, respectively). Even though the numerical difference in ECM yield in the present experiment between untreated and heat-treated lupin not was statistically significant, the relative increase in ECM yield of 5% of heat-treated *versus* untreated lupin corresponds very well with what can be expected based on the results from the preliminary experiment and the expected response on increased supply with metabolisable protein according to the Danish requirements.

Conclusions

In intensive experiments heat-treatment seemed to improve the protein value of organically grown protein supplements, such as blue lupin, by decreasing rumen degradability. Results from the production experiment indicate that this positive effect on protein value may have a subsequent positive effect on milk production – though not statistically significant. Therefore, when lupin was used as protein supplement heat-treatment seemed to be beneficial. Without heat-treatment, the protein value of lupin equals that of cereal.

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ECONOMICS AND FARMERS' PERSPECTIVES

THE RELIABILITY OF ORGANIC CERTIFICATION: AN APPROACH TO INVESTIGATE THE AUDIT QUALITY

Gabriele Jahn, Matthias Schramm, Achim Spiller

University of Goettingen, Institute of Agricultural Economics, Chair for Food Marketing, Platz der Goettinger Sieben 5, 37073 Goettingen, Tel.: +49 551 39 9897, E-mail: gjahn@gwdg.de, mschram1@uni-goettingen.de, a.spiller@agr.uni-goettingen.de

Keywords: organic certification, audit quality, agency theory

Abstract

Increasing complexity and first scandals indicate that the current control structures for organic food is insufficient. The main challenges are different methods of implementation on the national level and the collaborative responsibility between the public and the private sector. Both often cause lacking clarity and disagreements. The following contribution focuses on instruments to enhance the quality of certification of organic food. Only a few of the suggested instruments have been included as necessary requirements yet. Given the risk of deficient quality assurance and at the same time increasing control costs, it seems urgent to trigger discussions on risk-oriented auditing and to improve the current certification system.

Introduction

Quality assurance is a crucial issue for the organic market. The information asymmetries related to the process-oriented attributes of organic production (credence quality) can not easily be bypassed by classical quality signals such as advertising, branding, and guarantees. Over the past years a certification system has been established to ensure organic quality. However, it is conjecturable that certification systems are susceptible to opportunistic behaviour (McCluskey, 2000). In a market in which the company to be supervised can choose its own auditor, misleading incentives may occur. From the viewpoint of the certification body, a cheap certification can be a decisive competitive advantage in certification markets. Low-cost strategies might significantly affect the quality of inspections. Hence, the underlying institutional structure can considerably influence the effectiveness and reliability of the whole certification system. Only if the label is recognized as a valid signal, customer’s confidence will increase.

The following analysis deals with the control validity of the organic certification system. Thus, the relevant institutional framework is presented. The model based on a Principal Agent Approach provides the base for the discussion about the audit quality of organic certification. Additionally, results from the research on financial auditing complement the analysis.

Methodology

Basic Structure of Organic Certification

In most countries the organic certification system has a core structure as illustrated in figure 1. Key feature is that inspections are carried out by independent bodies (third party audit) conforming to standards laid down by external organisations. The starting point is the flow of goods between farmers, processors and consumers. The supplier provides the organic certificate serving as quality signal, which is issued by a neutral certifier based on the quality and certification standards laid down by the public sector (e.g., EU regulation 2092/91 or OFPA). Governmental certification systems are established to serve consumer protection purposes by providing quality labels to improve market transparency.

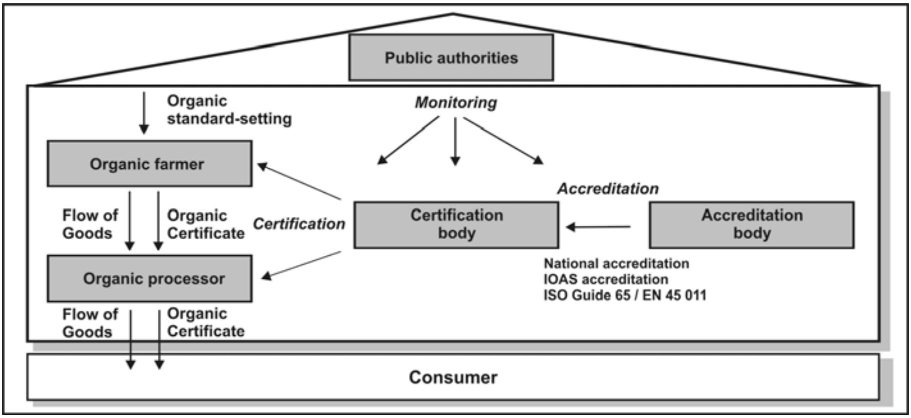

Figure 1: Basic structure of the organic certification system

According to the official guidelines, the basic structure of the organic certification system is the same. However, two main types of implementation can be differentiated:

Polypolistic structure: In the majority of the countries, the operative inspection tasks are delegated to private certifiers, which can be either domestic certification bodies or foreign ones (Wynen, 2004). An oligopolistic structure might occur as well, associated with strong national accreditation programmes and/or the public control of the organic certification market.

Monopolistic structure: Completely public driven systems as in Denmark or Finland are rather exceptional. In these countries, both monitoring and certification are carried out by public authorities. Thus, the realisation of organic control is part of a governmental bureaucratic process (Seppänen und Helenius, 2004). The working principle is similar in nations such as the Netherlands, where the public sector authorises one certification body to do the organic inspections (c.f., SKAL).

The Basic Research Model

The main focus of the following analysis will be on a certification market in which a supplier can choose between several certification bodies (*polypolistic type*). Our model refers to a variety of research approaches analysing the field of financial auditing. Since the seminal studies of Antle (1982) and DeAngelo (1981) many theoretical approaches to audit quality have been applied, generally based on decision theory, game theory, or agency approach.

The premise of the model is based on rational and risk-neutral agents tending to act opportunistically. Assuming the existence of a given inspection technology, the probability of discovering shortcomings grows with increased inspection intensity, as do investigation costs. Certification fees are fixed exogenously. Under these conditions, the certification body acts to minimize costs.

The certifier's optimisation calculus can be represented as follows: The certifier's marginal cost (MC_C) arise from the marginal cost of the inspection (MC_I) together with the marginal opportunity cost of the loss of the client (MC_O). The latter pertain to the contingency that a company will replace a certifier it views as too strict with a more lenient one. Against a unilateral minimization of these costs weigh the increasing costs of a deficient inspection being discovered (MC_D), which in turn are composed of the marginal cost of a potential loss of reputation resulting from inadequate inspections becoming generally known (MC_R) and the marginal cost of liability (MC_L). MC_D, as well as MC_L, will increase with decreasing audit quality (q). The costs of liability for example are composed of the probability of being held liable and the amount of the potential sanction. With a higher level of audit quality, the probability of being sanctioned decreases leading to an above average decline of the marginal cost of liability MC_L. Thus, the relevant cost functions to be minimized are as follows:

MCC = MCI + MCO (1)

MCD = MCR + MCL (2)

From the certifier's point of view, a cost minimum appears at the intersection of the two curves that determines the inspection quality to be estimated by the auditor (cf. Figure 2). From these considerations, we can derive four basic starting points for improving inspection quality: (1) extending the certifier's liability (increasing the marginal cost of potential liability), (2) intensifying the effects on reputation in the certification market (increasing the marginal cost of loss of reputation), (3) decreasing the certifier's dependence on the firm being inspected (reducing the opportunity cost of losing the client) and (4) reducing the inspection costs by improving certification technology (reducing the marginal cost of the audit).

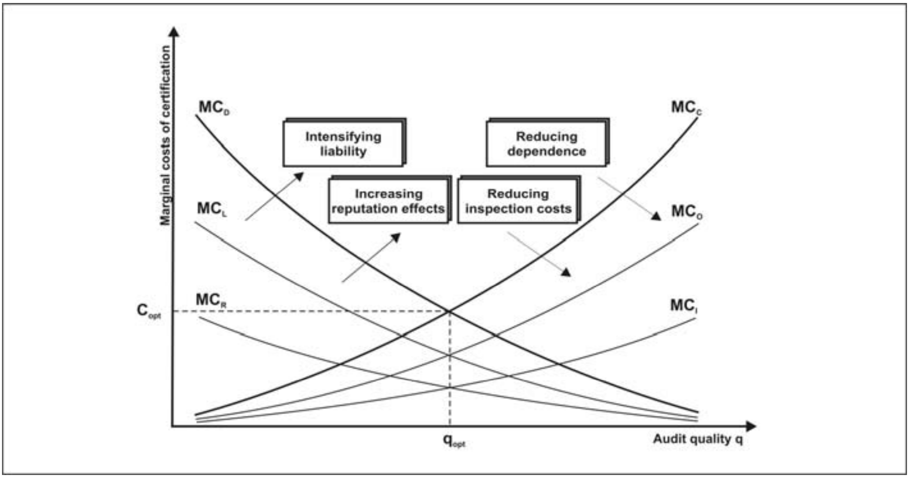

Figure 2: Determination of the cost minimum inspection standard

The Empirical Illustration and Discussion

Besides the more formal research, empirical studies on the quality of financial auditing are also widespread. However, an analysis of these empirical findings makes apparent that they are often debatable. The following section aims to outline initial starting points for how the audit quality of organic certification could be improved. It is based on the described model as well as on a qualitative expert survey conducted in 2004.

Intensifying Liability: Intensifying the inspector's liability raises the marginal cost of the liability and thus induces the certifier to increase the quality of the inspection. The certifier's probability of liability is qualified by the effective claims of negligence and the apportionment of the burden of proof. In auditing, there is no absolute liability, thus, in each case the certifier's guilt must be proven by the injured party. For outsiders, this is naturally difficult. For this reason, there is currently an intense debate on the preventative effects of absolute liability (Sunder, 2003).

In addition to costs arising from liability, penalties for non-compliance raise the costs for opportunistic certifiers: They might be ordered to pay penalties or even be excluded from system participation. In contrast to private certification approaches, the public responsibility in organic certification allows to enforce criminal prosecution for fraud.

Increasing Reputation Effects: An intensification of the effects on reputation would have an impact similar to that of the threat of liability discussed above. If there are no effects on reputation, supplier and certifier have a clear interest in superficial certification. The resulting adverse selection will be encountered only if marketing advantages are triggered by an accepted label and/or an inspection through a certifier known to be thorough.

Reputation increases with higher market transparency. At present, consumers as well as professional buyers have only very little information about the performance of different organic certifying agencies. They cannot judge their work and because of the process attributes, they are unable to evaluate their activities after purchasing the product. Only few customers actually prefer products from specific certification bodies.

Therefore, the disclosure of erroneous certifications by the standard owner would be a conceivable and efficient variation. Public authorities should enforce their monitoring and failed companies and inspectors should be named.

In most countries the organic certification market is very heterogeneous: Small agencies compete against big international agencies. However, the size of the certification body and the consequent strengthening of the effects on reputation is an option much debated in the literature on auditing. According to the findings of empirical studies in auditing, internationally renowned CPA groups can command higher auditing fees than lesser-known equivalent auditors (Niemi, 2004). This can be seen as a reputation bonus which would be lost if a scandal occurred. Therefore, in case of doubt, the shareholder should call upon the company to contract with a highly reputable certifier.

Reducing Dependence: Traditionally, driven by the organic association, organic controls and advisory services were carried out together. However, today separation is mandatory due to ISO Guide 65 (EN 45011). Separating consulting from certification could contribute to a further mitigation of the distinctly dependent relationship that develops if certifiers are also allowed to function as consultants. If the certification market functions as an entry into the lucrative consultancy market, the opportunity cost of losing a client increases significantly. Knowledge spill-over effects lead to a higher audit quality with the same input of resources. In addition, increased reputation effects can be a result of consultancy business combined with auditing.[1] Whether the total impact of a separation will be positive or negative is a matter of debate in financial auditing as well (Frankel et al., 2002, Windmöller, 2000). Further dependencies might be discussed regarding the dependencies between a certification body and organic farming associations or other huge producer associations.

Another issue is the danger of losing clients in the following period (so-called “low balling”-effect in financial auditing) which can have a decisive effect on the auditing report. Thus, it should not be allowed for producers to go “opinion shopping“ and change from one certifier to another without any restrictions. Nowadays, the organic certification guidelines still allow changing the certification body at any time even during the ongoing certification process.

Improvement of Inspection Technology: In the preceding sections, we assumed perfect inspection technology. In practice, with the same costs certifiers can have varying levels of success due to different levels of know-how or different software support. Improved inspection technology lowers certification costs and, at the same time, contributes to enhanced certification quality. In addition to vocational training and better technical support, appropriate instruments include risk-oriented inspection approaches and an improved exchange of data and information among the regulatory bodies. First projects are implemented considering these issues (cf., European Action Plan for organic food and farming or the EISfOM project).

In financial auditing the adoption of “risk-oriented auditing” is a popular method to enhance inspection technology. “Risk-oriented auditing” is associated with a specific classification of clients due to the likelihood of fraud. Higher audit frequencies and deeper audit intensities are necessary in settings with high audit risks. Additional spot checks increase the discovery of errors whereas long audit intervals are only appropriate for companies characterised by a low risk of fraud.

It becomes apparent that referring to former audit results can only be a starting point to integrate risk factors (GfRS, 2003). In addition to specific risk factors for the firms, a standard owner should consider the potential risk of damage (e.g., loss of reputation or health risk) and the amount of public attention in the case of a crisis in determining and weighting risk factors as well. The identification of risk leads to different audit intervals, additional spot checks, and suitable inspection methods. The key objective should be the optimization of the cost-benefit ratio associated with the controls by means of an assessment of fraud risks and a particular focus on “dangerous” clients.

[1] Seppänen and Helenius support a combined approach for the organic certification in Finland: “When organized systematically and consciously developed, advice in inspections could reinforce the dialogue between the formal, closed regulation, and the informal, more open “self-regulation” that is going on in local farming practices. (Seppänen and Helenius, 2004: 11)”

Conclusions

The conducted study highlights a variety of starting points, which must be considered when discussing a valid control quality of the organic certification system. It appears, however, quite difficult to evaluate the costs related to the above-mentioned procedures on a firm's level as well as on a macroeconomic level. An instrument which could have a cost reducing effect, would be an increasing implementation of the risk-oriented auditing. Similar positive impacts would also be associated with an increasing harmonisation of the national systems. Bureaucratic tendencies might have an opposite effect.

An issue often discussed is whether the monopolistic approach is more effective than the polypolistic one. A definite answer cannot be given. The suitability of a purely state-driven approach might primarily depend on the expertise of public agencies, but as well on the reputation of the public sector. Difficulties arise if the competencies between the public and the private sector are not clearly defined.

Altogether it becomes apparent that all changes of audit quality can just as easily have undesirable side-effects (e.g., restraint on competition, higher costs and prices). Such trade-offs are inevitable and recommend cautious progress. The overall quality will not necessarily rise. Nevertheless, preventing cheap talk is finally the *conditio sine qua non* for successful organic labelling.

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THE FINANCIAL SIGNIFICANCE AND IMPACT OF SUPPORT PAYMENTS FOR ORGANIC FARMS

Hiltrud Nieberg, Frank Offermann, Katrin Zander

Federal Agricultural Research Centre, Institute of Farm Economics, Bundesallee 50, 38116 Braunschweig, Germany, ph: +49-531-596-5207, hiltrud.nieberg@fal.de, www.bw.fal.de

Key Words: organic farming support, economic viability, international competitiveness

Introduction

Organic farming has been financially supported throughout Europe since 1994. In this period, the sector has shown very dynamic development. In the meantime, a large range of measures has been offered, targeting the promotion of the organic food sector. Measured against the level of finance expended, payments for the introduction and maintenance of organic farming continue to emphasise policies supporting organic farming in Europe. Against the background of increasing discussion on the shape and level of organic farming payments, the question emerges of their impact on the sustainable development of organic farming.

In this contribution, the main features of organic payments are first briefly presented. Then the importance that farmers from different European countries place on the payments with regard to their decision to convert and the economic viability of their farms is discussed. On the basis of farm models and farm accounting data, the significance of organic payments, in relation to other agricultural supports and to organic price premiums, will be analyzed, followed by a discussion of their influence on international competitiveness.

Materials and methods

The analyses are based on (a) a survey of organic farms (b) farm models of typical farms in different European countries and (c) on information from the European Farm Accountancy Data Networks (FADN).

a) In Winter and Spring 2003, 550 organic farmers from 11 European countries (Austria, the Czech Republic, Denmark, Estonia, Germany, Great Britain, Hungary, Italy, Poland, Slovenia, Switzerland) were personally interviewed. The farms were randomly chosen within the whole country or within selected regions of a country. All farms visited first started conversion before 2001.

b) Crucial for the international competitiveness are the relative production costs. Organic farming payments cover part of the production costs, so that products can be sold at a lower price. To analyze the importance of organic farming payments relative to the production costs, models of 10 typical farms in five European countries (Austria, Germany, France, the Czech Republic and Slovenia) were used. The farm models stand for a group of similarly structured farms which represent an important share of organic farming in their country. The data base for the models is statistical data and expert knowledge (Häring, 2003; IFCN, 2004). The results are presented for the organic beef sector. Production costs include all cash costs, depreciation and opportunity costs for own factors, like land, capital and labour. They are recalculated for 100 kg produced carcass weight. The same is true for the payments paid for the area used by the beef fattening activity in the farm. Whole farm payments are allocated according to the share of beef production in total farm returns.

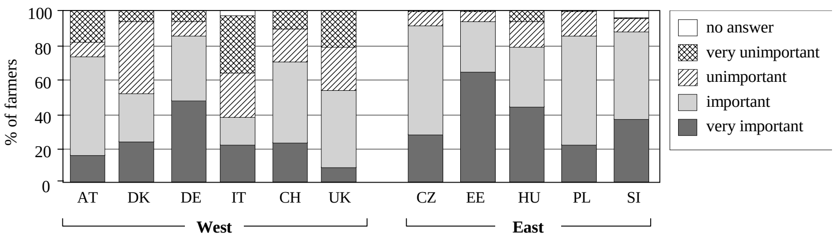
c) Farm Accountancy Data Networks provide extensive information on economic indicators, including very detailed information on direct payments and revenues. As farm accounts provide data on actual payments received, this data source implicitly accounts for farm-individual factors influencing eligibility for support payments and payment levels. The EU FADN contains farm accounts of approximately 60,000 farms and, since the accounting year 2000, a variable allowing the identification of organic farms has been added to the database (D'Avino, 2004). The importance of the support for organic farming is analysed by relating the respective payments to revenues and farm income indicators as well as to other support payments. The results are differentiated by farm characteristics such as farm type, size and country to provide an insight into the underlying determinants of the variances. In addition, based on time series data from several national FADNs, the development of the support to organic farms is analysed and compared to similar indicators for comparable conventional farms.

Results

The promotion of organic farms in the EU takes place on the basis of the EC regulation 1257/1999 on support for rural development. Organic farming is one of many agri-environmental measures offered within the framework of the Programme for Rural Development. According to EC Reg. 1257/1999, the payments have to be calculated on the basis of income foregone, additional costs resulting from the commitment given, and the need to provide an incentive (max. 20%). Due to the strongly differing conditions in the various European countries, both the design of the measures and the level of premiums vary widely between the European countries (see Lampkin *et al.*, 1999; an update will be available soon). For example, in 2004, payment rates for conversion of arable land varied between 97 € / ha in Estonia and more than 300 € / ha, e.g., in Austria and Slovenia.

The significance of organic payments was assessed differently by the 550 farm managers surveyed (Fig. 1). In answer to the question, "What is the significance of the organic farming payments for the economic viability of your farm today?", 74% said that the organic payments were important or very important. Large differences can be found between the countries. About 90% of the Eastern European farmers judged the organic payments as important or very important for economic viability of their farms. Of the Western European farmers questioned, only slightly more than 60% held this opinion. In Germany the portion is 86 %, and in Italy only 39%.

Figure 1:Farmer's assessment of the significance of the organic payments for their economic viability



Asked about the importance of the availability of organic farming payments for their decision to convert, farmers gave different answers in the West and in the East[1]. At least 56% of the Western European farmers judged organic farming payments to have been important or very important, whereas this share among East European farmers is 76%. In the West, the share of farmers who describe organic farming payments as being unimportant or very unimportant is highest in CH (65%) and lowest in DE (37 %). Among the Eastern European farmers, organic farming payments were least important in the decision to convert in SI (57% important or very important). The highest ranking for organic farming payments was given by Polish farmers. Only 7% declared that organic farming payments were unimportant when they decided to start with organic farming.

With respect to competitiveness in international markets, the comparison of production costs for the year 2002 in selected farm models shows that organic beef can be produced at lowest cost in the Czech Republic (Figure 1). Nevertheless, production costs also vary widely between the farms in the selected Eastern European countries. Going more into detail, it turns out that labour costs, including opportunity costs for labour, are even higher in Eastern European farms as a result of low labour productivity. Due to inefficiencies in production in the former cooperatives, there are obviously no economies of scale in the large German farms. All of the countries covered by this study, except France, offer organic farming maintenance as well as conversion payments to their farmers. They account for 7 to 16% of the production costs, with differences within the countries themselves as well. Slight competitive disadvantages exist only for French farmers as they do not receive any organic maintenance payments, but they do not cause changes in the relative production costs reduced by the named payments. The differences between the countries are not stressed, so that an influence of organic farming payments on the competitiveness of organic beef

[1] This question was answered only by farmers who received payments when they converted to organic farming.

production is not very likely. Taking into account all of the government payments to farmers changes the picture completely, as a severe impact on cost relations, and by that on the competitiveness between countries, can be shown.

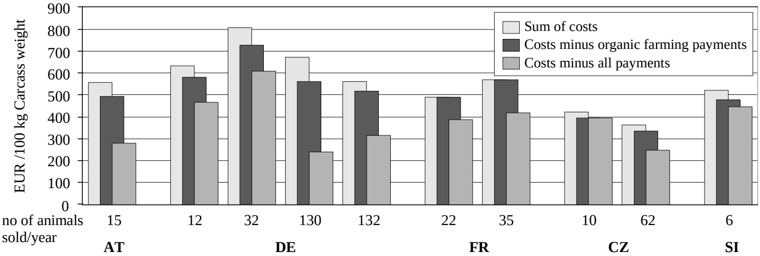
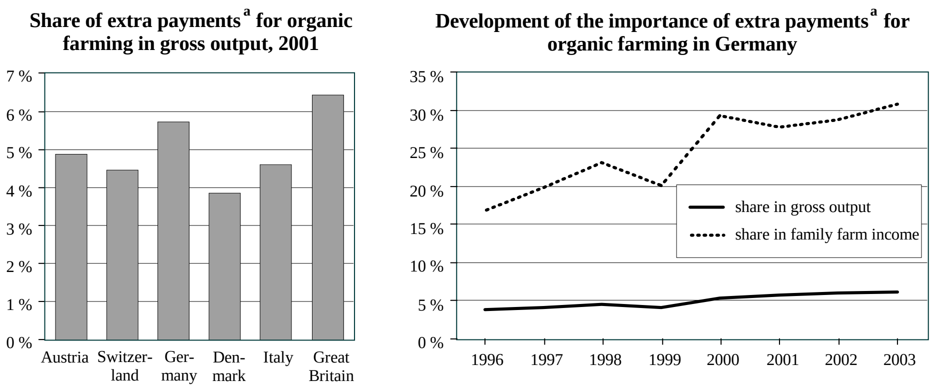


Figure 2: Costs and payments in organic beef production in EUR/100kg carcass weight

Due to recent reform of the Common Agricultural Policy, and the accession of the Eastern European countries to the EU, the importance of payments may change significantly.

First results of the analysis of the FADN-data highlight the large differences in the importance of support payments for individual organic farms. The revenues caused by price premiums for organic products are often more important than direct payments, especially in arable and horticultural farms, and in regions with low levels of support. In some countries, even though the absolute level of specific support to organic farms is high, the relative preference for organic agriculture is low (Figure 3) and remarkably similar across countries. This is because other agri-environmental programmes exist with high payment levels for which the organic farms would be eligible if the specific organic support measures did not exist. It seems that on average, the dependency of organic farms on support payments has increased in some countries over the years as a result of rising payment levels, reduced prices and a shift in the type of farms converting. This needs, however, to be substantiated in further analyses.



[a] Calculated as the difference of payments from agri-environmental programmes received by organic and comparable conventional farms.

Figure 3: Importance of extra payments for the profitability of organic farms

Conclusions

The paper provides an analysis of the impact of support payments for organic farms on the economic viability and competitiveness in Europe, using different data bases and different methodologies. Final conclusions will be drawn upon completion of the analysis. First results indicate that organic support payments are quite important for most European organic farmers, and that the dependency of organic farms on support payments has increased over the years, while the influence of these payments on the international competitiveness may be less than is commonly perceived.

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GOING ORGANIC: FARMERS' PERCEPTIONS OF BENEFITS AND COSTS

Nur H. Rahayu (1), Carl Smith (2) and Iean Russell (3)

(1) School of Natural and Rural Systems Management (NRSM), University of Queensland (UQ), Gatton Campus, Gatton, Queensland 4343 Australia, s4035642@student.uq.edu.au
(2) School of NRSM, UQ Gatton, Australia, c.smith2@uq.edu.au
(3) School of NRSM, UQ Gatton, Australia, irussell@uq.edu.au

Key Words: organic farming, decision-making model, Bayesian Belief Network

Abstract

This paper discusses the progress of a research project using Bayesian Belief Networks in order to capture the complex reasoning behind the farmers' decision to convert to organic farming in Queensland, Australia. The project is conducting (1) workshops using the nominal group technique to identify the key benefit and cost criteria that farmers consider when making the decision to convert to organic farming, (2) a survey of farmers to populate a Bayesian Belief Network containing these criteria; and (3) sensitivity analysis to identify those criteria that most influence farmers' perception of the benefit-cost of organic farming. The outcomes of the sensitivity analysis will facilitate the identification of areas where policy intervention could influence farmers entering the organic food industry.

Introduction

For individual farmers, converting from conventional to organic production is often a challenging process due to the necessary change of established practices. The burden is borne by farmers alone even though the impacts may benefit wider society. The present research therefore examines the complex range of social, financial and environmental factors influencing farmers' perceptions of the benefits and costs of converting too organic farming, using a probabilistic model. The model aims to integrate the range and variability of farmer viewpoints surrounding the decision to convert, so that policy levers most likely to attract farmers to the organic industry can be identified.

Methodology

The approach used for decision modelling is similar to that of Bacon *et al.* (2002), who used Bayesian Belief Networks (BBNs) (Jensen, 2001) to model farmers' satisfaction with alternative land use options. The advantages of using BBNs in decision-making modelling are that they can (a) include a range of farmer viewpoints (variability) with respect to decision-making criteria, (b) integrate tangible and intangible decision-making criteria, (c) represent the decision-making process as a graphical model, and (d) be used to conduct sensitivity and scenario analyses to examine how policy interventions could influence farmers' perceptions of benefits and costs.

The study initially selected organic farmers following the certification process in the Sunshine Coast and Darling Downs Regions, Queensland, Australia, based on their willingness to participate in workshops. The Nominal Group and Pin Board techniques (Carman and Keith 2004) were used in two workshops to identify common factors attracting and inhibiting farmers to adopt organic farming. These factors were separated into benefit and cost criteria. The benefit criteria included factors attracting farmers to organic farming, while the cost criteria included barriers to conversion. These criteria were presented back to a group of organic farmers in a subsequent workshop for validation.

Based on the workshop outcomes, a BBN model was built and populated using results obtained from a preliminary survey of nine organic farmers. The survey asked the farmers to rate and weigh the cost and benefit criteria for two options – conventional farming and organic farming. Likert scales (from 1 (very low) to 5 (very high)) were used in the survey to obtain an individual farmer's ratings for the criteria, while a Pie Chart technique (whereby an individual draws a pie chart to indicate the percentage importance given to each criterion) was used to obtain an individual farmer's weightings for the criteria. For each criterion, a score was calculated by multiplying an individual farmer's rating and weighting. In the BBN model, the sum of the benefit criteria scores represents an individual's overall benefit score for an option, while the sum of the cost criteria scores represents an individual's overall cost score for an option. The outcome of the model is a benefit-cost ratio for each option, which is the benefit score divided by the cost score.

The BBN model was then used to identify the relative influence of the benefit and cost criteria on the benefit-cost ratio, hence identifying those decision-making factors that have the greatest influence on farmers perceptions of benefit-cost.

Results and Discussion

Table 1 shows the findings from the workshops. Note that it contains both tangible (such as 'Profitability' and 'Certification Costs'), and intangible (such as 'Family Health Benefit' and 'Satisfaction') decision making criteria. Other authors have reported similar factors. Padel (2001), for instance, reported the following as commonly cited motivations for adopting organic farming:

1. Husbandry and technical reasons – animal health problems, soil fertility and erosion problems

2. Financial motives – solve existing financial problems, secure future of the farm, cost saving, premium marketing

3. Personal health – own and family health problems, ergonomic reasons

4. General concerns – stewardship, food quality, conservation, environmental, rural development

Padel (2001) also suggests that opposition in the farming community and social isolation, perceived lower profitability and higher risk, certification constrains, technical problems, lack of policy support, undeveloped markets and unavailability of credible information are potential barriers to the broader uptake of organic farming.

Fairweather (1999) reported chemicals in food, personal health concerns, price premiums and environmental concerns (such as soil health) as some of the reasons attracting New Zealand farmers to organic farming. Burton *et al*. (2003) also reported that concerns about the environment and the sustainability of the food production system were important determinants in the adoption of organic farming practices in the UK.

Table 1: Costs and benefits of converting to organic farming identified in the workshops.

Benefit Criteria	Cost Criteria
Family Health Benefit: Benefit to the health of farmers and their families. **Consumer/Society Health Benefit**: Benefit to the health of consumers and society. **Environmental Protection**: Maintenance of the quality of soil, water, air and biodiversity. **Profitability**: Difference between financial returns and costs. **Satisfaction**: Self-esteem and positive feeling that the farming practices implemented are responsible. **Collaboration**: Group support and cooperation between producers. **Research and Educatio**n: Contribution to science and education for agriculture industry.	**Certification Costs**: Certification fees, audits, levies. Complexity of Certification Process: Difficulties in meeting certification requirements, paper trail, bureaucratic process and time involved. **Risk**: Guarantee of success of enterprise due to yield risk and price risk, no quick fix. **Information Services**: Availability of information on farm management and best farming practices **Quality of Government Suppor**t: Quality of government support/incentives in terms of coordination, extension services and certification processes. **Unpopularity/Ridicule**: Being 'odd', lack of acceptance by neighbours, not taken seriously. **Undeveloped Market**: Higher market involved or no market exists.

Figure 1 shows a simplified version of the BBN model developed using the benefit and cost criteria in Table 1, and the results obtained from the preliminary survey of nine organic farmers. The benefit criteria are listed on the left hand side of the model while the cost criteria are listed on the right hand side. Each criterion has state ranges between zero and five, which is the score given by individual farmers for each farming option (the farmers' rating for an option multiplied by the farmers' weighting for the criterion). The probability distributions in Figure 1 show the distribution of criteria scores given by the farmers for the organic farming option (note the 'Organic Farming' option in selected in the Farming Option box in the model). Roughly 13% gave organic farming a score of less than one for 'Family Health Benefit', 76% scored it between one and two and 10% between two and three. When compared to the other benefit criteria, most of the farmers gave 'Family Health Benefit' a relatively high score. Meanwhile, under cost criteria, 'Certification Costs', 'Complexity of the Conversion Process' and 'Risk' where given scores distributed toward the high end compared to the other cost criteria.

Overall, the model shows that for most farmers surveyed, the benefit score for organic farming exceeded the cost score, that is, approximately 63% of farmers had a benefit-cost ratio greater than one. For 37% of the farmers the benefit-cost ratio was less than one. This shows that 37% of farmers had chose to grow organically in spite of the fact that their perceived costs of organic farming exceeded the benefits. Please note that the percentages here are intended to illustrate how the model shows the results from the preliminary survey.

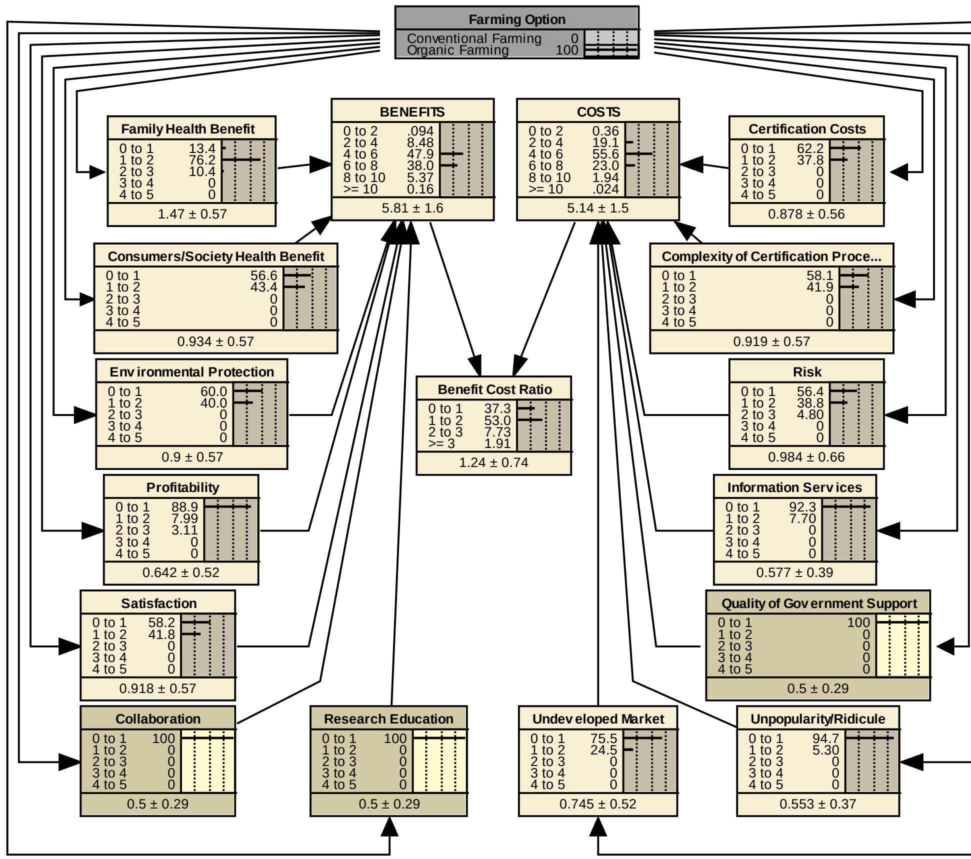

Figure 1. The populated BBN model

The full BBN model (not shown in this paper) was used to conduct a sensitivity analysis on the benefit and cost criteria. This was done to identify those criteria where a shift in the rating would cause the greatest shift in the benefit-cost ratio. Table 2 ranks the benefit and cost criteria separately the in order of influence on the benefit-cost ratio, for the organic farming option (one being the highest rank). Table 3 ranks all criteria in the order of influence on the benefit-cost ratio, for the organic farming option. The results show that while Environmental Protection, Family Health Benefit and Satisfaction rank highly amongst the benefit criteria (Table 2), overall they achieve only mid level ranking (Table 3). On the other hand, Risk, Complexity of Certification Process, Certification Costs, and Undeveloped Market rank highly amongst the cost criteria (Table 2) and overall (Table 3).

The preliminary model and sensitivity analysis presented here were based on a small survey of nine organic farmers. Further work will entail conducting a wider survey of farmers, both organic and conventional, to ensure that the probability distributions in the BBN model are representative of a wider population. This will help to identify differences between organic and conventional farmers in the distribution of criteria ratings, weightings and benefit-cost ratios for both conventional and organic farming. These differences may provide a useful comparison with the characteristics of early and late adopters discussed by Padel (2001).

Table 2: Ranking of benefit and cost criteria in relation to influence on benefit-cost ratio

Benefit Criteria	Cost Criteria
1. Environmental Protection	1. Risk
2. Family Health Benefit	1. Complexity of Certification Process
3. Satisfaction	2. Certification Costs
4. Consumers/Society Health Benefit	3. Undeveloped Market
4. Profitability	4. Information Services
5. Research Education	4. Unpopularity/Ridicule
5. Collaboration	5. Quality of Government Support

Table 3: Ranking of all criteria in relation to influence on benefit-cost ratio.

1. Risk	7. Profitability
1. Complexity of Certification Process	7. Consumer/Society Health Benefit
2. Certification Costs	8. Information Services
3. Undeveloped Market	8. Unpopularity/Ridicule
4. Environmental Protection	9. Quality of Government Support
5. Family Health Benefit	9. Collaboration
6. Satisfaction	9. Research Education

Although based on a small sample of organic farmers, the preliminary results indicate that policy interventions to reduce risk, complexity of the certification process or certification costs could have a relatively large influence on farmers perceived benefit-cost of organic farming. Confirmation of this is the subject of a wider survey of farmers, both organic and conventional.

Conclusions

Farmers consider a complex range of issues when making the decision to convert to organic farming. These issues include many tangible (such as financial) and intangible (such as health) factors and the degree to which each of these influences an individual farmer varies. The BBN approach to decision modelling outlined in this paper has the advantage of being able to integrate a variety of different farmer viewpoints regarding the costs and benefits of converting to organic farming. The analytical capabilities of the BBN model (sensitivity analysis) allow for the factors most influencing farmers perceptions of benefit-cost to be identified, and therefore potentially identify how policy levers can influence the decision to convert. Preliminary results based on a survey of nine organic farmers have indicated that a shift in cost factors including risk, complexity of certification process, certification costs and undeveloped market had a relatively high influence on their perceived benefit-cost of organic farming. If similar results are obtained from a wider survey of both organic and conventional farmers, these may be areas were policy intervention could have a relatively large influence on the adoption of organic farming practice.

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ECONOMIC ANALYSIS OF STOCKLESS, HORTICULTURAL CROP ROTATIONS ON A MODEL FARM IN TEMPERATE ZONE ORGANIC SYSTEMS

Ulrich Schmutz, Chris Firth and Francis Rayns

HDRA, Ryton Organic Gardens, CV8 3LG Coventry, UK, +44 2476303517, uschmutz@hdra.org.uk, www.HDRA.org.uk/research

Key Words: Organic farming, organic horticulture, vegetables, stockless systems, farm economics, horticultural costings, rotational planning, risk-analysis, sensitivity analysis, model, conversion

Abstract

Research draws on an organic research farm site in central England with a temperate zone climate - fairly common for the northern lowlands of Europe. The soil type is a sandy loam with 591 mm rainfall. Detailed economic and agronomic data have been collected since conversion began in 1995. The economic analysis discusses rotational gross and net margins of more than 30 different rotations with different fertility building and vegetable crops (potatoes, cabbages, onions, carrots, leeks and parsnips). Sensitivity and risk analysis of key variable costs important for successful organic vegetable production are shown. Rotational gross margins varied from –570 €/ha to 6,341 €/ha. Highest output-risk was introduced by yield variations, not price variation. Highest cost-risk was introduced into the system by variations of casual labour for weeding and organic crop protection.

Introduction/Problem

Limited data are available on specialised horticultural rotations; most research focuses on arable or livestock rotations. However, horticultural crops are important because in terms of value they comprise a large part of developed organic markets even if production areas and hence impact on the biodiversity issues are small. The understanding of the longer-term rotational effects of different vegetables on the economic and agronomic performance of these production systems is limited. Insufficient use of nitrogen can expose this valuable resource in organic systems to leaching and cause environmental problems.

Methodology

An area of 13 ha at the University of Warwick HRI research station in Wellesbourne, Warwickshire, England, was monitored since conversion in 1995. At an altitude of 45 m and with an average rainfall of 591 mm the site has a temperate zone climate. The soil type is a poorly structured sandy loam with irrigation equipment available, however only used for plant establishment. Detailed economic and agronomic data were monitored since the start of conversion. Fertility building crops were used whenever possible, no livestock manure was added and only one green-waste compost application of 25 t/ha was made. Further agronomic details are given elsewhere (Rayns et al. 2002).

Three different conversion strategies were used. Following conversion, the different strategies were continued in different patterns of rotations. As a control, an arable conversion strategy was used. The farm experienced therefore a conversion to organic systems and a management change to specialist horticultural production. As a “near to farming” system there are no defined replications, however many patterns of similar treatments during the years are available for a statistical analysis. Variations in the system were: different fertility building crops and vegetables (potatoes, cabbages, onions, carrots, leeks and parsnips); different length of fertility building periods and different percentages of vegetables, cereals (spring barley, spring wheat); and fertility building crops (grass/white clover ley, undersown white clover, vetch, grazing rye) in the rotations.

All costings were measured *on-farm*, only some adjustments were necessary to reflect the research type of the farm. Costings collected at a crop level were used to calculate crop and rotational gross and net margins. Rotational costs not allocable to any specific crop or intercrop were also measured. Real prices and marketable yields were used and for sensitivity analysis modelled ones were used. The casual labour rate use was 5.71 €/h in 1996 and increased to 7.57 €/h in 2002.

The economic data were referenced to a group of ten commercial vegetable farms in England; however their economic data are not available for publication. An internal comparison shows that their average economic data are quite similar to the Wellesbourne data, justifying the approach using this "model farm" data to draw conclusions on average or typical commercial horticultural farms.

Risk was measured as percent coefficient of variation (%cv) of a given data set. As an environmental indicator, estimates for nitrogen leaching using expert knowledge were made.

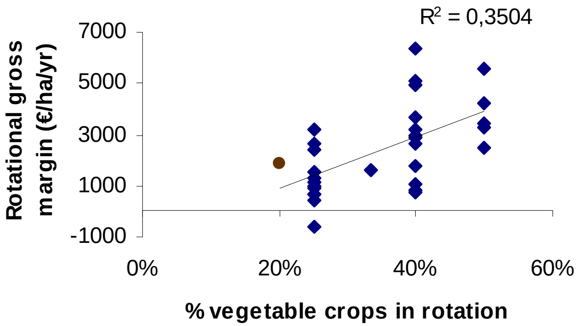
Results and discussion

Analysis of rotational gross margins

Specialist organic horticultural rotations produced higher rotational gross and net margins compared to organic arable rotations; however it also presented higher risk. The rotational gross margins varied greatly from -570 €/ha/year to 6,341 €/ha/year. They were not normally distributed. The average rotational gross margin of horticultural rotations was 2,400 €/ha/year. The arable rotational gross margin was 1840 €/ha/yr, however the conventional arable rotation used before conversion produced only a farm gross margin of 1,000 €/ha/yr. Therefore, the farm gross margin was increased through conversion and management change to organic horticulture.

The percentage of vegetable crops in the rotation was significantly related to rotational gross margin (Figure 1). Rotational net margins were highly correlated to gross margins (data not shown).

Figure 1: Rotational gross margins (€/ha/year) of 30 organic vegetable rotations (with 25%-50% vegetable crops in rotation, diamonds), compared one arable rotation (5-year, one potato crop = 20 % vegetables, circle).



Other factors such as length of the initial fertility-building period, length of the rotation, choice of other crops in rotation and subsidies (set-aside, organic aid) had little effects on the system. The average cereal gross margin (spring barley and spring wheat) was 745 €/ha and the average fertility building gross margin was 328 €/ha. Therefore, replacing fertility building with cereal cropping, or less subsidies for set-aside, had only a little effect on the rotational gross margin compared to a successful vegetable crop with a gross margin of 5,669 €/ha on average.

Economically, the most successful vegetable crops grown on the light sandy-loam soils were potatoes, carrots and parsnips with average gross margins (from 12 crops grown during 4 years) of 7,904 €/ha (potatoes) and 9,908 €/ha (carrots). Cabbage and leeks were more difficult to grow with gross margins of 5,450 and 4,233 €/ha, respectively. Onions failed (849 €/ha) and were later replaced by parsnips. Rotations with higher vegetable contents (up to 80%) were not investigated.

Analysis of vegetable crop gross margins and selected variable costs

The highest output risk was introduced by marketable yield variations (29%), while prices were less variable (10%). The most variable crop yields were measured in onions and cabbage (42%).

Among the different vegetable crops, the highest variation of total costs (variable and allocated fixed costs) was found in potatoes and cabbages (Table 1). However, overall variable costs and fixed costs did not vary too much, on average less then marketable yields.

Table 1: Average variable and casual labour costs in €/ha of five organic vegetable crops grown during 1998 and 2001 and risk as % cv (coefficient of variation, sample size = 12 per crop, onions 10).

	Variable Costs	Risk %cv	Casual labour	Risk %cv
Potatoes	€ 5,142	18%	€ 2,098	24%
Cabbage	€ 5,712	17%	€ 2,052	38%
Onions	€ 6,566	10%	€ 3,638	22%
Carrots	€ 15,453	10%	€ 9,444	13%
Leeks	€ 11,558	6%	€ 7,014	10%
Average	€ 9,016	12%	€ 4,913	21%

Further variable cost analysis (Table 2) showed highest variable cost for casual labour (54%). Casual labour was used for work like lying and moving fleece, planting, weeding, harvesting, grading and packing. Costs for packaging and transport were also relatively high, followed by costs for organic (where available) seeds and transplants. Crop protection costs and other costs were relatively low.

Therefore, further rises in seed costs with the exclusive use of organic seeds and transplants has an important effect on the production cost structure. The same is true for the availability and quality of the casual labour force used and further increases in casual labour rates. Increases in casual labour rates, e.g. by 10%, have a direct effect on average vegetable gross margin reducing it to 5164 €/ha.

Highest cost risk was introduced into the system by variations of casual labour for weeding and organic crop protection (Table 2). However, crop protection costs, which included the use of fleece, were only 5% of the variable costs and therefore the high variation, a reflection of changing weather conditions during years, is less relevant to the overall system.

Table 2: Breakdown of average variable costs in €/ha of five organic vegetable crops grown during 1998 and 2001 and risk as % cv (coefficient of variation, sample size = 58 crops).

Variable costs (av. of veg, €/ha/yr)		%	Risk (%cv)
Casual labour	€ 4,913	54%	21%
Casual labour for hand weeding	*€ 1,135*		59%
Packaging & Transport	€ 1,848	21%	28%
Seed, Transplants	€ 1,622	18%	14%
Crop protection	€ 438	5%	82%
Other	€ 194	2%	
Total Variable Costs	€ 9,016	100%	

Casual labour costs – A comparison with data for casual labour hours published in the Netherlands (Geven 1999) shows that casual labour costs (using UK labour rates of 7.29 €/h) are similar for some crops like leeks and onions, higher for potatoes and carrots and lower for cabbage. On average the casual labour costs where 151% of the Dutch data, which give no indication of variation.

Rotational costs - The variable costs shown (Table 2) refer only to the crop-related costs usually published in farm management handbooks (Lampkin et al. 2004). Costs applicable to the whole rotation, like short-term fertility building crops or weeding and sub-soiling not allocable to a certain crop are not included. This rotational cost varied between 50 and 200 €/ha/year depending on rotation and were 140 €/ha/year on average. Costs for annual fertility building crops are not included in the rotational costs.

Weeding costs - The total weeding costs (Table 3) are added up from casual labour costs for hand weeding (counted as a variable cost) and mechanical weeding costs (counted as an allocated fixed cost). During 1998-2001, hand-weeding costs were reduced and replaced with mechanical weeding. The overall weeding costs were therefore reduced by 10%, although they still averaged 1308 €/ha.

Environmental costs - Estimates for nitrogen leaching (between 40 and 60 kg N/ha) were not correlated to rotational gross margins (data not shown).

Table 3: Average weeding costs (casual labour and mechanical weeding costs) in €/ha of five organic vegetable crops grown during 1998 and 2001 and trend in % of linear regression (sample size = 58 crops).

Weeding costs (€/ha, average of 5 vegetables)						Trend	
	1998	1999	2000	2001	Average	lin. Reg	%
Casual labour	1290	1352	1322	575	1135	-218	-19%
Mechanical	78	95	205	316	174	83	48%
TOTAL	1368	1446	1528	891	1308	-135	-10%

Conclusions

On this "model farm" with light and poorly structured soils, it was possible to successfully convert a stockless arable system to organic farming. The conversion to arable organic, with only potatoes as the vegetable crop, already produced higher rotational gross margins. A further management change to horticultural rotations with different vegetable crops produced even higher rotational gross margins; however, this incurred a higher variation of outputs and costs. A better understanding of risks and their management is integral to further proliferation of this organic system. Referencing the results to a group of commercial vegetable farms showed (data not available for publication), that their average economic data are similar to this model farm and therefore more generalised conclusions might be possible. Nutrient management was successful using only fertility building crops and green waste compost. No livestock inputs were necessary. However, in this research, rotations had only 50% vegetable crops as a maximum; rotations with higher vegetable percentages (up to 80%) were not studied. They can be more profitable but nutrient and other agronomic management might be more challenging. The data can be used in farm advisory and farm business planning as well as for scientific research feeding into model based decision support systems for planning and optimising organic and conventional horticultural crop rotations (Schmutz et al. 2004).

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LAND USE, CONVERSION AND RURAL DEVELOPMENT

DETERMINANTS OF SPATIAL DISTRIBUTION OF ORGANIC FARMING IN GERMANY

Barbara Bichler (1), Anna Maria Häring (2) Stephan Dabbert (1) Christian Lippert (1)

(1) University of Hohenheim, 70565 Stuttgart, Germany, +49/711/459 2546, bichlerb@uni-hohenheim.de
(2) University of Applied Sciences Eberswalde, 16225 Eberswalde, Germany, +49/3334/657 348, ahaering@fh-eberswalde.de

Key Words: Organic Farming, Spatial Distribution, Spatial Autocorrelation, Location Factors

Abstract

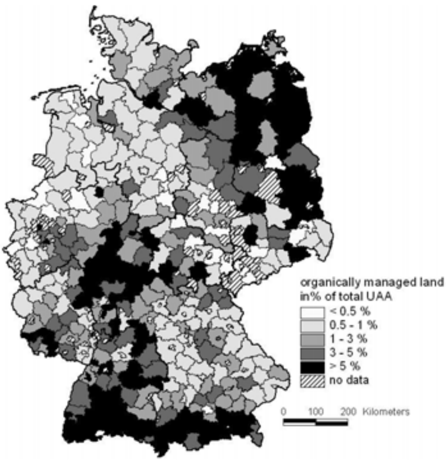
The share of organically managed land is spread unevenly throughout Germany and shows pronounced regional concentrations. The spatial distribution of organic farming is assumed to be influenced by several factors. Location factors of farms are regionally different and thus may influence the spatial distribution of organic farming. Agglomeration effects and therefore spatial dependence are also considered important in determining spatial distribution.

These factors with a potential influence on the spatial distribution of organic farming can be divided into four categories: natural factors, farm-structure factors, socio-economic factors and political factors. Their possible influence on the spatial distribution of organic farming is analysed by several statistical methods: ordinary least squares regression model, spatial autoregressive models, analysis of variance and Spearman correlation. Of the analysed factors, spatial contiguity has the strongest influence on the spatial distribution of organic farming (indicating relevant agglomeration effects).

Introduction/Problem

The spatial distribution of organically managed land throughout Germany shows remarkable differences (see Figure 1). However, contiguous regions with a similar share of organically managed land often are observed.

Figure 1: Spatial distribution of organic farming in Germany (in 2001)



Source: own calculations based on Statistische Landesämter (2004)

Factors with a possible influence on the spatial distribution of organic farming can be subdivided into the following groups:

Natural factors describing land use patterns (i.e. soil quality), *Farm-structure factors*, like the share of grassland, affecting - besides the natural conditions - the production pattern within a region.

Socio-economic factors describing aspects related to consumers, processors and the proximity of farms to markets and agglomeration effects. Furthermore, socio-economic factors cover the population structure (i.e. income, population density).

Political factors describing the political framework within which the farmers act; e.g. the different levels of subsidizing organic farming in different Federal States and the incidences of protection areas, like water- and nature protection areas.

However, the focus of this paper lies on the supposed relevance of agglomeration effects. A study for the German Federal State Hessen indicates the importance of agglomerations of organic farming (Hermanowski 1989). Additionally, in Southwest Germany the relatively high share of organic farming has been explained by the proximity to Switzerland, which has been considered as the "most important innovation centre for organic farming" (Sick 1985). On the one hand, the relevance of proximity, which finally allows for agglomeration effects, lies in the diffusion of innovations. For example, farmers already producing organically in a region offer to non-organic farmers the possibility to observe successful organic practices and feel reassured that organic systems are feasible in their locale (Lohr and Salomonsson 2000). Furthermore, Latacz-Lohmann et al. (2001) consider positive network-externalities important for the agglomeration of organic farms.

Methodology

Based on the literature, several hypotheses are developed to test the influence of the factors mentioned above on the spatial distribution of organic farming. The statistical methods used are: (a) spatial autoregressive models, (b) ordinary least squares regression model (OLS), (c) analysis of variance and (d) Spearman correlation analysis.

(a) To assess the influence of proximity (as a possible indication of agglomeration effects), two different autoregressive models are used: the First-Order Autoregressive Model (FAR) and the Mixed Autoregressive Model (SAR) (Le Sage 1999). The FAR-Model attempts to explain the variation in the share of organically managed land as a linear combination of the corresponding shares of the neighbouring regions without any other explanatory variables. As a result, the estimated parameter indicates the extent to which proximate regions are influenced by each other. The FAR-Model has the form $y = \rho Cy + \varepsilon$. The vector y is a logarithm of the deviations from the mean of the dependent variable (share of organically managed land in %). C is a spatial weight matrix, ρ is the scalar spatial lag coefficient that accounts for the impact of the share of organically managed land (%) in neighbouring regions, and ε is the vector of normally distributed error terms (Le Sage 1999).The second model, the SAR model, includes further explanatory variables in the model to examine the influence of location factors (like share of grassland, soil quality, etc.) on the spatial distribution of organic farming. It has the form: $y = \rho Cy + X\beta + \varepsilon$, where, now, y is a vector of the logarithm of the share of organically managed land, x is a design matrix accounting for further independent variables, and β is the parameter vector of independent variables to be estimated (Le Sage 1999). The results are an estimated parameter ρ for the influence of proximate regions, as well as estimated parameters for the other independent variables tested. The estimated parameters have to be interpreted similar to those of OLS-Models.

(c) For the influence of the spatial proximity to processors of organic food, the analysis of variance is used. Therefore, around the location of organic processors (mills and dairies) a determined circumference of 20 km (dairies) and 40 km (mills) has been drawn. Every region that lies within this circle,is considered as 'close' to a mill or dairy. All other regions are considered as 'distant'.

(d) The Spearman correlation is used to analyse possible determinants of the spatial distribution of organic farming that cannot be tested by OLS or the autoregressive models. This is the case for, e.g. the influence of different farm types (multicollinearity with other factors), and for land use of agricultural area, e.g. share of cereals or pulses (normal distribution of variables could not be obtained, even after different transformations).

For the statistical analysis, agricultural and economic data obtained from the agricultural farm census in Germany in 1999 (e.g. Statistische Ämter des Bundes und der Länder 2001) and other sources on NUTS1 3 level are used.

Results and brief discussion

In the following, only the most significant determinants of the spatial distribution of organic farming are discussed. Parts of the results of the analysis, using methods (a) and (b), are presented in Table 1.

Table 1: Results of ordinary least square regression and of the spatial autoregressive models

	Germany		
Determinants	OLS	SAR	FAR
Natural factors			
Soil quality (Bodenklimazahl)	-0.03***	-0.015***	
Farm-structure factors			
Share of grassland (in %)	n.s.	n.s.	
Farm size (ha)	0.001 n.s.	n.s.	
Socio-economic factors			
Income (1000€ per head and year)	n.s.	n.s.	
Population density (per km^2)	n.s.	n.s.	
Spatial dependence (indicator ρ)		0.51***	0.63***
Political factors			
Support levels for organic and conventional agriculture			
Comparison of theoretical payment level (in €)	-0.009***	-0.005***	
Differences of payment levels arable land (€/ha)	n.s.	n.s.	
Differences of payment levels grassland (€/ha)	0.008***	0.004***	
Nature conservation area (in %)	0.07***	0.04**	
Water protection area (in %)	0.01***	0.009*	
adj. R^2	0.23	0.26	0.37

level of significance 10%, ** level of significance 5%, *** level of significance 1%, n.s. not significant.
Used Software: MATLAB from The MathWorks; Syntax for calculation of the spatial autoregressive models from Le Sage (1999). Source: Bichler & Häring (2004)

The relationship between the *natural factor* 'soil quality' and the share of organically managed land is significantly negative.

An example for the influence of *farm-structure factors* is the positive relationship between 'farm size' and the share of organically managed land within a region. According to the statistical models used here, the share of grassland has no significant influence on the spatial distribution of organic farming.

The *socio-economic factor* 'spatial dependence' seems to have a relevant influence on the spatial distribution of organic farming (SAR ρ = 0.51***, FAR ρ = 0.63***). In the latter case, the coefficient ρ, as an indicator for the existence of agglomeration effects between regions, has to be interpreted in the

[1] Nomenclature of Territorial Units for Statistics (in the European Union)

following way: if the geometrical mean of the share of organically managed land in the neighbouring distincts increases by 1% the share of organically managed land within the considered region will rise at 0.63%.

Comparing the regression coefficient ρ in FAR with the corresponding coefficient in SAR, it emerges that ρ is smaller in the SAR model. This can be traced back to the fact that in the SAR model several other factors are considered. In conclusion, neighbouring regions have a strong influence on each other regarding the share of organically managed land.

The other *socio-economic factors* ‘population density’ and ‘income per head’ are not significant. Within the category *political factors*, the different indicators for the ‘level of support’ for organic farming are tested. The positive influence of the support level for organically managed grassland on the share of organically managed land area has to be mentioned. Also tested within this category is the relation between protected areas and the share of organically managed land. This relation is also positive.

The coefficient of determination (R^2) for the FAR Model is 0.37, for SAR 0.26 and for OLS 0.23. This shows that part of the spatial distribution of organically managed land can be explained by the used independent variables.

Due to methodological constraints, e.g. precondition of normal distribution, several factors could not be tested with the multivariate models. In these cases, the methods (c) and (d) are used. (c) The factor ‘proximity to organic processors’, e.g. organic dairies, has been tested with analysis of variance. As a result, the ‘proximity of dairies’ has a positive influence on the share of organically managed land. On the contrary, this cannot be confirmed for organic mills. (d) The influence of the factor ‘farm type’ and ‘agricultural land use’ is tested with the Spearman correlation. Regarding farm types, the strongest positive influences on the share of organic farming are the share of commercial farms (0.14**) and the share of permanent crop farms (0.22***) within a region. For the share of agricultural land use, the positive influence of the share of set-aside area (0.24***) on the spatial distribution of organic farming has to be mentioned.

Conclusions

The aim of this analysis is to investigate the influence of several factors on the spatial distribution of organic farming. The most important result is the highly significant influence of spatial dependence on the distribution of organically managed land, suggesting the existence of relevant agglomeration effects. Thus, if organic farming shall be supported politically, the results of this analysis can give an indication for accounting agricultural subsidies. Supporting of networking, information transformation and communication among the actors are promising means to increase the share of organic farming.

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TOTAL CONVERSION TO ORGANIC FARMING OF A GRASSLAND AND A CROPPING REGION IN AUSTRIA– ECONOMIC, ENVIRONMENTAL AND SOCIOLOGICAL ASPECTS

(1) Bernhard Freyer (2) Ika Darnhofer, (3) Michael Eder, (4) Thomas Lindenthal (5) Andreas Muhar

(1, 4) Department of Sustainable Agriculture Bernhard.Freyer@boku.ac.at, Thomas.Lindenthal@boku.ac.at
(2, 3) Department of Economics and Social Sciences, Ika.Darnhofer@boku.ac.at, Michael.Eder@boku.ac.at
(5) Department of Landscape, Special and Infrastructure Sciences, Andreas.Muhar@boku.ac.at
University of Natural Resources and Applied Life Sciences, Gregor-Mendelstr. 33, 1180, Vienna, Austria
++43 1 47654 3751, www.boku.ac.at

Key Words: Organic Farming, farm economy, nutrient balances, landscape, attitudes

Abstract

The implications of a full conversion to organic farming were analysed for two Austrian regions (a grassland area: Liezen, and a cropping area: the Weinviertel). The results show few differences between organic and conventional farms in the grassland region. In the arable region a full conversion to organic farming shows marked benefits not only for the environment but also from an economic point of view. Different preconditions in scenarios underline that the prognosis for r future income is uncertain. In both regions, the majority of farmers emphasise different reasons that they did not see organic farming as a realistic alternative to their current production system.

Introduction

The share of organic farming in Austria is about 10% of the total agricultural area. More than 80% of the organic farms are situated in mountain areas. Most products can be marketed well; only for dairy products and meat is supply higher than demand. Against this background, in a two-year project we investigated various ecological, economic and social aspects of different scenarios for a total conversion to organic farming in both a dairy and a cropping region and formulated recommendations for measures to increase the share of organic farming.

Methodology

Two study regions were selected to include both an area with an already high share of organic farms in a grassland-based dairying area: Liezen in the Province of Styria (where 30% of farms are organic) and an arable crop production area: the Weinviertel in Lower Austria, where 1% of farms are organic. For the economic analysis, characteristic farm types for each region were identified using a cluster analysis of farm data from the EU's Integrated Administration and Control System (IACS). In the grassland region seven farm types were identified, differing in production intensity and kind of livestock (dairy cows and/or suckler cows). In the arable region, 11 farm types were identified, which differ in arable land area, existence of vineyards, and type of animal husbandry. With the help of linear optimisation, economic models were calculated for each farm type. The policy and direct payment schemes assumed were those in effect in 2000. The reference scenario is the current situation.

Two scenarios were modelled, one assuming all organic products could be sold with organic premiums at the level of the year 2000, the other assuming organic products could be sold only at conventional prices. In the arable region, a third scenario was modelled that assumes organic premiums and additional compulsory nature protection and biodiversity enhancing measures (e.g. 5% share of grassland or the planting of hedgerows). The investments required for converting are accounted for in the grassland-based cattle farms, since these must adapt their animal housing to comply with organic regulations. The additional fixed costs (e.g. for capital, maintenance, insurance) for the necessary investments are calculated using annual total fixed costs. In a cropping region, assuming that farmers produce mainly standard crops, no additional machinery is required, as the comb harrow needed for mechanical weed control is available on most farms. Investments may be necessary on farms which that new crops or speciality crops (e.g. herbs) or that start on-farm processing. Since these two options were not included in the models, no costs for investments are taken into account in the cropping region. The ecological effects were investigated at the farm level using nutrient balances and on the regional level using existing landscape and vegetation data. The sociological investigation of attitudes regarding conversion to organic farming was based on qualitative in-depth interviews with farmers (groups and individuals), students and teachers from agricultural schools, as well as with other key actors from the agricultural and food sector. Quantitative information was derived from a mail survey of 700 farmers.

Results and brief discussion

Farm economy

In Liezen, the grassland region, the whole farm gross margin (taking into account additional capital costs for investments) after conversion would be higher for all farm types. The highest increase (25%) was calculated for suckler cow farms. For all other types the increase would be between 0% and 6%. Assuming conventional prices for selling organic products and organic prices for concentrates, the whole farm gross margin would decrease sharply, in particular for the intensive dairy farms (-14%). Due to the low use of concentrates, the whole farm gross margin of the suckler cow farms would still be higher by 5 to 10%. These results are comparable with those of a study by Kratochvil et al. (2003).

In the arable crop area the model results show that given the current prices for organic products and despite the lower yields (-26% for grain, -40% for maize), the value of production would increase, as would the whole farm gross margin (see Tab. 1). A shift among cultivated crops could be expected, with a decrease of grain (-33%), vegetable, and potato production and an increase of (fodder) legumes. Without price premiums for organic products, several farm types would face lower whole farm gross margins than under conventional production practices, despite direct payments for organic farming (see Tab. 1). Additional environmental protection measures that are included in the third scenario would result in lower whole farm gross margins even if the price premiums for organic products can be maintained (see Darnhofer et al. 2003).

Tab. 1: Changes in farm gross margin relative to the conventional scenario for the modelled farm types in the Weinviertel (arable crop area)

Farm type[1]	Arable farms				Arable farms with vineyards					Vine-yards	Pig fattening
Cropland/ wine (ha)	40* / 0	39* / 0	30 / 0	17 / 0	41* / 2	41* / 3	31 / 5	19 / 4	18 / 6	0 / 2	46 / 0
Organic premiums	+50%	+42%	+89%	+86%	+71%	+61%	+104%	+95%	+109%	+116%	+56%
Conven-tional prices	-26%	+8%	+20%	+16%	-22%	-9%	+ 7%	+1%	+1%	-32%	-5%
Organic premiums + additional measures	+33%	+21%	+62%	+58%	+51%	+39%	+79%	+72%	+86%	+89%	+39%

[1] The farm types not only differ in land area, but also in types of crops planted; farms marked with an * plant sugar beet

Aggregation at the regional level

The farm-level results were aggregated to analyse the effects at the regional level. In the Liezen region, assuming the milk quota remains at the current level, the number of cows would increase by 13% due to the calf feeding requirements and the lower milk yields per cow. Assuming the factor endowment (grassland area, animal housing) remains the same, the number of heifers would be reduced to 36% of the reference (conventional farms). The ox-fattening enterprises, which is present at a low scale in Liezen, remains unchanged. More cull cows (+13%), male calves (+13%) and female calves (+186%) are sold. To compensate, an additional 1500 heifers would have to be purchased as replacement. The use of concentrates would be reduced by 15%, and the cost of concentrate would be higher by 57%. The purchase of straw would increase by 15%. The number of large animal units would be reduced by 6%. The whole farm gross margin of all farms that formerly were conventional would increase by 10%. Two-thirds of this increase is due to higher direct payments, the remainder is due to increased prices for organic products. The total additional annual costs for investments in animal housing are approx. 1.29 million €.

For the Weinviertel region, assuming organic price premiums can be achieved, a reduction of 4% in small-grain production could be observed. However, there is a differentiation: the production of winter grains would increase from 36% to 49% of the arable area, and summer grains decrease from 27% to 9% of the arable area. The area occupied by root crops would decrease from 8.7% to 2.4%, which is mainly due to a reduced area of sugar beet. The share of the area planted with legumes would increase from 6% to 30%. With regard to the amounts produced, small grains would decrease by 33%, field vegetables by 39% and potatoes by 40% compared to the conventional reference scenario. The largest increase in production would occur with peas (+237%) and oil pumpkin (+139%). On the monetary side, the total value of the agricultural production in the region would increase by 32%, assuming organic price premiums. Assuming the price premiums can be sustained even after the widespread conversion to organic farming, the increase in total gross margin of the region, from 110.78 million € to 179.60 million € (+62%), is higher than the increase in direct payments (from 68.54 million € to 95.39 million € or +39%). These figures are based on the farms included in the model, which represent approximately 78% of the agricultural area of the Weinviertel.

Effects on the landscape level

In the grassland region Liezen, only a few changes can be expected, as the current level of intensity is relatively low: the share of organic farming is already at 30%, with an additional 30% of farms enrolled in an agri-environmental program supporting the exclusion of mineral fertilisers and pesticides. This means that in most of the region the cattle density even in conventional farms is already at a level where conversion to organic farming would not cause significant additional extensification effects (see also Schiller 2000). Such effects would probably only occur locally in some areas at the valley bottom, where a decrease of the nutrient level could lead to higher biodiversity of the meadow fauna. Due to the specific regulations of the Austrian funding scheme for organic farming, it can be expected that the use of alpine summer pastures will become more attractive for the farmers, thus contributing to the preservation of a traditional element of the alpine cultural landscape. In the cropping region, a total conversion would lead to higher biodiversity both in fauna and flora, due to higher diversity of crops and lower impacts on neighbouring biotope structures. Results from the economic models show that root crops would be reduced. On the other hand, legumes will increase to 30% of the cropping area. The number of grain species also increases. Furthermore, the rotation schemes would include more winter grain and cover crops. All these factors will particularly favour beneficial organisms such as predatory arthropods. The dramatic reduction of pesticide input will, of course, significantly improve the general biodiversity of fauna and flora both within and outside the production areas (Weiger & Willer 1997). The EU regulations for organic farming do not include any standards concerning a minimum percentage of non-production areas such as hedgerows or other biotopes of agri-ecological relevance. Therefore, the conversion of an intensively managed and highly mechanised cropping region to organic farming will not necessarily lead to a significant change of the size and structure of accompanying biotopes.

Nutrient balances

In the cropping region Weinviertel including the vineyard farms (average of 9 conventional and 7 organic model farms) the average of organic farms is -23,6 kg N ha^{-1} yr^{-1} lower than in conventional farms. The average of the organic arable farms without vineyard farms is +5,9 (organic) and +29,2 kg N ha^{-1} yr^{-1} (conventional). In the grassland region Liezen the reduction is -5,0 kg N ha^{-1} yr^{-1} (organic: +12 kg; conventional: +17 kg N ha^{-1} yr^{-1}; average of 6 conventional and 6 organic model farms). The dairy farms vary between +40,4 (conventional) and +26,6 kg N ha^{-1} yr^{-1} (organic). In the cropping region, the balances of the organic cropping farms range between +5,9 kg and +12,3 kg N ha^{-1} yr^{-1}. The phosphorus and potassium balances in organic cropping farms are negative (-0,2 to - 8,3 kg P ha^{-1} a^{-1}; -1,0 to -22,9 kg K ha^{-1} yr^{-1}), whereas the conventional farm balances vary between -11,7 and +10,1 kg P ha^{-1} yr^{-1} and -18,3 and +51,2 kg K ha^{-1} yr^{-1}. In the grassland region the differences of phosphorus and potassium balances are low (average of all farms: conventional: +1,8 kg P and +6,2 kg K ha^{-1} yr^{-1}; organic: -0,2 kg P and +3,3 kg K ha^{-1} yr^{-1}).

Conventional farmers' attitudes concerning organic farming

In both regions, the majority of the interviewed conventional farmers did not see organic farming as a realistic alternative to their current production system. Farmers feared higher economic risks and a higher dependency on direct payments. They rejected the intensive monitoring and reporting schemes established in organic farming, and also the special requirements (e.g. for hygiene) in direct marketing. In the grassland area, a very important obstacle is the animal housing requirements, which for many farms would require significant investments. In the cropping region, sugar beet has been identified as a critical issue. It is the crop with the highest gross margin in the area, and farmers are unwilling to give it up after conversion, which they may have to, since there are no specific processing and marketing opportunities for organic sugar beets. Most of the students and teachers in agricultural schools know about organic farming, but that knowledge is mostly restricted to the organic regulations, with little concern for ecological interrelationships. In both regions there is a lack of possibilities for training and support in organic farming, as has been pointed out by the conventional farmers themselves. Also, both farmers and teachers doubt consumers' willingness to pay more for organic products and point out the studies showing the discrepancy between consumers' professed interest in organic products and their actual purchasing behaviour.

The written surveys of farmers show that in the grassland region about 12% of respondents are considering a conversion to organic farming. Among the most important barriers to conversion are the perception that the required investments in animal housing are too high, the perception that the direct payments and organic premiums do not cover the additional costs, and the assessment of the current premium for organic milk as too low. In the arable region 5% of farmers are considering an eventual conversion to organic farming. The three most important barriers to conversion are: fear of weeds and pests, too much additional labour, and the fear that the income will be even more dependent on direct payments (Schneeberger et al. 2002).

Conclusions

Under the assumption that organic products can be sold at a premium, a conversion to organic farming would be economically beneficial for all farm types. However the changes modelled assumed only a regional conversion. Should the conversion be widespread at a national level, further changes would have to be considered in the models, e.g. a potential decrease of product prices due to an increased supply, or changes in the prices of inputs. As the limited effect of a drop in prices for organic inputs and products to conventional prices show, the economical attractiveness of organic farming is partly dependent on the Austrian scheme of direct farm payments,. With a higher proportion of organic farms, the total volume of direct payments would also increase, therefore a change of the funding scheme would have to be expected. Although the calculations were done before the Mid-Term review of the Common Agricultural Policy (CAP) in 2003, studies have shown that organic farming remains attractive under the new CAP regimen (Schmid and Sinabell 2005). A total conversion to organic farming would require significant changes in the entire product chain from production through processing and marketing to the food consumption patterns of consumers. Although conventional farmers indicate a fear of increased labour requirement as a major impediment to conversion, research results on labour requirements do not support this perception. Given the limited availability of farm labour and the prevailing reluctance to use non-family wage labour, most organic farms adjust their production programme rather than increase their labour input. This (and other misconceptions) show that a key to increasing the share of organic farming is information. Organic farming must not only be promoted through economic arguments, but also presented in an integrative way, emphasizing its social, organisational and educational aspects.

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ORGANIC LAND USE PATTERNS IN THE EU: A SPATIAL AND DYNAMIC ANALYSIS

Danilo Gambelli (1), Maria Elena Paladini (1), Susanna Vitulano (1), Raffaele Zanoli (1)

(1) Università Politecnica Delle Marche, 60100, Ancona, Italy, +39 071 2204629 danilo@agrecon.univpm.it

Keywords: organic agricultural area growth, specialisation index, shift-share, barycentre analysis

Abstract

The aim of this paper is to measure changes in organic farming growth based on a comparison of organic land use in the 1998-2003 period, aiming to individuate the role of countries' structural factors and policies for organic farming.

The main goal is to understand how the adoption of organic farming has evolved in the EU territory, using three main approaches:

- analysis of the peculiar characteristics of the EU countries in terms of organic production specialisation
- shift-share analysis for decomposing the organic UAA growth rates into basic factors;
- analysis of time evolution of organic crops localisation through the individuation of barycentre variation of the organic production;

Introduction

Organic farming is supposed to be based on a different land use approach due to its specific technology based on rotations and specific crops and livestock activity for maintaining land fertility without the use of external inputs. Technical and agronomical requirements are not the only factors affecting land use in organic farming, and the specific support policies play an important role with respect to development. Therefore, the analysis focuses on the organic land use in EU 15+CH, aiming to catch effects on organic land use due to general trends, country specific factors and possible influences coming from the change of organic farming policies from 1998 to 2003.

Data come basically from official government sources, but show very often a different structure across countries. Therefore a great effort was necessary to homogenise data in terms of aggregation of crops, and territorial breakdown (NUTS). In particular, NUTS 2 data disaggregation is available only for some countries, (AT, CH, DE, ES, FR, IT) with the required crop structure.

Methodology

Modification of organic production attitude across EU countries is analysed basically through the following approaches:

- use of barycentre analysis for mapping geographical localisation of main crop production
- computation of a set of specialisation indexes for the main crop production at national level
- application of shift-share analysis for the evaluation of the main determinants of countries organic land growth

The methods have been chosen trying to reach a compromise between the necessity of keeping a robust approach, and that of extracting a picture of the situation of organic land use in EU from different perspectives.

Geographical representation of the barycentres of the main organic crop productions is performed based on the spatial mean, or barycentre (Unwin 1981). For this analysis NUTS 2 data have been used in order to increase computation accuracy. The spatial mean of a region is defined by an average latitude and an average longitude. The EU average spatial mean for each crop area is obtained as a weighted average of the regions spatial means, where the weights are the share of crop areas in each region (Bartola et al. 1989).

Specialisation indexes (SI) investigate if nations across EU show specialisation (SI >0) or "de-specialisation" (SI <0) in crop production. The SI approach has also been used to analyse the EU country specialisation in organic land use through time: the analysis is performed for three reference years (1998, 2001, 2003).

The investigation of land growth determinants is made using Shift-Share analysis (Dunn 1960). Following Randall (1973) standard Shift-Share analysis can be modified focussing on the decomposition into a Structural Component (SC), and a National Component (NC) of the Net Relative Change (NRC) of each country organic UAA growth with respect to EU average. SC represents the effect on NRC due to the land use structure of each country, and reflects the degree to which the local area specializes in industries that are fast or slow growing nationally; NC indicates growth or decline in land use due to the local area's competitive position in a given crop production, and can be interpreted as the part of NRC that can be attributed to specific national factors, like policy effects, but also soil and climate factors, specific national economic endowment, etc (Dinc 2002). Shift-share analysis has been often criticised (Holden et al. 1989). Nevertheless, if it is used as an accounting procedure, it can avoid the theoretical hypothesis required for more inferential purposes, and provide a strong base for interpretation of dynamic evolution of economic phenomena through time.

Results

Barycentre analysis results are presented with a map showing the shifts of barycentres localisation for each of the main crop types taken into consideration, referring to the following years: 1998, 2001, 2003 (see Figure 1). Please note that due to lack of data for 1998 UK and IR are not included in the analysis. Two main groups of crops can be individuated: the "northern" crops are composed by cereals, grassland and fresh vegetables, whose barycentre is mainly located in the centre of EU; the southern crops are basically permanent crops, with baricentres located around the Mediterranean Sea. The temporal shifts of barycentres are generally quite small, with the exceptions of fresh vegetables, and fruit and berry plantations showing the same strong shift towards: east. In both cases this is due to a strong increase of UAA for such crop in IT, stronger in 2001 for vegetables, and in 2003 for fruit crops.

Figure 1: Barycentres of organic UAA per crop type and year in EU (UK, IR excluded, CH included)

Legend

○ Cereals 1998	● Cereals 2001	**● Cereals 2003**
◇ Fresh Vegetables 1998	◆ Fresh Vegetables 2001	**◆ Fresh Vegetables 2003**
□ Grassland 1998	■ Grassland 2001	**■ Grassland 2003**
△ Fruit Plantations 1998	▲ Fruit Plantations 2001	**▲ Fruit Plantations 2003**

Specialisation Index analysis shows results concerning:

- Table 1: National SI for 2003, showing the crop type for which each country is more or less "specialised";
- Figure 2: Time variation (1998-2003) of SI for the overall EU + CH organic UAA showing time evolution of countries specialisation in organic production;

Table 1 reflects quite a high differentiation, with the exception of Mediterranean countries that show a common specialisation in fruit and berry production, PT, ES and GR underlining the important role of olive production, and central Europe countries with a strong specialisation in grassland production.

Figure 2 shows on the positive (negative) axe the countries where the share of organic UAA is higher (lower) than EU average; Scandinavian and Alpine countries, plus IT and UK have the higher SI, but all these countries, with the exception of UK tend to reduce their specialisation through time.

Table 1: SI for EU countries by crop, 2003. NB SI ranges between -1 and 1

	Cereals	Fresh vegetables	Other arable land crops	Grassland	Fruit & berry plantations	Vineyards	Olives and other permanent crops
AT	-0.04	-0.62	0.36	0.04	-0.73	-0.54	-1.00
BE	0.00	0.62	0.39	-0.21	0.35	-1.00	-1.00
CH	-0.70	-0.04	-0.67	0.76	-0.75	-0.73	-0.94
DE	0.22	0.01	0.24	-0.10	-0.61	-0.68	-0.95
DK	0.26	-0.35	0.56	-0.34	-0.91	-1.00	-0.96
ES	-0.03	-0.27	0.13	-0.37	0.45	0.32	0.60
FI	0.46	-0.51	0.37	-0.38	-0.74	-1.00	-1.00
FR	-0.10	0.09	-0.16	0.21	-0.28	0.35	-1.00
GR	-0.11	0.07	0.37	-0.97	0.54	0.69	0.88
IE	-0.78	-0.16	-1.00	0.89	-1.00	-1.00	-1.00
IT	0.05	-0.03	-0.48	-0.09	0.39	0.34	0.31
NL	-0.34	0.86	0.04	0.07	-0.38	-1.00	-1.00
PT	0.14	-1.00	-0.94	-0.15	0.03	-0.36	0.64
SE	0.26	-0.73	0.22	-0.08	-0.96	-1.00	-1.00

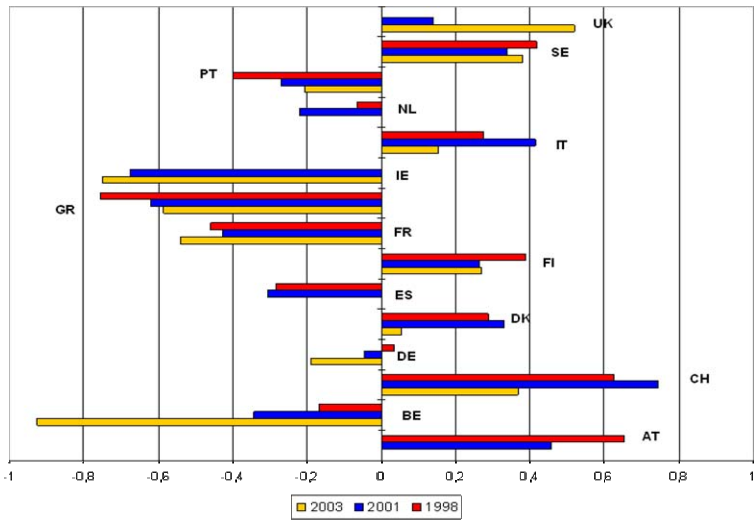

Figure 2: SI of the organic UAA in the EU countries: a time comparison

Shift-share analysis provides

- Table 2: split of Net Relative Change into SC and NC for the period 1998-2003, (for UK, Ireland and Luxembourg, data where not available for the entire period considered). NRC is the % differential with respect to EU+CH organic UAA growth rate, and SC and NC are components of NRC; Table 3: time evolution of country classification by SC and NC.

Table 2. Results of S&S analysis on national organic farming (1998-2003)

	NRC	SC	NC
Austria	-0.680	0.075	-0.756
Belgium	-1.707	-0.075	-1.631
Denmark	-0.198	0.053	-0.251
Finland	-0.181	0.215	-0.396
France	0.502	0.055	0.447
Germany	0.004	0.031	-0.036
Greece	2.339	-0.030	2.368
Italy	0.100	-0.068	0.168
Netherlands	-0.762	0.000	-0.762
Portugal	2.213	-0.152	2.365
Spain	0.270	-0.098	0.368
Sweden	-0.103	0.035	-0.138
Switzerland	-0.352	-0.072	-0.280

Table 3. Countries classification by SC and NC - 1998-2001 and 2001-2003

	NC>0	NC<0	NC>0	NC<0
SC>0	France	Austria	Austria	Denmark
	Greece	Finland	Finland	Netherlands
	Portugal		France	
	Spain		Germany	
			Sweden	
SC<0	Denmark	Belgium	Greece	Belgium
	Italy	Germany	Portugal	Ireland*
	Luxembourg	Netherlands	Spain	Italy
		Sweden	Switzerland	United Kingdom*
		Switzerland		

*2001-2003 only

The NRC in Table 2 indicates that Portugal and Greece have the stronger positive growth differential with respect to EU average, while Belgium and Austria the most negative ones. In general, the NC accounts for the higher share of the NRC, while the SC has a relatively higher importance in Finland and Portugal. Such results offer evidence of the strong importance of national factors in the explanation of the organic UAA growth, hence supporting the hypothesis for the crucial role of policies for organic farming. Also worth to mention is that all the Mediterranean countries show for the 1998-2003 period positive NC, hence suggesting the hypothesis of a particular importance of policies for organic farming in these countries. The time split of Shift and Share results classification in Table 3 shows considerable changes of country classification. Mediterranean countries remain with positive NC, with the exception of IT in the second subperiod (this change actually reflects the funds reduction for organic policies in IT). France is the only country with positive SC and NC in both the subperiods.

Conclusions

The paper provides an overall description of the main evolution of organic farming land use pattern between 1998-2003, offering for the first time an analysis of this issue at the EU level. The joint use of different methodologies allows to investigate the dynamics of organic UAA growth in EU from different perspectives. The basic results seem to show the relative competitiveness of Mediterranean countries in organic land growth, particularly due to the strong importance of Mediterranean organic crops.

The crop mix does not show a particular influence on the organic land growth, being dominated by the weight of country specific factors; the hypothesis of an active role of policies for organic farming can therefore not be rejected, even if further investigation are necessary in order to better understand the possible influence of other country specific factors in organic UAA growth.

As a very final remark, it is to mention that data quality is often an issue and data collection for organic farming is worth more attention from the competent statistical bodies.

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LOCALISATION AND RECYCLING IN RURAL FOOD SYSTEMS – IMPACT AND SOLUTIONS

Helena Kahiluoto, Artur Granstedt (2), Stefan Bäckman (3), Holger Fischer (4), Annamari Hannula (1), Salla Kakriainen (3), Veronica Krumalova (3), Markus Larsson (5), Tiina Lehto (6), Marko Nousiainen (3), Päivi Pylkkänen (3), Thomas Schneider (7), Laura Seppänen (3), Pentti Seuri (1), John Sumelius (3), Olof Thomsson (2), Kari Vesala (3), Antto Vihma (3)

(1) MTT Agrifood Research Finland, Ecological Production, Partala, Huttulantie 1, 51900 Juva, Finland, +358-40-5118335, helena.kahiluoto@mtt.fi, http://www.mtt.fi
(2) Swedish University of Agricultural Sciences, Sweden; The Biodynamic Research Institute, Sweden
(3) The University of Helsinki, Finland
(4) Leibniz-Centre for Agricultural Landscape and Landuse Research (ZALF), Germany
(5) Mälardalen University, Sweden
(6) South Savo Regional Environment Centre, Finland
(7) Department of Physical Geography and Quaternary Geology, Stockholm University, Sweden

Key Words: food system, sustainability, localization, recycling, multidisciplinarity

Abstract

The aim of the study was to assess the impact of an increased share of local organic food based on local resources, especially on increased recycling (i.e. the impact of increased locality or localization), on sustainability of rural food systems around the Baltic Sea. Obstacles and solutions for sustainable localization and recycling were also identified. In addition to these main objectives, a methodological interest in developing interdisciplinary research processes was also incorporated. Case food systems in eight Baltic countries were studied on the basis of interviews and stakeholder workshops, as well as by analysis of environmental indicators and economic parameters at farm and food system level by a European multidisciplinary research group. According to the results, marked benefits on environment, local economy and social sustainability can be obtained through enhanced recycling and an increased share of local organic food in the rural food systems. These benefits require, however, well-informed choices for performing localization and recycling in a sustainable manner. Recycling, especially in agriculture, but also at the food system level, ensures environmental benefits while locality relieves that and is crucial for the benefits in local economy and social sustainability. The scale of sustainable localization varies, however, according to the product and process concerned. In some cases, recycling between the farms seems to require smaller economic compensation than recycling within the farms. To realize the potential of localization and recycling, marked obstacles have to be overcome by providing economic incentives for recycling to farmers, a local certificate and information to consumers and intensified cooperation between the local stakeholders.

Introduction

Food systems have developed towards global, linear and centralized systems with regional specialization. This development contributes to a transfer of value added from rural regions to urban areas followed by unemployment, emigration and disintegration of social structures. This also complicates recycling organic matter thus increasing nutrient emissions to waters, including the Baltic Sea, which is rapidly becoming devastated. Agriculture, which contributes half of the eutrophicating emission, has most potential for reduction, while the load from point sources has already been reduced to 10 to 20% of the total load (HELCOM 2003). In addition to the decrease in nutrient leaching, enhanced recycling in agriculture results in lower emissions of greenhouse gases (Larsson 2005). Now that eight out of nine countries around the Baltic Sea are members of the European Union, co-ordinated, cost-efficient approaches are facilitated. On the other hand, if the production regimes of the new member states would be adapted to the industrialised agriculture of Denmark, the eutrophicating nitrogen (N) emissions would increase by 50-75% (BERNET 2000).

Even in organic agriculture, European regulations and subsidies have not motivated a development of local food systems, nor recycling of organic matter between plant and animal production or between consumption and production. Instead, less local and less recycling organic production has emerged. On the other hand, the principles and goals of organic farming require reliance on local resources and recycling, adaptation to local conditions and connecting farmers and consumers. There is also a rapidly growing interest and activity around food produced locally, based on local resources, and produced in an environmentally friendly, recycling manner. The growing interest in local food is not only based on appreciation of fresh food of known origin, but also on the hypotheses that more local food systems would be more sustainable in terms of improved recycling, decrease in energy consumption and related emissions and more vital and resilient local economy and community. This work attempted to test these hypotheses. Based on the results, solutions for sustainable localization and recycling were sought and disseminated together with the stakeholders.

In this paper, the synthesis of the work is presented by formulating common answers to the main research questions of the study, in an interaction between the different disciplines. The research questions were the following: What would be the impact of localization (i.e. the impact of an increased share of local organic food based on local resources, especially on increased recycling) on rural food systems? What are the main obstacles for sustainable localization and increased recycling in these cases and what kind of alternative solutions can be identified? In addition to these main objectives of the study, there was also a methodological interest of developing interdisciplinary research processes.

Methodology

A case food system in all of the participating eight countries surrounding the Baltic Sea (Seppänen 2004) was investigated by a European multidisciplinary research group. The main focus was on one Swedish (Järna) and one Finnish (Juva) rural food system, where initiatives by stakeholders in organic, local food had emerged. The initiatives and interactions of the stakeholders were studied on the basis of interviews and workshops. The impact of an increased share of local, organic food and recycling of organic matter within the food system and agriculture was analyzed through material flows and nutrient balances in combination with direct nutrient load measurements. The nutrient loads of the organic, recycling farms were compared with statistics representative of the present dominating farming system on the basis of the primary nutrient balance, which indicates the ratio between harvested nutrients and input nutrients from outside the system to crop production (Seuri 2002, Granstedt *et al*. 2004).

The impact on the economy of case farms was investigated by linear programming (Bäckman & Krumalova 2005). Scenarios were created to assess the possible gains and income forgone by enhanced localization and recycling, and by the potential incentives. Sensitivities of activities at the farms to changes in prices and support were studied indirectly, e.g. on the basis of validity ranges. Numerous institutional and environmental constraints were analysed. The impact on the local economy was assessed using an input-output model developed in the project (RegAE-model) and the effects on social sustainability by interviews with stakeholders, focusing on equality and justice, influence potential and social capital (Larsson et al. 2005) as well as on the vitality of the community. The consumption habits based on food purchases, and constraints for use of local, organic food were also monitored in 9 households in Järna and 13-15 households in Juva. The disciplinary work was performed in an interaction with an interdisciplinary process, to create a synthesis for providing answers to the common research questions. The obstacles and alternative solutions were discussed with the stakeholders to formulate recommendations.

Results and brief discussion

Impact of localization and recycling

Case studies on ecological, recycling farms showed that with a high degree of recycling, integration of animal and plant production and compensation of the unavoidable N leaching by use of leguminous plants, it is possible to decrease the surplus of nutrients remarkably compared with a system that separates crop and animal production as in the current conventional agriculture in Sweden, Finland and Denmark. The primary nutrient balance, which indicates better environmental performance, was thus higher on mixed farms than on stockless farms due to a higher share of nutrients recycled from animal husbandry to crop production. The use of legumes as the N source compared with mineral fertilizers or purchased fodder was also a positive factor, as was a lower livestock density and thus better utilisation of nutrients in manure for crop production. The nutrient flow from consumption through the food system back to agriculture was scarce, with a high potential for enhancement. Localization of processing tends to increase energy consumption per product due to the smaller scale, but it enables use of local renewable energy. An increase in food demand directly hit the local/regional processing industry with all its multiplier effects, but the impact on agriculture and other industries was small, indicating an import of raw material and other inputs and limited local cooperation.

The meaning of locality to the stakeholders in relation to the geographical dimension varied from village or municipality to country level. Problems of equality, both in distribution of benefits and the means of control, have generally been linked to centralizing food systems. As a result, from the point of social sustainability, locality of the food system seems to have a greater impact than the mode of production. In Järna community with a more homogeneous value base, however, several stakeholders emphasised the personal importance of organic production and, for many producers, organic production was at least as important as the economic aspects. The producers involved in local organic production demonstrated high levels of social capital and trust in each other. According to the interviewed stakeholders, localization increases the possibility to influence the food system. In addition, the distribution of benefits was considered fairer in local food systems. This holds true especially for the position of farmers. In addition, locality appeared to strengthen the market for organic food thus enhancing recycling. The scale of sustainable localization seemed to depend on the product and the population density, and there is a requirement for export of food from rural areas to cities.

Obstacles and solutions

In agriculture, several points were identified which hinder nutrient load to the environment in manure handling and cultivation techniques. However, the highest potential for enhancing recycling and thus increasing locality of inputs and reducing nutrient load to the environment, appeared to lie in joining the nutrient cycles of animal husbandry and crop production either within a farm or between the farms, for utilization of the nutrients and carbon in manure and legumes efficiently. Currently, locality of fodder is not required in EU regulations on organic farming. Price premium based on locality or economic incentives based on the primary nutrient balance would internalize externalities thus motivating farmers to employ recycling. Utilization of the existing production capacity could also be enhanced by trade between farmers. On a regional and country scale, recycling within agriculture would require redistribution of animals. To reduce the nutrient load, recycling within agriculture appeared to be more important than from the demand chain, but recycling of phosphorus (P) to back to agriculture is especially important in order to prevent excessive soil depletion. Recycling at the food system level faces fewer obstacles in rural communities with no industry and close vicinity of fields than in cities. It can be enhanced by using separately collected bio waste in agriculture instead of green areas and roads partly outside the region, like at present in Juva. The slaughterhouse waste representing a marked share of P flow from the fields, but now used for fodder manufacturing outside the region, could alternatively be recycled. Even the sewage sludge could be returned to the fields as there is no polluting industry.

The monitored households revealed a much higher potential for an organic, local diet than the current average diet in the countries. The food consumption of the monitored, interested families represented 71% and 25% organic and 31% and 20% local food (by weight) in Järna and Juva, respectively, while the overall average share of organic food is 2% and 1% in monetary value in Sweden and Finland, respectively. The most important factor for the difference in the share of local organic food between Järna and Juva seems to be the difference in availability. The monitored families in Juva identified challenges to improve the availability and selection as well as information on the impacts of that choice. Underdevelopment of processing and marketing food locally were problems also experienced by other stakeholders. Increased local and regional processing also offers the most potential for improvement of the local economy of the food system. Diversification of the marketing routes could increase the availability and level of information by improving the direct contact between farmers and consumers. Improved cooperation between the farmers and contract-based planning with the institutional kitchens and local shop-keepers have potential to improve the availability of local organic food as well as the competitiveness of local food chains. A certificate is an aid to recognizing local food, but it should require locality at several stages of production. Differences between the families in the priority of local organic food was reflected in the fact that, even if price was mentioned as the first constraint for increased share, there was no correlation between the income of the family and the purchase of local organic food. In Juva the average expenditure on food was rather lower than the average in country, while the opposite was the case in Järna, demonstrating that the local organic diet is not necessarily more expensive.

Conclusions

Benefits for the environment, local economy and social sustainability are obtainable by increasing the share of local organic food and improving recycling in the rural food systems. Locality of consumption is more important for local economy and social sustainability than for the environment. Recycling within agriculture is the most crucial environmental factor. The benefits include reduced nutrient emissions, increased employment and public finance, and improved fairness, opportunity to influence and social capital. These benefits require, however, well-informed choices for introducing localization and recycling in a sustainable manner. In addition, marked obstacles have to be removed before this potential can be exploited. Well-allocated economic incentives or price premium for farmers, consumer information on the impact of localization and recycling and a local certificate, as well as increased local cooperation between the farms and between the different stakeholders in production, recycling and trade would be key factors for enhanced ecological, economic and social sustainability in Baltic rural food systems.

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THE DEVELOPMENT OF FARM SIZE ON DANISH ORGANIC FARMS - A COMMENT ON THE CONVENTIONALISATION DEBATE

Vibeke Langer, Pia Frederiksen and Jørgen Dejgaard Jensen

(1) Department of Agricultural Science, The Royal Veterinary and Agricultural University, Hojbakkegaards Alle, DK-2630 Taastrup, Denmark, +45 3528 2383, vl@kvl.dk

(2) Department of Policy Analysis, National Environmental Research Institute, P.O. Box 358, DK- 4000 Roskilde, Denmark, +45 4630 1207, pfr@dmu.dk

(3) Danish Research Institute of Food Economics, The Royal Veterinary and Agricultural University, Rolighedsvej 25, DK-1958 Frederiksberg C, Denmark, +45 3528 6800, jorgen@foi.dk

Key words: Organic farming, structural development, conversion, farm size

Abstract

Average farm size is reported to increase on Danish organic farms, giving rise to the question whether one of the perceived measures of 'conventionalisation', land concentration, is taking place. The increase may be due to size differences in the farms entering and leaving the organic sector or to size enlargement on existing organic farms. Size enlargement is examined in a cohort of 236 farms which converted to organic farming in 1997 and remained organic in 2004. In this group the largest 5% of farms covered 24% of the area in 1997, increasing to 27% in 2004. Changes in farm size on a total of 302 organic farms show that a majority of farms increased their size, with larger farms being more likely to enlarge than smaller. There are no indications that larger organic farms expand their area directly at the expense of smaller organic farms, however, a full evaluation requires that farms leaving the organic sector are also included.

Introduction

In the ongoing debate about 'conventionalisation' of organic farming (here understood as the risk of replicating the recent history of conventional farms in industrialized countries becoming larger, more specialised and more intensive), farm size is seen as an important parameter of this structural development. Rigby and Brown (2003) suggested a set of "widespread perceived characteristics of organic farming as opposed to conventional agriculture", including "small farms versus large farms, family farms versus agribusiness ownership, and mixed cropping versus monoculture", and studies of consumer perception of organic farmers and farms show that consumers of organic products largely associate organic and conventional farming with these traits (O'Doherty, 2004). However, both Guthman (2004) and Hall and Mogyorody (2001) stress the need to analyse these characteristics in the specific national or regional context. As an example, family farming in the traditional sense does not historically play a large role in Californian agriculture and is thus less meaningful as a measure of conventionalisation in this context (Guthman, 2004), whereas in Denmark corporate ownership of farms is an exception due to legislation.

The notion of "conventionalisation" as an undesired possible future process builds on assumptions about the present state of organic agriculture: namely, that organic farms have until now been smaller, less specialised and less intensive than conventional, and that this state may now be changing. The assumption that organic farms are smaller than conventional is probably true in some contexts, but in most European countries organic farms are similar or larger in average size than conventional (Anonymous, 1999). Another assumption made is that of mixed farming as a fundamental characteristic of organic farming, implying that organic farms are less specialized than conventional farms. Langer (2002) showed, looking at a cohort of 448 converting farms, that a conversion to organic farming does not lead to instant changes in specialisation on individual farms, as most of the farmers planned to maintain the same production and thus the same degree of specialisation as they have had as conventional farmers prior to conversion. However, in some contexts conventional farms which convert to organic farming may be less specialised already before conversion, and certainly some highly specialized farm types like pig production do not convert at all. The third assumption, that organic farms are less intensive than conventional, is probably true in many contexts, e.g. conventional Danish dairy farms which convert, are farms with a lower stocking intensity that average conventional dairy farms (Langer, 2002).

Increasing average farm size as seen in the organic farms in Denmark (from 22 ha in 1990 to 48 ha in 2003) (Plant Directorate, 2003) may result from one or more of the following developments: 1) growth of existing organic farms, more or less evenly distributed on farm sizes, 2) the exit of small organic farms with large farms staying in the organic sector and 3) new converters to organic farming being larger than existing organic farms. 1) focuses on what takes place 'internally' in the organic sector, whereas 2) and 3) concern the dynamics between the organic and conventional farming sector. Here we focus on development 1) and explore whether uneven growth takes place, e.g. large organic farms grow more than small which implies that an area concentration is taking place. When exploring whether such concentration takes place, overall statistics do not offer much information and there is a need for empirical data on the direction in which individual organic farms move, as pointed out by Hall and Mogyorody (2004). Their studies from Ontario showed that only on farms specialising in field crops, larger farms were more likely to have increased their area or to have plans for future expansion. Taken as a whole, Hall and Mogyorody concluded that in terms of farms size there was only limited support for the conventionalisation thesis.

In this paper we explore the development in farm size in a group of Danish organic farms during the last 5-7 years in order to investigate whether significant growth takes place on organic farms and whether 'concentration' of land, i.e. that the distribution of land becomes more skewed in favour of large farms, is happening.

Methodology

Development in farm size was investigated in two samples. First, changes in farm area was followed on a cohort consisting of all farms submitting applications for certification in 1997 for a seven year period starting at their conversion in 1997. For farms which could be found in both 1997 and 2004 (N=236), data on farm area in 1997 was combined with data from an electronic database of all organic farms certified in 2004 (Plant Directorate, 2004). Second, in order to include farms which were not selected according to conversion year, area changes were followed on 66 farms converted in or before 1999, distributed in four case areas representing different landscapes and distribution on farm types in Denmark. We used farmers' annual reports on land use and livestock from 1999, data from an interview survey of land use and production on 10% of all organic farms completed in 2001 (Frederiksen and Langer, 2004) as well as electronic databases for 2004 (Plant Directorate, 2004). Additionally, changes in herd size were followed on 20 dairy farms belonging to this group.

As the measure of farm size we used the area utilized for production, i.e. the sum of arable fields, permanent grassland and set-aside, regardless of whether the land was owned or rented. Land not used for agricultural purposes (e.g. roads, forest) was not included. Farms were classified according to size in three classes: "small" <20 ha, "medium" 20-50 ha, and "large" >50 ha. As a measure for changes in farm size we used the following classes: major growth (>100% increase), considerable growth (50-100% increase), minor growth (10-50%), no change (+10% to -10%), minor decrease (10-50% decrease), considerable decrease (>50%).

Results and brief discussion

From 1997 to 2004 farm size increased on average by 61% on the 236 farms converting in 1997. The total area covered by the farms and thus the average farm size increased by less, namely 43%, from 37,9 ha in 1997 to 54,3 in 2004, indicating that growth is not evenly distributed. In 1997 the largest farms, 5% of farms, covered 24% of the total area utilized by the farms, whereas the largest 20% of farms utilized 58% of the land. In 2004 this distribution had changed to 27% and 62% of land use respectively (Fig. 1), indicating that on these farms which were all converted to organic farming in 1997, an overall growth as well as some land concentration can be seen. In order to compare with all Danish farms, the same calculation was made on the sample with farms smaller than 5 ha excluded, as is done in the Danish National Statistics. This showed that compared with all Danish farms in 1998 the distribution of area on the organic farms converting in 1997 was similar: the largest 5% of farms covered 22% of the area in organic and 24% in conventional (Hansen, 2001). Similarly, in 2004 the largest 5% of organic farms covered 24%, compared with the largest 5% of all Danish farms covering 26% of the total area in 2003 (Agricultural Statistics, 2004), indicating that the rate of change for the organic sector is similar to that of the conventional.

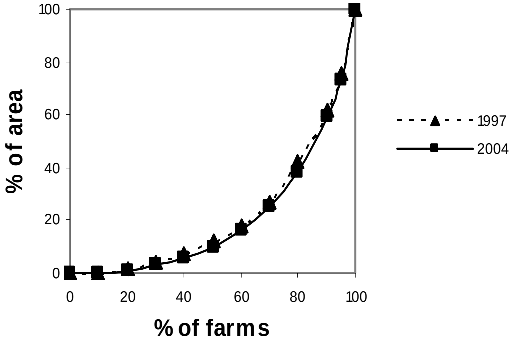

Figure 1. Degree of concentration of land on 236 organic farms in 1997 and 2004

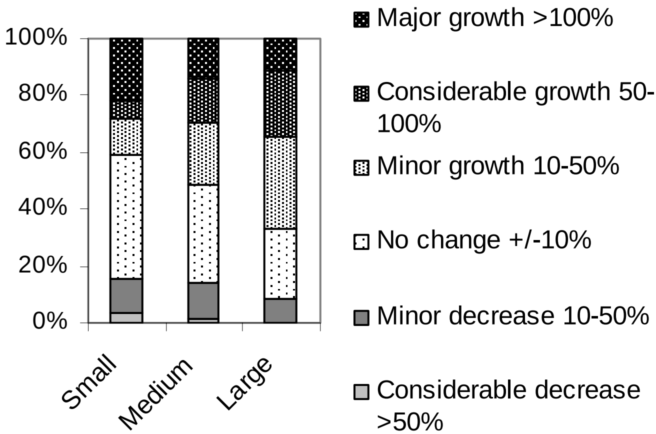

Figure 2. Proportion of farms increasing and decreasing in farm size among 236 organic farms from 1997 to 2004. Large farms (N=61) are more than 50 ha, medium farms (N=58) are 20 to 50 ha, small farms (N=116) are less than 20 ha.

Among the 1997-converters larger farms seemed to be more likely to grow in size than smaller farms. 67% of large farms had grown within the seven years since conversion compared with 52% of medium and 41% of small farms (Chi^2 =26.9, P=0.003). Farms remaining unchanged (i.e. farm area varies with less than 10% during the period) amounted to 44%, 34% and 25% of large, medium and small farms (Fig. 2).

Among the 66 farms in four case areas, converted in 1999 and before, the same trend of both a net increase in area of farms from 1999 to 2004, as well as larger farms being more likely to expand their area, were seen. In this group 62% of large farms had increased their area during the years 1999 to 2004 as compared with only 24% of small farms. However, for this group the differences were not significant. Large farms included in this analysis were mainly (80%) run by farmers who considered themselves full time farmers, whereas medium and small farms were mainly (75%) run by part-time and lifestyle farmers. Individual trajectories made for twenty organic dairy-farms in this sample suggest that dairy farms during the period have followed two strategies: one being medium or large farms following the traditional structural development of increasing herd size and area. The other being medium size farms consistently maintaining the same area around 50 ha and the same herd size of 40 to 55 dairy cows unchanged during the whole period, a farm and herd size similar to the average conventional dairy farm in 1995 (Agricultural Statistics, 2003).

Discussion and conclusion

The results presented here indicate that farm structure in the organic sector is highly dynamic. Organic farmers are subject to the same external factors, which erode incomes for conventional farmers, where mainly the already large farmers follow a strategy of size enlargement (Lobley and Potter, 2004). The organic dairy farms on which increases in farm area are closely linked to increases in livestock numbers, illustrate the size enlargement strategy for these farmers as a response to the decreasing prices of organic milk. In this light the overall enlargement seen here, with 50% of all farms included having increased their size and 36% remaining unchanged, is not surprising. The disproportionate expansion of the larger farms thus does not seem to affect enlargement on small and medium farms strongly. However it is important to stress that the data presented here do not encompass the interchange of farms between the organic and conventional sector, but only some ‘internal’ dynamics. As competition for land is often a limiting factor for size enlargement, looking at the organic sector as separate from the conventional does not offer a full picture. Neither are market effects of expansion of large farms, e.g. smaller farms leaving the organic sector because of market competition, revealed here.

The future debate on the scale issue requires empirical data for farm changes under different conditions, historically and regulatory and should include both ‘internal’ dynamics and the interchange between the conventional and the organic farming community. Additionally it may include the ongoing discussion about farm diversification to investigate whether size expansion and diversification are necessarily two separate developmental pathways or whether organic farmers adjust to a changing world in ways different than conventional.

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CONVERSION OF FRENCH SUCKLER CATTLE FARMS TO ORGANIC FARMING: ADAPTATION OF THE SYSTEM AND ITS ECONOMIC CONSEQUENCES

Patrick Veysset

INRA Clermont Theix, Laboratoire d'Economie de l'Elevage, 63122 Saint Genès Champanelle, France,Tel.: +33 (0)4 73 62 45 10, E-mail: veysset@clermont.inra.fr

Key words: beef cattle, farming system, economics, modelling, organic farming (0F)

Abstract

French suckler farmers need advice on the impact of the conversion to OF. To help them with their decision making process, we constructed an LP model that optimises the farming system, taking OF constraints and nitrogen balance into account. According to the model, the shift to OF had a greater impact on a mixed crop-livestock farm system than on that of a grassland farm. As a result of the very high cost of organic N fertiliser and the necessity of maintaining the N balance, the shift to OF in the case of the mixed farm resulted in less emphasis on cereal and more emphasis on livestock. For this type of farm, a significant drop in its proportional costs due to extensification was sufficient to maintain the overall gross margin of the holding. For the extensive grassland farm, the production system remained almost the same after the conversion. In this case, only a slight area extensification was needed. Costs increased due to the higher price of the concentrates purchased, and a 30% increase of the selling price of the meat was therefore necessary to maintain the overall gross margin.

Introduction/Problem

Since 1997, the number of organically-farmed suckler cows has considerably increased in France (+320%). By 2003, 1.3% of the French suckler cows (54,000 cows on 1,760 farms) were raised in organic farming (OF) systems. One effect of the BSE crisis in 2000 was an increase in the demand for organically-produced beef, with products selling at substantial prices. Since 2002, this demand has stagnated, it has become difficult to sell the animals and prices have dropped. Faced with these difficulties and the strict specifications concerning OF, suckler farmers need advice before converting their systems to OF. One of the main characteristics of suckler farming is the diversity of the production systems (land use, degree of intensification, type of livestock farmed). This diversity can be an asset for adapting systems to changes in the farming environment.

The aim of this work was to study the impact on the adaptation and economy of two suckler cattle farms in the Charolais area of France and to assess, within the context of a conversion to OF, the price increase of the products necessary to maintain economic profitability. This was a model-based study.

Methodology

Instruments used

We devised Opt'INRA (Veysset *et al.*, 2005), an LP model that represents and optimises the operation of a Charolais suckler cattle farm. Opt'INRA maximises the overall gross margin by optimising the production system with a large number of constraints, both internal and external to the holding. The OF principles and constraints were transcribed into Opt'INRA (Veysset *et al.*, 2003). Since the plant nitrogen provision is an essential point in OF, we included an N-balance constraint. The N-balance is the difference between nitrogen leaving the farm with the sale of beef and crop products, and nitrogen entering the farm, including N fixed by the legumes (Simon & Le Corre, 1992). Opt'INRA was applied in a single-period approach. We started from a stable conventional situation and arrived at a stable OF situation. The period of conversion was not taken into account.

References used and farms studied

The technical consequences of the application of the OF specifications were determined from data supplied by existing observation networks (Pavie & Vaucoret, 2004).

We studied the impact of the conversion to OF for two farms with radically different structures. The structural characteristics (farm area, arable area, number of cows) and technical characteristics (type of animals sold, stocking rate, yields) of both farms selected were very close to the average of farms in each of these two types of farming categories (Rica France, 2001):

- A grassland farm specialised in beef production producing steers (90 ha, 100% forage area, 55 calvings). This system, which is mainly operated in upland areas, is characterised by extensive practices as regards both area and animals, with long-cycle fattening. Grass is well used to minimise the purchase of concentrates.

- A mixed crop-livestock farm producing store animals (200 ha, 52% cash crop area, 90 calvings). This system is found in intermediate areas where major crops and livestock farming coexist. The areas are intensified with large amounts of off-farm inputs. Meat production is not very intensive with nil fattening.

<u>Hypothesis</u>

The herd productivity criteria were unchanged and husbandry costs other than those of food and forage were considered to be identical to those of conventional systems (Becherel, 2004).

The ban on chemical fertilisers entails a drop in pasture yield of –14 to –23%, and a drop in the forage area costs of -10 to -60%, depending on the initial situation. The cereal yield decreased by 52%.

The nitrogen balance had to be slightly positive (+30 kg N/ha) to counteract the losses due to runoff and volatilisation. The model can balance this N-balance, either by choosing to purchase organic N fertiliser (the unit of organic N costs about 10 time more than the unit of chemical N) and/or by choosing an optimal cropping plan (Veysset, 2002).

The rations proposed met two conditions: to maintain the animals' performances and to comply with specifications. The concentrates used were either cereal-pea mixtures grown on site or commercial organic concentrates.

The value of store animals was evaluated on the basis of conventional farm gate prices (no specific market). In 2001, the average price of animals considered as OF products (fattened females and steers) was 35% higher than the conventional price and only 10% higher in 2003. We tested different levels of OF beef selling prices: the conventional price plus a premium from 0 to 40%. Until 2002, the selling price of the OF cereals (and the purchase price of the concentrates) was twice as much as the conventional price. It was 70% higher in 2003. In our study, the selling price of the OF cereals was from 30 to 90% higher than the conventional price. The average premium prices tested were +20% for the meat and +90% for the cereals. After this first simulation, we also tested the combinations of the different price levels.

The economical data (sale prices of the conventional animals, CAP subsidies) are those of the year 2003.

Results and brief discussion

The results are given in Table 1 for conventional production (Conv.) and for conversion to organic production (OF), on the basis of different combinations of meat and cereal premium prices.

<u>Grassland farm:</u> the shift to OF with average premium prices (20% for the meat and 90% for the cereals) did not make a big difference. A medium level of legumes in pastures (20%) was sufficient but necessary to balance the N-balance without N input. A slight area extensification was required and the decrease in the number of livestock units (-10%) was achieved by fewer calvings (47 *vs* 55). The shift to OF was not followed by a drop in consumption of concentrates. Instead, it generated an increase in costs due to the higher price of the concentrates purchased. The total proportional costs increased by 22%, while the product remained the same. Lastly, the overall gross margin decreased by 6%. Unless the meat sold for premium prices, it was not profitable to produce fattened steers. In this case, the gross margin decreased by 14%.

For this holding with 100% forage crops, the increase in the selling price of the meat necessary to maintain the overall gross margin should be greater than 30%. Depending on the price of cereals (and thus the concentrates), this necessary price increase per kg should be in the 30% range (Figure 1).

<u>Mixed crop-livestock farm:</u> with average premium prices (20% for the meat and 90% for the cereals), the shift to OF resulted in less emphasis on cereals (cash crop area: 20% *vs* 52%) and more emphasis on livestock (livestock unit: 170 *vs* 126, fattened animals) in order to maintain an equilibrium for the nitrogen balance without N input (the purchase price of organic fertilisers was too expensive). The reduced use of inputs afforded a reduction in costs (-48%), while the product decreased by 5%; the gross margin then increased by 10%, compared to the conventional system. Even with no increase in meat sale prices, the

gross margin was 2% higher due to the reduction of costs. With no increase in meat prices and with a 30% increase in the price of cereals, the gross margin decreased by only 1%.

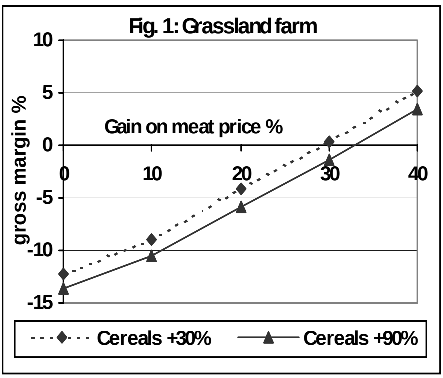
This farm maintains or even increases its overall gross margin without increasing meat prices (Figure 2). The opportunity cost of OF beef is not much higher when the selling price of cereals is high rather than low because the cash crop area cannot be increased due to the high price of the organic fertilisers. In other words, the N balance constraint is reached with an optimal cropping plan and not with purchased N input.

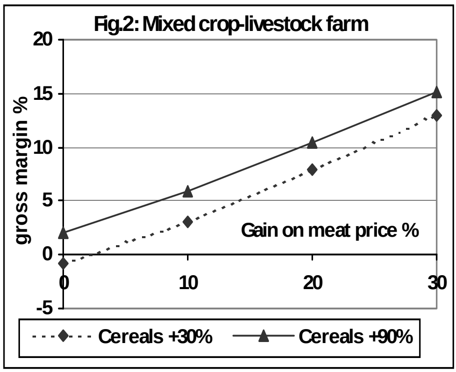
Table 1: two suckler cattle production systems studied by modelling: characteristics and economic results of the farms, before and after conversion to OF

	Grassland farm				Mixed crop-livestock farm			
System	Conv.	OF	OF	OF	Conv.	OF	OF	OF
Premium price on meat		20%	0%	20%		20%	0%	0%
Premium price on cereals		90%	90%	30%		90%	90%	30%
Farming area (ha)	**90**	**90**	**90**	**90**	**200**	**200**	**200**	**200**
Cereals, mixture (ha)	-	-	-	-	123.8	39.0	39.9	38.7
Including sales	-	-	-	-	*84.7*	*21.4*	*22.4*	*20.4*
Forage area (ha)	90	90	90	90	96.2	161.0	160.1	161.3
Including grass	*90*	*90*	*90*	*90*	*91.4*	*152.4*	*151.5*	*152.5*
Number of calvings	**55**	**47**	**53**	**47**	**90**	**86.4**	**99**	**100**
Livestock Units	100.5	90.6	90.1	90.5	126.1	169.6	169.0	170.6
Stocking rate	**1.12**	**1.01**	**1.00**	**1.01**	**1.31**	**1.05**	**1.06**	**1.06**
Fattened animals (%)	64	75	50	75	0	75	45	43
Total production (k€)	88.9	88.7	83.5	88.7	223.2	211.1	198.9	194.3
Total costs (k€)	17.7	21.6	22.0	20.4	60.5	31.3	33.0	33.0
Overall Gross Margin (k€)	**71.2**	**67.1**	**61.4**	**68.2**	**162.7**	**179.8**	**165.9**	**161.3**

For both farms, the overall gross margin rose by 4.5% for a 10% increase of the premium price of meat (refer to graphs in Fig. 1 & 2).

Figure 1 & 2: variation of overall gross margin related to obtained premium prices for OF meat for two levels of premium prices for OF cereals.





For a farmer, the conversion to OF is not only based on economic considerations; the shift to OF is a more complex process that takes broader environmental concerns into account (Pacini *et al.*, 2003).

The labour aspects are not covered in our study although organic livestock farming seems to require more time (because of the individual approach to care, using natural treatments). We consider that the reduction in the number of animals should offset this additional labour.

One of the crucial points to be considered concerns the types of animals sold and their price. Trends in the cattle margin will depend on the number of animals that can be sold on the OF market, whereas the male production option is ill-defined, with the possibility of a new and growing demand for grazing bullocks or even trough-fed males. The selling price can also be either practically constant throughout the year (specific OF sector, short circuit) or fluctuate according to the supply/demand ratio (supermarket). At the present time, the organic meat production sector is not yet structured.

Conclusions

In view of its specific constraints, OF, more than conventional agriculture, has to be constantly seeking the most rational systems, the best balances providing the greatest degree of self-sufficiency (feed for livestock) and allowing economies of range (mixed, complementary systems) rather than economies of scale.

The effects of the conversion of suckler cattle farms to OF are different, depending on the initial system. The most intensively farmed holdings (per hectare or per animal) and those most intensely based on cereals (and therefore, the most input-hungry), undergo a significant drop in their proportional costs due to extensification. For initially extensive holdings, the decrease in inputs in OF is not sufficient to offset their higher purchase costs (feed for livestock). The increase in the selling price of the meat necessary to maintain the overall gross margin of the holding primarily depends on the proportion of crops over the total area.

The market for organic products, though still marginal, is expanding. It is possible that its growth may not necessarily take place in step with the supply from newly converted stock farms. This could lead to transitional situations that may be difficult for those stock farms that have to bear the extra costs of OF production with no guarantee of any corresponding price increase. The problem is not with the conversion period since French farmers receive incentive conversion grants, but after the conversion instead, once they are OF-certified and don’t receive any subsidies for this particular farming system. If there is no profit to be made on the products, some farmers may be forced to abandon the system.

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POLITICAL INSTRUMENTS FOR ORGANIC FARMING

STAKEHOLDER ASSESSMENT OF AGRICULTURAL POLICIES REGARDING ORGANIC FARMING: SYNTHESIS RESULTS FROM 11 EUROPEAN COUNTRIES

Anna Maria Häring (1), Daniela Vairo (2), Raffaele Zanoli (2), Stephan Dabbert (3)

(1) University of Applied Sciences Eberswalde, 16225 Eberswalde, Germany, +49/3334/657 348, ahaering@fh-eberswalde.de
(2) Dipartimento di Ingegneria Informatica, Gestionale e dell'Automazione, Polytechnic University of Marche, Via Brecce Bianche, 60131, Ancona, Italy, +39/071/2204994, daniela@agrecon.univpm.it, zanoli@agrecon.univpm.it
(3) University of Hohenheim, 70565 Stuttgart, Germany, +49/711/4592541, dabbert@uni-hohenheim.de

Key Words: Organic farming policy, policy development, SWOT analysis, stakeholder involvement

Abstract

The accession of new countries to the EU has combined two very different patterns of organic farming development under a new and unique market and policy framework. An approach to policy learning and innovation that addresses the unique situation of the organic farming sector in the recently enlarged European Union is presented. Part of this effort in bringing together stakeholders of the organic farming and general agricultural policy sector within the EU, was a series of one day-workshops in 11 European countries (AT, DE, DK, CH, CZ, EE, HU, IT, PL, SI, UK) with the objective of formulating policy recommendations for the development of the organic farming sector. Close personal contact of participants in these workshops provided a platform to exchange ideas and network at the national and transnational level. This contribution presents the synthesised results from all national workshops highlighting the current situation of organic farming policy in Europe and providing recommendations for future policy design.

Introduction

Organic farming has become an inherent part of European agriculture in the Old and New EU Member States (MS), and specific policy support for organic farming has been developed in all MS (Lampkin *et al.* 1999, Häring *et al.* 2004, Prazan *et al.* 2004). Policy support has played a significant role in stimulating organic farming growth; however, the conditions for the development of organic farming differ widely between Member States. The first policy intervention for organic farming was the implementation of Council Regulation (EC) 2092/91 in 1991 harmonising the definition of organic farming. In 1992, for the first time, area support for organic farming was introduced within the agri-environmental programmes (Council Regulation (EC) 2078/92). The subsequent reform of the European Common Agricultural Policy (CAP) (Agenda 2000) by the Rural Development Regualtion (Council Regulation (EC) 1257/99) provided a framework for MS to continue the agri-environmental measures and introduce other measures to support the development of rural areas. Among these, MS introdcued a range of measures supporting organic farming (Häring *et al.* 2004). The CAP Reform 2003 continued the Rural Development Regualtion; MS have the chance to revise their Rural Development Programmes by the end of 2005. Once gain, this poses the question of how to develop a policy framework that ensures the further development of organic farming.

There is no single 'best way' of policy development for organic farming. However, to innovate policies or to assess the transferability of 'good practices' from one country to another it is essential to understand the specific national environments' policy practices and their impact on the development of the organic farming sector. This requires a broad debate among stakeholders. Thus, a structured form of participation of and consultation with policy stakeholders was developed to contribute to a scientifically based formulation of policy recommendations at the national and EU level (Vairo *et al.* 2005a). Stakeholder involvement was achieved through two national and one EU level workshop that were managed to facilitate policy learning (Dolowitz and Marsh 2000) among stakeholders of a country and across countries. The objective of this contribution is to present the developed methodological approach of stakeholder involvement. Furthermore, the results of the first series of national workshops will be presented, highlighting the current situation of organic farming policy in Europe and providing policy recommendations for the development of organic farming[1].

Methodology

A series of workshops (one national, one EU level, and a second national workshop) was designed to facilitate policy learning among stakeholders of a country and across countries in the involved European countries from three points of views (Dolowitz and Marsh 2000, Vairo *et al.* 2005a):

1) At the national level, there is an opportunity to facilitate policy learning among stakeholders of a country, to create a national network, and to create agreement able to produce future actions.

2) At the transnational level, there is an opportunity for the MS to learn from each other (e.g. New and Old MS), to create transnational networks, and to reduce the differences in national policies and policy innovation.

3) Since these workshops are an EU-wide 'experiment' in developing organic farming policy recommendations, there is an opportunity creat a link between national and transnational stakeholder networks and the EU commission.

Following the approach of a multi stakeholders process (MSPs) (Hemmati 2002), participants from four groups were involved in the process to assure a good representation of perspectives: policy makers, organic sector representatives, non-organic sector representatives, and third parties.

In April 2004 the first series of workshops was conducted in 11 European countries (AT, DE, DK, CH, CZ, EE, HU, IT, PL, SI, UK) according to common guidelines (Häring and Vairo 2004a). The objective of these workshops was to assess the effectiveness of different policy instruments in each country, and to develop suggestions for future policy instruments to positively influence the development of the organic farming sector in the respective country (Vairo & Häring 2004a, 2004b). The workshop group discussion was structured in three phases:

1) Definition of SWOT: The analysis of organic farming policy was based on the methodological approach of SWOT analysis. On the one hand, participants analysed their country's specific policy instruments' strengths and weaknesses. On the other hand, looking at the external (uncontrollable) environment of the organic farming sector, participants identified those areas that pose opportunities for organic farming in their own country, and those that pose threats or obstacles to its performance.

2) WOT rating: Participants assessed which weaknesses were most relevant in the organic farming policies of their country (criteria: high impact and high importance), which opportunities could be exploited for organic farming in their country (criteria: high attractiveness and high probability), and which were the threats against which the sector needs to defend itself (criteria: high seriousness and high probability).

3) Identification of policy instruments: Participants were asked to elaborate possible policy instruments to address weaknesses, opportunities and threats through brainstorming. This led to a list of recommendations for national policy makers and provided the basis for the discussion of a EU policy framework for organic farming during an EU-level workshop in February 2005 (Vairo *et al.* 2005a).

Results from all 11 countries' workshop groups were analysed by iterative coding to achieve a cross-national analysis with the objective of identifying the most relevant WOT concepts and policy instruments (Vairo *et al.* 2005a).

Results and brief discussion

Stakeholders assessment of current organic farming policy in the EU and potential external influences on the development of the organic farming sector

Regarding organic farming policy in the European Union, strengths were seen in the generally favourable political climate towards organic farming, an active dialogue of policy makers and institutions with organic

[1] Subproject 'Identification of the dimensions of a new European Organic Farming Policy post EU-expansion', which is part of a larger project 'Further Development of Organic Farming Policy in Europe, with particular emphasis on EU Enlargement (EU-CEEOFP)' (QLK5-2002-00919).

interest groups, the priorisation of marketing and consumers by policy, GMO legislation protecting organic farming, a reliable organic inspection system, and a diverse offer of support measures.

The most relevant weaknesses of organic farming policy were seen in the lack of coherence of policy, inappropriate support of communication with consumers, and an inappropriate support of capacity- building measures for the diverse characteristics of organic farming. Furthermore, research and development should be more strongly supported. More generally, another major weakness was seen in the details of the design of policy measures and a lack of integration of organic farming policy with other policies (e.g. rural development, environment, etc.).

With regard to the external, uncontrollable environment of the organic farming sector, participants saw the most relevant opportunities for the organic farming sector in current societal trends (e.g. health, environment, food quality) creating demand, the reform of the European Common Agricultural Policy, and favourable natural conditions for organic farming and farming systems with a high conversion potential. Furthermore, a productive organic actors network, a generally favourable political climate, and an increasing consumers' awareness were seen as opportunities for organic farming in the future.

The most severe threats to the organic farming sector were seen in GMO contamination, the competition for markets with producers of emerging countries and large food retailers due to EU enlargement and increasing globalisation, coupled with a weak interest of consumers in organic food and their low willingness to pay organic price premiums. Furthermore, poor standards and a bureaucratic and false certification system, the structure and low efficiency of existing farms, and a decreasing quality differential between organic and conventional products were seen as major threats to the organic farming sector in the future.

Policy strategies to develop the organic farming sector in the EU

A wide range of policy instruments or policy strategies to address weaknesses, opportunities, and threats was developed by workshop participants. However, this contribution can only present policy instruments for the example of the weakness 'lacking coherence of policy' and the most relevant opportunity ('current societal trends [health, environment, quality] creating demand').

The current opinion of stakeholders in the EU is that the lack of coherence in policy could be addressed by an Action Plan for Organic Farming. To develop an Action Plan, a roundtable should be created that brings together a newly established organic farming committee at the ministry with organic stakeholders. The resulting Action Plan should be linked to Action Plans at the EU and regional level and should include quantitative targets and concrete actions for their achievement. This could be supported by specific training for policy implementers. This could also include giving priority to organic farming in all Rural Development (investment, processing, etc.) and Nature Protection Measures, assisted by an increased funding from non-agricultural sources. This could encourage the linkage of tourism, organic farming, and regional development as one part of stimulating the creation of clusters of organic farming.

An Organic Action Plan could encompass measures to improve communication with consumers, such as public information and promotion campaigns on organic farming. Capacity building in organic farming could be improved by increasing the opportunities for education and training in organic farming, e.g. by increasing the number of organic advisors, and by creating links and information exchange among stakeholders, e.g. by an organic web portal.

Stakeholders also recommended improving research and development by prioritising organic farming in national research funding or by introducing the option of integrated funding among different sectors, e.g. by providing tax relief for enterprises supporting organic research. Furthermore, coherence of policy could be increased by a 'green' tax reform, which could include a tax exemption on organic direct payments for organic farms, a reduced VAT on inputs and services to organic farming as well as on organic products, or a specific tax on pesticides, mineral fertilisers, and nutrient output, indirectly benefiting the relative profitability of organic farming.

Several strategies of stakeholders in the EU were proposed on how to exploit the opportunity of current societal trends that seem to be creating demand. To improve communication with consumers, public information and promotion campaigns or educational activities, e.g. on organic quality, were proposed. Better communication could also be achieved by a higher market transparency for consumers, for example by efforts to develop new products and to establish a few strong organic brands. This could be supported by research focussing on consumer expectations, on the health aspects of organic food, and on improving organic food and processing.

Current societal trends could also be exploited by improving the organic market for consumers by stimulating international trade for a wider product range and higher competitiveness of traders, and by stimulating public procurement and the cooperation of policy with retailers.

Furthermore, an integration of organic farming into health policy could contribute to communicating the benefits of organic farming to a wider audience. In addition, a national organic farming observatory could contribute to these efforts by collecting and disseminating statistical information on organic farming. These efforts could in part be financed by the application of a pesticide, fertiliser, and nutrient output tax.

Conclusions

The series of national workshops described here was a first step to policy learning and policy transfer for the organic farming sector in Europe. A wide range of organic farming actors was involved in the assessment of organic farming policy, and a wide range of policy instruments and strategies was developed addressing the previously identified weaknesses of organic farming policy, along with opportunities and threats for the organic farming sector. The ideas on policy instruments and policy strategies developed in these workshops have the potential to spread widely within the organic farming sector. Results fed into and provided the base for a discussion at the EU level in a second workshop with EU level stakeholders and representatives from national workshop groups in February 2005 (Vairo *et al.* 2005b).

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IMPACT OF THE EU COMMON AGRICULTURAL POLICY ON ORGANIC IN COMPARISON TO CONVENTIONAL FARMS

Anna Maria Häring (1) and Frank Offermann (2)

(1) University of Applied Sciences Eberswalde, 16225 Eberswalde, Germany, +49/3334/657 348, ahaering@fh-eberswalde.de

(2) Frank Offermann, Institute of Farm Economics, Federal Agricultural Research Centre (FAL), 38116 Braunschweig, Germany, +49/531/596 5209, frank.offermann@fal.de, www.bw.fal.de

Key Words: organic farming, agricultural policy, European Union, Rural Development Programmes

Abstract

Farms in the EU receive considerable support from the Common Agricultural Policy. Support for organic and conventional farms is analysed, covering a wide range of different Common Agricultural Policy support measures. The current design of the Common Market Organisations tends to disadvantage organic farming systems, although developments in the last two CAP reforms (years 1992 and 2000) and the latest reform (2003) have reduced the discrimination of extensive farming systems and now provide opportunities to introduce measures to meet some of the needs of organic farms.

Introduction/Problem

Agriculture in the EU traditionally receives considerable support from the Common Agricultural Policy. In most member states, organic farms receive specific support. The objective of this paper is to compare and to evaluate support to organic and conventional farms, covering a wide range of different support measures from the 1st (Common Market Organisations) and the 2nd pillars (Rural Development Programmes) of the CAP and highlighting differences between member states and regions.

Methodology

Direct payments and price support from the Common Market Organisations (CMOs) for organic and comparable conventional farms are analysed based on the European Farm Accountancy Data Network (FADN). The database contains the accounts of approximately 60000 farms. The most recent data accessible refers to the accounting year 2000. However, identification of organic farms was only possible for ten of the EU member states (Austria, Belgium, Denmark, Finland, Germany, Great Britain, Luxembourg, the Netherlands, Portugal and Spain). While the sample farms of the EU-FADN are selected as to allow a nearly representative picture of EU agriculture, it is not clear how 'representative' the sub-sample of organic farms is, as data on the distribution of organic farms in the population is still sparse and the farming system (e.g. organic/non-organic farming) is not a stratification criteria in sampling (D'Avino 2004). Therefore, all of the results presented are based on simple averages rather than on an application of the weighting factors. To enable a meaningful evaluation of the CMO payments to organic farms, all figures are compared to the payments received by a reference group of comparable conventional farms. For the establishment of a suitable reference group, conventional farms with a similar 'production potential', i.e. a similar endowment with production factors had to be selected (for a discussion of the concept of comparable conventional farms see Lampkin, 1994 and Offermann and Nieberg, 2000).

Expenditure through price support instruments such as tariffs and export subsidies is estimated by the Producer Support Estimate (OECD 2002). For organic products, it is difficult to assess the impact of the general EU market-price support mechanisms on the prices for organic products. International trade of organic products is comparatively limited, with non-tariff barriers possibly rating a higher importance than classical market price support instruments, and there is currently no 'world market price' for organic products. For this study, an attempt will be made to estimate market price support for organic products based on the market price support for conventional products, even though it must be noted that little information exists on the exact interactions between organic and conventional farm gate prices (Offermann 2003).

Support provided within the Rural Development Programmes (RDP) for organic and conventional farms was analysed based on qualitative and, where available, quantitative analyses of relevant provisions (e.g. eligibility criteria, restrictions, payments received) in 6 selected EU Member States (Austria, Germany, Italy, Spain, UK and France) (Häring et al. 2004). In countries where RDP are implemented on a regional basis, case study regions were chosen. These case studies provide an overview of the measures in place and analyses of their attractiveness for organic farms compared to conventional farms. Direct payments for organic and conventional farms are analysed based on the FADN. Additionally, where no other information was available comparative model calculations based on average regional organic and conventional farms data provided by Eurostat (2003) and the theoretical potential uptake of applicable measures were used (Häring et al. 2004).

Results and brief discussion

Organic farms receive on average approx. 20% more direct payments per hectare than comparable conventional farms, mainly due to the significantly higher support received from the agri-environmental programmes (Table 1). However, organic farms receive 18% fewer direct payments per hectare from the Common Market Organisations than comparable conventional farms. Organic farms receive considerably fewer area payments for cereals, oilseeds and protein crops. Specifically, the eligibility of maize for silage for these payments in many countries favours conventional farming. Conventional farms receive much higher payments for olive growing, as production aid for olive growers is paid per tonne of olive oil delivered and is therefore linked to the actual output.

Table 1: Direct payments for the first pillar of the CAP to organic and comparable conventional farms in different countries in the EU in Euro/ha UAA in 2000

	Finland		Portugal		Austria		Spain		Germany		Denmark	
Payments for	Org	Con	Org	Con	Org	Con	Org	Kon	Org	Con	Org	Con
Grandes Cultures	113	148	15	58	62	81	92	103	110	181	122	182
Olives	0	0	41	132	0	0	38	67	0	0	0	0
Set-aside	17	15	0	9	5	7	13	17	13	22	15	23
Bulls	23	24	2	6	9	18	0	7	6	11	6	13
Slaughter	5	5	0	1	5	6	0	2	3	3	7	10
Suckler cows	15	2	5	10	24	14	0	0	34	11	3	1
Extensification	13	7	4	7	34	25	0	0	15	0	2	0
Sheep + Goats	3	0	18	18	0	0	4	23	4	0	1	0
Total	188	201	85	240	139	151	146	220	186	229	155	230

Source: Offermann (2003) based on FADN-EU-GB AGRI/G.3

Price support instruments such as tariffs and export subsidies play a major role within the Common Market Organisations. In the EU, this indirect support to farms still accounts for the bulk (60%) of the Producer Support Estimate by the OECD. First estimates indicate that the benefit for organic farms from price support measures of the Common Agricultural Policy is 20-25% lower than that for comparable conventional farms.

The most important measures supporting organic farming are the agri-environmental measures (Figure 1). These are implemented within the Rural Development Programmes, the “2nd pillar of the CAP”. Organic farming support implemented within the agri-environmental measures makes up approx. 15% of expenditure on agri-environmental measures, covering 7.5% of agri-environmental area.

On average, 89 €/ha are spent on the area under agri-environmental measures, while 186 €/ha are spent on organically farmed area. In all countries, except Portugal and the UK, average payments per land area are higher for organic than for the average of other agri-environmental measures.

The highest difference in payments received through the agri-environmental measures between organic and conventional farms can be observed on horticultural and arable farms. Nevertheless, in many EU countries payments are nearly as high for integrated production, the closest alternative to organic farming, or combinations of other agri-environmental measures (Häring et al. 2004). In other countries specific provisions for organic farming are made, i.e. in Austria the ceiling of total payments for farms > 100 ha is higher for organic farms than for conventional farms.

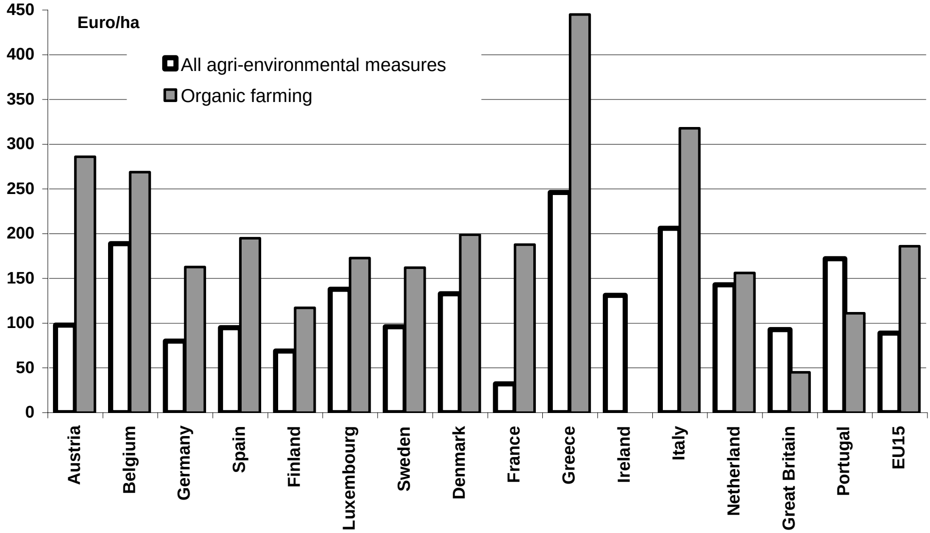

Figure 1: Average expenditure on the agri-environmental measures in the EU (2001) (EC 2004)

Other measures implemented within the Rural Development Programmes – although not always quantifiable - are also important instruments for supporting organic farming. Investment aids rarely benefit one specific farming system. However, in the region of Marche (Italy) the maximum investment support rates are 10% higher for organic than for conventional farms. Similarly, few examples of specific targeting of organic farming in processing and marketing measures exist. In Austria, for example, the marketing of organic milk and dairy products is supported, as is the establishment of processing and distribution structures for fresh vegetables and potatoes and marketing structures for oil pumpkins (Häring et al. 2004).

Specific support for vocational training of organic farmers is not included in the RDPs of the case study regions. However, in some cases training for agri-environmental issues are clearly emphasised and organic farmers may indirectly benefit, e.g. in France. Similarly, in England and Wales and Austria, various educational projects are implemented although no specific mention of organic farming is made in the measure.

Payments for Less Favoured Areas (LFA) tend to be slightly higher on organic than on conventional farms as organic farms are more likely to be found in LFA. Furthermore, some countries implement specific measures that benefit organic farms in LFA. For example, in the UK specifically targeted payments for organic farms that are not part of the Organic Farming Scheme are made and in Marche (Italy) LFA payments are only made to farms not relying on GMO.

Conclusions

Currently, the design of the CMOs can pose a disadvantage to organic farming systems, even though the CAP reform of 1992 and the subsequent Agenda 2000 reform have generally reduced the discrimination of extensive farming systems by reducing the level of price support for a number of products, compensating farms for losses of revenue via direct payments. The latest reform, decided on in June 2003 and gradually coming into effect until full implementation in 2012, will further improve the relative competitiveness of organic farming systems by decoupling most of the direct payments from production and strengthening the 2nd pillar. Measures implemented within the new RDP will be decided upon in 2005. They will provide an opportunity to design suitable provisions to meet some of the needs of organic producers and provide conventional farmers with incentives to convert.

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MAKING POLICY – A NETWORK ANALYSIS OF INSTITUTIONS INVOLVED IN ORGANIC FARMING POLICY

Heidrun Moschitz (1), Matthias Stolze (2)

(1) Research Institute of Organic Agriculture (FiBL), CH-5070 Frick, heidrun.moschitz@fibl.ch, www.fibl.org

(2) Research Institute of Organic Agriculture (FiBL), CH-5070 Frick, matthias.stolze@fibl.ch, www.fibl.org

Key words: agricultural policy, network analysis, organic farming development, institutions

Abstract

As organic farming has become an instrument of European agricultural policy, the organic sector is required more and more to become politically active. This paper presents results from an EU-funded project i) analysing the development of organic farming institutions for the period of 1997-2003 in eleven European countries and ii) investigating networks of organic farming policy on national and EU levels following the network analysis approach. The study concludes that institutions within the organic farming sector in new EU member states are still developing, and their relationship with mainstream farming institutions is characterised by a state of competition. In 15 (old) EU countries and Switzerland, this relation is more oriented towards co-operation and has been described as being in a state of creative conflict. Countries with a high share of organic farming show signs of consolidation of their institutions. Organic farming policy networks are bigger in size and denser in these countries compared to the small networks in new member states. Organic farming organisations, as well as state institutions play an important role in all national networks for organic farming policy-making. On the EU level, the network of organic farming policy actors is still at an initial stage. The different patterns of relationship between institutions and networks of the organic sector provide a basis for recommendations for political strategies of organic farming actors.

Introduction

Organic farming has stepped out of the niche and become more and more an issue and an instrument of agricultural policy in Europe (Dabbert *et al.*, 2004). Institutions that have not focussed on organic farming issues so far increasingly influence its framework. As a result, the sector has been forced to build up its own political structures to interact with both public authorities and the mainstream farming community. Agro-economic research has so far focussed on impact assessment of existing policy measures and the development of new policy instruments (e.g. Stolze, 2003). This contribution takes a structural perspective and highlights the functioning of policy networks. It is embedded in the framework for the analysis of participation of third sector organisations (or non-governmental organisations) provided by Casey (2004). He identifies four factors that determine the influence of such organisations in the policy process: the political and socio-economic environment, the nature of the policies they are seeking to influence, the characteristics and resources of the involved organisations and the network of actors. The research analyses the influence of different development stages of the organic sector on its institutions and their interaction with mainstream agriculture in eleven European countries. Furthermore, it shows to what extent policy networks have developed in order to influence organic farming policy and which network structures have been established.

Methodology

The study is based on two methodological approaches: The institutional development of the organic sector for the years 1997-2003 follows the concept Michelsen et al. (2001) developed in a survey of six countries for the years 1985-1997. Network analysis is applied for exploring how far organic farming policy networks have been established. Michelsen et al. (2001) described three types of interaction between institutions of the organic sector and the mainstream in the domains agriculture (farming), market and policy, labelled as “cooperation”, “competition” and “creative conflict”. Whereas the first two types of interrelation hinder further development of the organic sector (the distinction between organic and conventional is levelled down or contact between the two sectors is completely missing, respectively), “creative conflict” is the basis for the development of organic farming. Michelsen et al. (2001) also introduced a path of six steps for a successful organic farming growth – a concept that we use as a basis for our analysis of 11 countries. These steps are: i) establishment of an organic community, ii) political recognition, iii) financial support, iv) positive involvement of the general farming community, v) established organic food market and vi) establishment of an institutional setting (see Table 1). In the current study Moschitz et al. (2004) on the one hand transfer the Michelsen et al. (2001) approach to new countries and, on the other hand, reapply it to some countries that were already included in the earlier study as a basis for comparison of institutional development between two periods of time. For studying how far policy networks have been established, how they work and how efficiently they function, network analysis has proved to be a suitable instrument. With its help one can explore which actors make up the organic farming policy network, who is powerful, and how close relations are within the organic sector, as well as between the organic and the mainstream agriculture sector. In addition, network analysis enables an objective comparison of policy networks in different countries (Wasserman and Faust, 1994). Computing and visualising of the various network measures was done with UCINET (Borgatti et al., 1999) and Visone (Brandes et al., 2003) software.

Results

The analysis of how organic sector institutions have developed considers three groups of countries: a) new EU member states (CZ, EE, HU, PL, SI), b) old EU member states with an average organic sector (DE, EN, IT) and c) countries with a large organic farming sector (AT, CH, DK). Despite some remaining variance within these groups a number of group-specific characteristics of the institutional development could be identified (Moschitz *et al.*, 2004).

Table 1: Steps undertaken on the path for successful organic farming growth by different countries

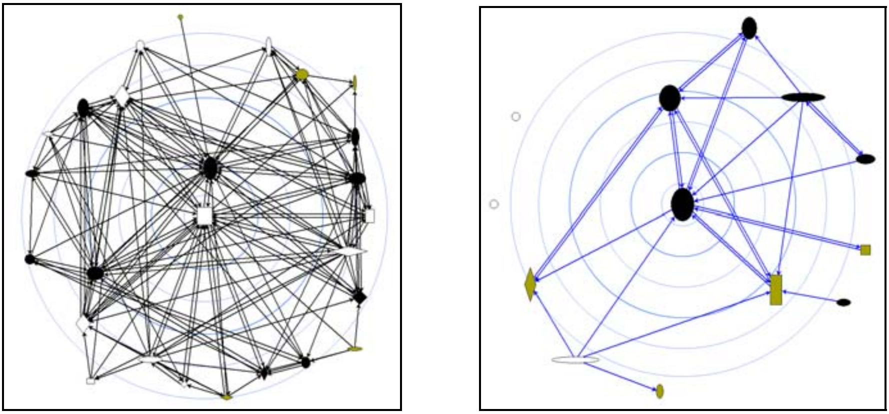
Country group	① established organic sector	② political acceptance	③ financial support	④ acceptance by general farming community	⑤ established organic food market	⑥ institutional setting
New EU states	●	◖	●	○	○	○
old EU, average organic share	●	●	●	◖	●	◖
old EU, large organic share	● ◖	●	●	●	● ◖	●

○ missing ◖ partly completed ● fully completed ● ◖ repeatedly undertaken

Source: own representation

As can be seen from Table 1, in none of the new EU member states has the organic sector undertaken more than the first three steps on the path for a successful organic farming development. In countries with an average or large organic sector (except IT) all steps have been undertaken at least partly and some have been undertaken a second time. Institutions of the organic and the mainstream sector compete with each other in the new EU member states (except CZ), which clearly distinguishes them from the group of countries with a large organic sector. Here, constructive debate and mutual acceptance between the sectors dominates – a relationship that Michelsen *et al.* (2001) call "*creative conflict*". In the group of countries with an average organic sector, such a relationship is only developing at present, and institutions necessary for "*creative conflict"* are still being built up. In comparison with the period 1985-1997 that was analysed by Michelsen *et al.* (2001), no significant change in the relationship between organic and mainstream institutions could be observed in countries with a large organic farming sector. The organic sectors in these countries show signs of consolidation. In contrast, those countries with an average organic farming sector that were also surveyed in the first study (DE and EN) show a greater dynamic. This dynamic is also mirrored by the higher growth rates of the share of organic farming in these countries compared to those with a large organic farming sector (Lampkin, 2004).

The question asked for analysing the organic farming policy network was "With whom do you collaborate closely?". Organic farming policy networks in the countries studied vary with regard to size and the number of links established between actors (i.e. the level of stated collaboration). Figure 1 shows that old EU member states show a denser network with more actors involved compared to new EU member states. This indicates that the longer the history of the organic sector, the better developed are the policy structures. Networks also differ in terms of who occupies the central position: the state (in our example, this is the case for AT) or an organic sector organisation (in our example, this is the case for CZ). Within each country network, the analysis identifies players who are actively involved in policy making and distinguishes them from actors who remain rather passive.



● / ⬬ private actor ■ / █ state actor ⧫/◆ others white/black: oriented towards organic/mainstream farming

The left chart shows the organic farming policy network of an old EU member state (Austria). The right chart shows the case for a new EU member state (Czech Republic). Obviously, more actors are involved in the Austrian network and it is denser than the Czech network. Private organisations are found in central positions in both networks. In Austria, the most central position is kept by a state institution.

Figure 1: Two examples of organic farming policy networks in an old and a new EU member state

Source: own representation, computed with Visone (Brandes et al., 2003)

Despite differences between countries some general characteristics of organic farming policy networks can be derived. In all networks organic farming organisations play the role of information brokers. They gather information from the actors and pass it on to other actors in the network. In those countries where organic farming organisations are politically recognised and cooperate with each other, they play the central role in the networks. In addition, the state is an influential actor in the policy networks, whereas organisations of the mainstream farming sector are rather found in the periphery. On the EU level, a network for organic farming has been only poorly established so far. However, expert interviews showed some potential for development as the importance of organic farming is broadly accepted by stakeholders.

Conclusions

Based on the framework for political influence developed by Casey (2004) we can draw some conclusions for the influence of organic sector organisations on the policy process. The political situation of organic farming differs from country to country. Obviously, overall political and socio-economic frame conditions are different in new and old EU member states. Transformation processes in the new member states are ongoing and still influence the environment in which policy is made (Prazan et al., 2004). Organic farming has found its way into agricultural policy to varying extents, and thus the possibilities for organic farming organisations to lobby for their issue are different. Furthermore, the organic farming sector is established to different levels in each country, not only in terms of its size, but also in terms of unity of the farming community. Against this background the organic farming sector has built up different networks to influence policy processes. These networks, in turn, have an impact on the role that organic farming organisations can play in (organic) farming policy making. Thus, the organic sector faces different challenges in different countries if it aims at increasing its political influence.

The development of the organic sector calls for dynamic institutions. To maintain organic farming identity and in order to sharpen the political profile of the organic sector debate with state and mainstream agriculture institutions is necessary. As soon as the organic sector is settled to a certain extent it is important that its organisations prevent creative conflict with other sectors from changing to "*pure cooperation*". Such a change would jeopardize its distinctness from the conventional agricultural sector. The results of the analysis of the institutional development in connection with the network analysis results provide a basis for recommendations for political strategies of the organic sector. In order to effectively influence policy, the organic farming network should approach the existing network structures of mainstream agriculture policy. A cooperative relation with state agencies appears to be indispensable given their rather central position in the (organic) farming policy network. Cooperation within the organic sector is necessary to maintain a strong position in a constructive debate with the state and mainstream agriculture institutions. On the EU level, the potential of the organic farming sector to establish a network should be used. Ways have to be found to gain new allies and establish a permanent lobby for organic farming.

Abbreviations

AT: Austria; CH: Switzerland; CZCzech Republic; DE: Germany ; DK: Denmark; EE: Estonia; EN: England; EU:European Union; HU: Hungary; IT: Italy; PL: Poland; SI: Slovenia

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A POLICY IMPACT MODEL FOR ORGANIC FARMING IN SWITZERLAND

Jürn Sanders (1), Nicolas Lampkin (2), Peter Midmore (3), Matthias Stolze (4)

(1) Research Institute of Organic Agriculture, CH-5070 Frick, juern.sanders@fibl.ch
(2) Institute of Rural Science, UWA, Aberystwyth, SY23 3AL, Aberystwyth, UK, nhl@aber.ac.uk
(3) School of Management and Business, UWA, Aberystwyth, SY23 3DD, Aberystwyth, UK, pxm@aber.ac.uk
(4) Research Institute of Organic Agriculture, CH-5070 Frick, matthias.stolze@fibl.ch

Key Words: agricultural policy, policy impact assessment, modelling approach

Abstract

Although organic farming has expanded significantly in Europe in the last decade, a sectoral policy model is still missing that is able to analyse the impact of policy measures on organic farming. The use of programming models in the form of a sector-consistent farm group model seems to be a promising model approach, whereas applied general equilibrium models are regarded as less promising. An example is given for a policy impact model for organic farming. The bottom-up structure of this type of model makes it possible to analyse the impact of policy measures on farm incomes and volumes of production of organic and conventional farms at farm, regional and sectoral level.

Introduction/Problem

Organic farming experienced a considerable expansion in Europe in the last decade. From 1993 to 2001, average annual growth rate was 26% for the EU-15 (Hamm and Gronefeld, 2004). In the whole of Europe, in 2004, almost 6.3 million hectares were managed organically by approximately 170,000 farmers (Willer and Richter, 2005). The most important factors for the past growth were a growing demand for organic food and direct payments for organic management practices. While both factors remain important in the future, it is expected that the further development of organic farming is predominantly determined by the general policy environment of the farming sector in Europe (see Häring *et al*., 2004). The impact of policy measures on agriculture is commonly analysed by employing quantitative models. Until today, however, only a few models were developed that take organic farming explicitly into consideration (e.g. Häring, 2003; Offermann, 2003; Richter *et al*., 2001; Hartnagel *et al*., 2000) and the existing ones are, for various reasons, less suited to be used in practice as a policy assessment tool. Against this background, the aim of this paper is to discuss critically the applicability of applied general equilibrium models and programming models in this area and to present a concrete example for a policy impact model for organic farming.

Applicability of two different quantitative modelling approaches

In the last three decades two different modelling approaches were mainly employed to analyse the effects of comprehensive medium-term policy changes on agriculture:

Applied general equilibrium models (AGE models) are fully based on micro-economic theory, where the level of supply and demand is a consequence of maximisation behaviour of economic agents and prices are a result of this pareto-optimum. The aim of an equilibrium model is the determination of equilibrium prices and quantities under different policy scenarios.

Mathematical programming models (MP models) are based on an objective function (generally but not necessarily profit maximisation) that is optimised under certain constraints. In other words, programming models simulate the rational economic behaviour of farmers by optimising factor allocation under pre-determined objectives and economic conditions. They are able to analyse in detail the effects of supply-based policy measures.

AGE models represent the agricultural sector in the form of product-specific supply and demand aggregates. Analysing organic farming in an AGE modelling framework requires a database that explicitly distinguishes between organic and conventional production structures as well as the distribution of organic and conventional products for intermediate and final use (Jacobsen, 2002). Due to the highly aggregated database, however, AGE models are not able to differentiate between regions or farm types. This is a disadvantage insofar as in some countries organic farming is located only in certain regions or comprises only certain farm types. In Switzerland, for example, 57% of all organic farms are located in the mountain area so that regionalised results would have more explanatory power in conveying the effects of policy changes on organic farming. The conversion behaviour can be simulated indirectly by changes in supply and demand. This means that no direct conclusion can be drawn with respect to the impact of policy measures on the number of organic farms or the land area under organic management. Critically, one must regard the necessity to use price elasticities of organic food which is required to model demand behaviour. Currently, only a little reliable information exists about price elasticities of organic food (see for example Enneking (2003), Wier and Smed (2000)). Due to the relative small size of the organic market, however, it is doubtful whether price elasticities of a base year can also be used for the ex-ante period with a different market situation. Furthermore, other research studies indicate (e.g. Hempfling, 2004) that, beside the level of price premiums, demand for organic products is also highly affected by the marketing policy of retailers so that price elasticities have generally only limited explanatory power.

Mathematical programming models are already often used to model economic and production-orientated problems of organic farming (e.g. Offermann, 2003; Richter et al., 2001; Stolze, 1998; Braun, 1995; Dabbert, 1990). An advantage of this approach for policy analysis is that the agricultural sector can be represented through individual farm models, so that the various interrelationships of individual farm activities can be taken into account. Due to the bottom-up structure, programming models are able to analyse possible adjustments at farm level as well as changes at regional and sectoral level. The development of organic farming can be steered endogenously by additional behavioural constraints that determine whether the individual farm model is managed organically or not. The major shortcoming of using a programming model is connected to the necessity to postulate exogenously price and demand figures. This means that trade policies (e.g. tariffs, tariff quotas or export subsides) cannot be directly represented in the model. In order to avoid this disadvantage, Hanf and Noell (1989), for example, proposed to link a supply-model with a market model. However, as outlined above, building a market model for organic farming is still connected with considerable problems, so this approach does not seem to be a promising option.

Having discussed the applicability of AGE models and programming models as a policy impact model with special emphasis on organic farming, one may conclude that a programming approach appears currently to be the more suitable one. In the following section, the design of a policy impact model for organic farming is described to give an example of how a quantitative model that is employed to analyse the effects of policy measures on organic farming may look.

Design of a policy impact model for organic farming

For the development of a Swiss policy impact model for organic farming, the modelling framework of the German model FARMIS has been used. Originally developed for the German agricultural sector, FARMIS has recently been extended to cover other EU member states (Offermann et al., 2005). For Switzerland, FARMIS was adapted to the specific Swiss policy environment and advanced by a farming-system differentiated representation of the agricultural sector.

The model is a comparative-static process-analytical non-linear programming model that represents the Swiss agricultural sector. Following other sector programming models, CH-FARMIS is divided into four modular units. The *data unit* comprises all data that are needed to construct the model. The *data processing unit* includes all steps to derive complete input-output tables for each farm model to determine the forward projection of ex-ante variables and to generate the weighting factors for the aggregation procedure. The *optimisation unit* comprises all individual farm models that are used to optimise the factor allocation and the production programme of farms and farm groups, respectively for a baseline and various alternative scenarios. Finally, the *output unit* comprises the presentation and analysis of the optimisation procedure.

In total, CH-FARMIS consist of 2075 individual farm models that were built on the basis of real farms of the FADN. The technical coefficients of the farm models are either directly taken from book-keeping records or adapted by using ordinary least square regression estimates. Furthermore, the farm data also provide information about the obtained prices and direct payments as well as production costs. By using farm model specific weighting factors, individual farm data can be aggregated to sectoral accounts. The individual farm models are grouped into 30 farm groups according to the farming system, farm type and geographic characteristics. This means that for each organic farm group a conventional counterpart exists that is defined according to similar criteria. An advantage of using FADN data is that a representative farm sample can be used as a basis for the model. However, because Swiss organic farms are mainly specialised dairy farms, not all farm types are included in the model. Currently, approximately 80% of all Swiss farms and 85% of all organic farms are represented.

The agricultural production is represented through 26 crop activities and 14 livestock activities. Factor allocation and production programme of each farm is optimised by maximising the sector income under certain policy and management restrictions. In order to avoid the problem of overspecialisation and jumpy simulation response, the base year model was calibrated using a positive mathematical programming approach (PMP). To generate the unknown marginal cost parameter, prior information about supply elasticities was used, as proposed by Helming et al. (2001). Using PMP is advantageous because it allows a perfect reproduction of the observed activity levels in the base year. By including the dual values of each activity, PMP models are able to generate more realistic results for the ex-ante period in comparison to classical NLP or LP models. On the other hand, the disadvantage of using PMP is that the dual values of only those activities that are also present in the base year period are known. For this reason, it is currently not possible to consider structural changes in the scenario application or to modify the dual values if farms convert to organic farming in the scenario run. However, this problem might be less severe in the case of Switzerland, since the majority of Swiss farmers do not change significantly the farm structure during the conversion process.

The new investment theory is used as a theoretical framework to describe the conversion behaviour of farmers. Assuming profit maximisation behaviour, the management system of an individual farm model is changed from conventional to organic farming if farm profits with organic management exceed profits with conventional management plus the costs caused by the conversion and costs caused by a risk-adverse behaviour. This approach also allows representing a re-conversion of farms. To identify the critical trigger for a change, Odening et al. (2004), for example, proposed to employ an econometric model. Since economic time-series data of organic farms are connected with a lot of uncertainties (due to the temporal heterogeneity of the sample) it is questionable whether this approach is able to generate reliable data. Therefore, the thresholds are not economically derived but simply assumed based on a farm survey where farmers were asked about the critical income disparity that would give sufficient incentive to convert a farm.

Programming models are unable to determine price changes endogenously, as discussed earlier, so commodity prices are generated through expert valuation. This procedure is also used to gain information about the future design of direct-payment schemes. The outcome of this qualitative approach provides input for the scenario run. The policy analysis is done in two steps. First, a simulation is done assuming that the policy environment will not change. Second, single policy measures are modified and the results of the two scenarios are compared.

Conclusions

The farm-group model CH-FARMIS is suitable for assessing the effects of supply-based policy measures and can be used to analyse the future development of organic farming. By using a bottom-up approach it is possible to analyse changes at farm as well as regional and sectoral level, considering the fact that conversion rates vary between different farm types and regions. Because of the relatively small size of the organic market, it is problematic to use price elasticities of the base year for the ex-ante period. For this reason, and because the marketing policy of retailers still has a considerable impact on the demand of organic food, the use of or combination with a market model (such as an AGE model) does not seem to be a promising approach. In future, it is necessary to extend the database to include farm types currently not represented. Furthermore, future research is necessary to improve the representation of structural changes and the conversion behaviour in the model.

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PROFIT AND GENDER IN ORGANIC COTTON FARMING IN BENIN: IMPLICATION FOR POLICY

Dansinou Silvère Tovignan (1), Ernst-August Nuppenau (2)

(1) Ph. D scholar[1], Professor[2] , Justus-Liebig University of Giessen, Institute of Agricultural Policy and Market Research, Senckenberg str. 3, D-35390 Giessen, Germany. E-mail: tsilvere@yahoo.fr or Dansinou.S.Tovignan@agrar.uni-giessen.de

Key words: Organic cotton, Profit function, Gender, Benin

Abstract

The development of organic cotton farming in Benin has unveiled the role of women as separate cotton producer, where approximately one third of organic cotton farmers are female (OBEPAB, 2004). This paper compares the profit of organic cotton cultivation by male and female farmers in Benin. Results showed that women increase their part of household income by producing organic cotton even though they make less profit than male farmers. It is suggested, that giving credit to female organic cotton farmers would contribute to increasing their profit and harmonizing the gender relationship in households. The paper also suggests designing a model to advise rural households in the allocation of female labour.

Introduction: why organic cotton and gender?

Cotton was introduced in Benin (like in most West African countries) during the colonial period. After the independence, cotton farming helped to build a commercial relationship between the country and the rest of the world. Currently, cotton accounts for 24% of the Gross National Product (GNP) and 64% of the country export revenue. In the world scenario, Benin is the 12th largest cotton exporter (MINOT *et al*., 2002).

The successive governments in Benin gave a strong organizational support to the cotton sector (input provision, credit, extension and marketing). Unfortunately, the governmental provisions were gender biased and hence women hardly benefited from both financial and technical supports. Women have limited access to modern inputs (pesticides and fertilizer) since these are distributed through farmers' organization, mostly composed of men, curtailing their chances for conventional cotton farming. Few women holding separate conventional cotton farms get access to those inputs through their husbands or other male relatives (VODOUHÈ, 2003). Mostly, women are employed as labour on the cotton farm of their husbands. Indeed, the dysfunction in the input provision system of conventional cotton is one of the factors justifying the adoption of organic cotton in Benin (TOVIGNAN and NUPPENAU, 2004).

The conventional cotton farming in Benin depends heavily on (more than 90%) imported chemical units. This type of farming has a severe negative impact on farmers' health apart from damages to the rural economy and the environment. The devaluation of the regional currency FCFA (1Euro = 655.95 FCFA) by 50 per cent in 1994 contributed to increases of prices of imported inorganic inputs and drastically reduced net income of cotton farmers. It is in this context that organic cotton farming was introduced in Benin in 1996. Organic cotton farming was a boon for women as they can manage the cotton farms with locally available inputs at lower price than conventional farmers and hence end their dependence on their husbands or male dominated farmers' organizations.

In this study, we investigate the profitability of organic cotton farming with a gender perspective. Implications of the study for policy making in order to improve profitability of organic cotton farming are also discussed. We emphasize the means to improve women's profits from organic farming without harming the socially constructed gender relationship within households.

Methodology

Study area and data collection

The study area is located in the *Zou* region in central Benin, the second most important cotton production zone after *Borgou*, where 77% of the area is organically cultivated. Data has been collected from 100 men and 54 women belonging to 100 households practicing organic cotton farming using structured interviews during August 2003 to January 2004. Only those households where both men and women are engaged in agricultural activities were considered in the research work in order to assess the flow of resources between men and women. Since the women in the sample households, as women in Africa in general, carry out a chore of household and social activities, it was extremely difficult to locate and interview all of them within the available time and resources.

Data analysis: Profit function approach

The most common methodology used for research on profit is based on the production function which explains how farmers combine different inputs to produce the output. One limitation in the estimation of this function is that input levels in such models are endogenous (ADESINA *et al*., 1997). QUISUMBING (1995: 6) suggested that this limitation might be handled by estimating the profit or cost functions instead of production function. Indeed, the profit function explains how farmers, by taking into account the market prices of inputs and outputs (which are exogenous variables), choose inputs and combine them to produce outputs (SADOULET *et al*., 1995).

YOTOPOULUS *et al*. (1976) and SIDHU *et al.* (1979) used the parameters of the profit function to estimate supply of output and demand for factors. However, CHAND *et al*. (1986) criticised the extensive use of profit functions pointing out some limitations. Our study does not aim to extend the profit function analysis to the factor demand. Instead, it intends to investigate how the gender of the farm manager contributes to the shift of the profit function. In addition, the profit function method is suitable to analyze the production behaviour in organic cotton farming because the output price in organic cotton farming is different from the one in conventional cotton farming. The premium price of certified organic cotton is 20% higher than the price of conventional cotton. Therefore, focusing on quantities (production function) alone may bias the estimation.

Let Π be the profit, V the output price, Q the output quantity and xi the inputs and Wi their corresponding prices. The profit function can be expressed as follow:

$$\prod = VQ - \sum_{i=1}^{n} W_i x_i \qquad (1)$$

The profit is a function of inputs prices similarly to the production which is a function of inputs quantities. The profit function models the relationship between profit and inputs prices.

$$\Pi = f(W_i) \qquad (2)$$

The functional form of the profit function depends on the type of production function. The most used functional forms are the Cobb-Douglas and the translog specifications. But the Cobb-Douglas formulation assumes a constant return to scale which is a restriction imposed by the functional form. Therefore, the more flexible specification of translog function is used in this study. The specified model is expressed as follows:

$$Ln\prod{}^* = \varphi + \kappa G + \phi PK + \theta_A LnA + \theta_P LnP + \theta_F LnF + \theta_L LnL + 1/2[\theta_{AA}(LnA)^2 + \theta_{PP}(LnP)^2 + \theta_{FF}(LnF)^2 + \theta_{LL}(LnL)^2] + \theta_{AL} LnALnL + \theta_{AP} LnALnP + \theta_{AF} LnALnF + \theta_{LP} LnLLnP + \theta_{LF} LnLLnF + \theta_{PF} LnFLnF + \varepsilon \qquad (3)$$

Where: Π* is the restricted profit (revenue less variable costs) normalized by the seed-cotton price, G is gender of the farm owner (women = 1 and men = 0), PK is the knowledge of the farm owner about pest management (1 if can identify the major cotton pests in the study area, 2 if can identify the natural enemies of those pests in the study area, 3 if can evaluate the damage and 0 if can identify none of them), A is the size of cotton farm, P, F and L are respectively the prices of pest control materials and fertilising materials, normalised by the seed-cotton price. The φ, θ, and κ Are coefficients to be estimated and ε is the error term.

Results and discussion

Data description

The table 1 presents averages of data used. The gross margin per person/day of family labour is a combined indicator that explains how the family labour is remunerated. This reveals a significant difference between men and women, which means that women make less remunerative family labour than men do.

Table 1: Gender disaggregated indicators of profit in organic cotton production

	Gender	N	Mean	Std. Deviation	t	Sig.
Area (ha)	*Men*	100	1.334	0.831	6.521	0.000
	Women	54	0.572	0.287		
Yield (Kg/ha)	*Men*	100	475.98	220	0.974	0.332
	Women	54	439.58	225		
Input cost per ha (FCFA)	*Men*	100	40220	8410	-1.382	0.169
	Women	54	43610	12870		
Gross margin per ha (FCFA)	*Men*	100	62595	83980	1.660	0.099
	Women	54	51340	55225		
Family labour per ha (Person/day)	*Men*	100	152	100	-2.020	0.007
	Women	54	160	229		
Gross margin per person/day (FCFA)	*Men*	100	415	111	1.790	0.028
	Women	54	320	109		

Empirical results

Results of the estimation of the profit function are presented in Table 2. For this paper, we focus only on the gender aspect.

Table 2: Translog profit function for organic cotton production in Benin

Explanatory variables	Symbols	Beta	Std. Error	t	Sig.
(Constant)		-34.712***	15.087	-2.301	.023
Gender	κ	-.123**	.185	-1.996	.042
KCPM	$\o$	.349***	.168	5.566	.000
FS *(A)*	θ_A	-.445	2.196	-.379	.706
LW *(L)*	θ_L	- 4.699***	17.880	- 2.482	.014
PPCM *(P)*	θ_P	-3.141***	8.725	-2.383	.019
PFM *(F)*	θ_F	-.795	6.730	-1.020	.310
FS* FS	θ_{AA}	.154	.131	1.153	.251
LW* LW	θ_{LL}	-9.586***	5.845	-2.918	.004
PPCM*PPCM	θ_{PP}	-1.666	1.990	-1.132	.821
PFM* PFM	θ_{FF}	-2.408**	3.283	-1.990	.049
FS * LW	θ_{AL}	-.222	.914	-.341	.734
FS * PPCM	θ_{AP}	-.385	.845	-1.457	.147
FS * PFM	θ_{AF}	-.711	1.055	-1.070	.287
LW * PPCM	θ_{LP}	-.200	4.060	-.232	.817
LW * PFM	θ_{LF}	.021	5.277	.022	.983
PPCM * PFM	θ_{PF}	-1.519***	4.442	-2.520	.013

F=12,694, sig. = 0.000, Adjusted R^2= 0.534, n = 154

Asterisks indicate significance at the following levels: *** 1%, ** 5% and *10%.

FS: Farm size, LW: Labour Wage, KCPM: Knowledge about Cotton Pest Management, PPCM: Price of Pest Control Material, PFM: Price of Fertilising Material. The term crop protection and fertilizing materials refer to botanical extracts, manure and the residue from palm oil processing called tchôtchôkpô for organic cotton production.

In the current article, as we focus on the gender aspect, coefficients other than gender are not explained. The coefficient related to gender is negative and significant and hence revealing that women are making less profit in cotton farming than men. However, having a separate cotton farm helps women to increase their share of household income by 12% in organic cotton production.

One major reason explaining this difference of profit could be the social organization of farming activities at the household level in the study area. Generally, the household (consisting of husband, wife and children) has a common farm (for food crops and cash crop), managed by the husband and every member (included the wife) is supposed to provide his/her part of labour on that farm. In addition, the wife is given a small plot of land on which she can grow the crop that she prefers. However, she has to contribute labour to the common farm before working for her own farm. Similar household organization framework was described by VON BRAUN *et al.* (1989) in the Gambian rice production system.

In the past, in Benin, women used to grow only food crops and vegetables on their own separate farm. The introduction of organic cotton removed many factors constraining women to grow cotton in the conventional cotton farming system. The difference of profit between women's farm and the common farm can be explained by this social obligation of working first in the household field before performing activities on their own farm. This contributes to lower valorization of women's labour on their own cotton farm.

Conclusion and policy implication

In spite of the lower profit women farmers are making from cotton farming, the income that they generate contributes significantly to the household's needs. To improve the profit women farmers make from organic cotton production, an official agricultural loan policy should be developed specifically for them. This loan can help women to hire labour to accomplish on time farming activities in their separate field. By making the life of women easier, the loan will help to avoid conflicts in the household as women will still be able to provide their share of labour in the common farm. Households should also be advised to handle the possible misunderstanding that might occur as a consequence of increasing involvement of women in their own cotton farm. Developing a model to promote a joint allocation of women labour and land distribution in rural household is necessary.

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IMPACT OF ORGANIC GUARANTEE SYSTEMS ON TRADE IN ORGANIC PRODUCTS[1]

Wynen Els

Eco Landuse Systems, PO Box 1121, Belconnen 2616, Canberra , Australia,
Tel.: +61-2-62583561, E-mail: els.wynen@elspl.com.au, Internet: www.elspl.com.au

Key Words: Organic farming, standards, certification, international trade.

Abstract

The need to meet a range of organic production standards and compliance systems to export to different countries imposes additional costs on producers in exporting countries. Harmonizing these systems would reduce these costs and facilitate international trade. Data on direct and indirect costs of non-harmonization were collected for the wheat and coffee sectors. Analysis using a bilateral trade model implies that the cost of non-harmonization of organic guarantee systems could be up to $US 550 million per year, with benefits going both to producers in the newly certified countries and consumers in the importing country. Producers in countries that already have preferential access, and producers in importing countries, could be disadvantaged as compared with the present situation.

Introduction

The present situation regarding varying standards in organic agriculture, with accompanying certification systems, causes problems for different players in the organic market. Harmonization of standards and certification could alleviate some of these problems by reducing direct costs (for inspection and certification) and indirect costs (related to production and marketing). These costs are incurred by producers and other players in the supply chain, such as processors, wholesalers and retailers. On the other hand, some exporters and producers in importing countries may be disadvantaged by a move towards increased harmonization due to increased competition. Consumers in importing countries can be expected to gain, and those in some exporting countries to lose with increased harmonization, when all effects have worked through the system.

Participants at an IFOAM/ UNCTAD/ FAO workshop in 2002 decided it was important to clarify the potential impact of non-harmonization on international trade flows. This study set out to quantify the effects, especially on exporting countries, of harmonization of organic standards and certification (Wynen 2004). As with most changes, gains and losses would not be evenly distributed, so an analysis of the changes due to harmonization includes not only the gains but also identifies the winners and losers. This paper is a summary of that report.

Methodology/data[2]

GSIM is a single commodity, static model with essentially four simultaneous equations – imports, exports, domestic prices and a market clearing equation that requires global imports to be equal to exports.3 Imports (equation 1) are a function of relative domestic and international prices and total expenditure on the commodity:

(1) $$M_{(i,v),r} = f(P_{(i,v),r}, P_{(i,v),s\,r}, Y_{(i,v)})$$

[1] This work was carried out during employment at UNCTAD, and is a summary of the report available from: http://r0.unctad.org/trade_env/test1/projects/itf/ITFelspaperFinalJulyFormatted.pdf

[2] Thanks to David Vanzetti for help with this section.

[3] GSIM was developed by Joseph Francois of the Tinbergen Institute and CEPR and H. Keith Hall of the U.S. International Trade Commission. The model is documented in a memo by these authors entitled ‘Global Simulation Analysis of Industry-Level Trade Policy’, October 2002. See also Francois, J.F. and H.K. Hall, “Partial Equilibrium Modeling,” in J.F. Francois and K. Reinert, eds., Applied Methods for Trade Policy Analysis: A Handbook, Cambridge University Press: Cambridge, 1997.

where $M_{(i,v),r}$ is imports, $P_{(i,v),r}$ internal prices, $P_{(i,v),s\ r}$ external prices and $Y_{(i,v)}$ expenditure on imports i in country v. Imports are modelled bilaterally, i.e. from one country to another. Because certification costs have a bilateral component, and possibly different from country to country, the change in costs lead to a change in relative prices that drive differential changes in imports from various sources. A bilateral specification is essential for understanding import regimes where some countries have preferential access. An elasticity of substitution parameter determines the extent to which changes in relative prices lead to a switch in the source of imports. [1]

Exports (equation 2) depends on world prices, $P^*_{i,r}$:

(2) $X_{(i,v),r} = f({}_rP^*_{i,r})$.

Domestic (internal) prices (equation 3) are linked to world prices by a price linkage equation:

(3) $P_{(i,v),r} = (1-t_{(i,v),r})P^*_{i,r}$

where $t_{(i,v),r}$ is any factor, such as transport or certification costs, driving a wedge between external and internal prices. These factors are assumed to be expressed as a percentage of the world price, rather than a flat fee per unit. This means tariffs or transport costs of $50 per tonne are divided by the world price and expressed as a percentage.

Finally, there is the requirement that global imports equals global equal exports:

(4) $X_i = M_i$.

To set up the model we first specify bilateral trade flows and associated certification costs. To simulate a scenario, certification costs in specific countries are altered and a new set of world prices are found to satisfy the requirement that global imports equal exports.[2] Once the model is solved new prices, imports, exports, government revenue and producer and consumer gains and losses can readily be calculated and reported. The solution compares two situations at a point in time and does not attempt to show the transition from one state to another or to assess the costs of adjustment. A further simplifying assumption is no changes in stocks. As a single commodity model (for example, wheat), potential linkages between other goods in consumption (for example, oats) or production (livestock) are ignored. In this model, we focus on traded goods and ignore production for domestic consumption, as time did not permit the extensive data collection at this stage. While understating the impacts, some preliminary work shows that extension of the data will not lead to qualitatively different results.

Trade data for the wheat exporting countries were gathered from government or marketing bodies - Argentina (SENASA), Australia (AQIS) and Canada (Canada Wheat Board); certification organization (Hungary); and traders (USA and Slovakia). Especially in the last case – traders – figures may be less reliable than when official figures are published (like in Argentina). For coffee, thirteen main exporters were identified, most of them in Central and South America. Figures from those countries are obtained from CIMS[3], and are likely to be reasonably accurate. Figures for other countries (in Africa, Indonesia and PNG) are from local traders and may be less reliable.

The direct (certification) costs in the different countries were obtained from relevant certification organizations. Costs are different in each country and depend on factors such as whether there is a domestic certifier or in which way the foreign certifier operates (such as through the domestic certifier, a domestic inspectors or foreign inspectors). Changes in costs due to harmonization depend on the original situation.

Because of problems with quantifying the effects of indirect costs, the model has had to resort to a range of assumptions regarding the costs, instead of using actual data. Assumptions were made after consultation with industry, and are shown below.

1 The Armington assumption implies imports from different sources are not the same but merely somewhat interchangeable. This means, for example, that Argentinean wheat exported to the European Union is not perceived to be the same as Canadian wheat. An elasticity of five implies a one per cent change in relative prices is associated with a five per cent change in the quantity of imports.

2 An Excel add-in, Solver, is used to solve this numerical optimisation problem.

3 Centro de Inteligencia sobre Mercados Sostenibles, Costa Rica.

The results of these models could be influenced by the responsiveness of supply and demand to changes in prices. In the model, the values for the elasticities of demand, supply and substitution were taken from UNCTAD's ATPSM-model (for details on values, see Wynen 2004 p.154; p.159 and p.181). As elasticities for organic products may well differ from those of conventional products, a sensitivity analysis was carried out.

Results and brief discussion

Data for international trade, certification costs, and assumptions for indirect costs and elasticities for wheat and coffee for 2002 can be found in Wynen (2004). The estimates of welfare gain with increased harmonization for wheat are summarized in Table 1, and those for coffee in Table 2. The tables reflect the different outcomes depending on the assumptions made regarding combinations of direct and indirect costs. The welfare gains quantify the total net gains, taking into accounts the gains and losses to producers in exporting countries, and consumers in importing countries. As noted earlier, the data doesn't include domestic production in the importing countries and consumption in exporting countries, so no impacts are recorded for domestic producers in importing countries and consumers in exporting countries.

For wheat, column 2 in Table 1 shows that direct costs for producers are included in all scenarios. However, only in option 1 (that is, the first row) are no other costs included, resulting in net welfare gains of US$ 36,500 for the wheat market as it was in 2002. A more likely scenario, although more assumptions were needed, is when the rest of the market chain also gains from harmonization (options 2, 5 and 6). In option 2, the total welfare gains are multiplied three-fold, bringing them close to US$ 119,000 or 0.4 per cent of the total value of the international organic wheat market.

Table 1: Summary of gains through harmonization in organic wheat trade

Option	Direct costs		Indirect costs					Total welfare	
	Producers	Supply chain	Minimal	General	$/farm	$/tonne	% value	US$	%
1	1	0	0	0	0	0	0	36,494	0.1
2	1	1	0	0	0	0	0	119,254	0.4
3	1	0	1	0	0	0	0	224,369	0.7
4	1	0	1	1	0	0	0	334,060	1.1
5	1	1	1	0	0	0	0	307,056	1.0
6	1	1	1	1	0	0	0	416,675	1.3
7	1	0	0	0	500	0	0	232,882	0.8
8	1	0	0	0	0	10	0	1,021,974	3.3
9	1	0	0	0	0	0	10	2,151,115	6.9
10	1	0	0	0	0	0	1	246,259	0.8

Note: 0 = not included in analysis, 1 or other value = included in analysis. Source: GSIM simulations

The rest of the columns in the table (options 3 to 10) are related to assumptions on indirect costs. Including minimal indirect costs without counting the cost to the rest of the supply chain (option 3) almost doubles the welfare gain as compared with option 2. An assumption of more generalized indirect costs across all exporters for all markets (option 4) augments this to 1.1 per cent or US$ 334,000 per year. The same options, but now including the cost to the rest of the supply chain (options 5 and 6) change the gains from harmonization to 1 and 1.3 per cent of trade value, respectively.

Returning to the assumption that only producers have reductions in costs with harmonization, and now also assuming a set figure for indirect costs per farm of US$ 500 (option 7), the gains are not that far from those under option 3. This is not surprising as this is a less refined variant of option 3, with indirect costs being independent of direct costs. The estimates of indirect costs of US$ 10 per tonne of wheat or 10 per cent of total farm gate value (options 8 and 9, respectively) mean considerably higher gains from harmonization, leading to gains of US$ 1-2 million, or between 3.3 and close to 7 per cent of the total value of trade. Option 10 then probes the returns to harmonization under the conditions that costs reach only 1 per cent of total value of farm output. The returns to harmonization then are less than 1 per cent.

The distribution of gains of harmonization is also an important consideration. For wheat, the greatest gains go to those countries that have a combination of high trade flows and high initial total certification costs. This means that, under many of the options of indirect costs, it is especially Canadian and US producers, and the Japanese and Swiss consumers, who gain. Hungary is a major exporter but trades essentially with one market (the European Union) and stands to gain little from measures that facilitate trade between the EU and other countries.

The test to changes in elasticity values for wheat demand and supply records little change in total welfare, although trade flows do vary somewhat. A higher elasticity of demand for organic food than for conventional would also lead to more of the gains going to producers, instead of consumers. In addition, although the magnitudes of trade may change, the direction does not and the implications of the results are quite robust.

The results of the analysis on coffee are summarized in Table 2. The options for coffee were rather similar to those in wheat. That is, the first two options combined indirect costs of 0 with minimal direct costs (option 1), and cost pertaining to the whole supply chain (option 2). Options 3 and 4 combined options 1 and 2, respectively, with indirect costs being equivalent to direct costs. The last two options combine option 1 with indirect costs equivalent to 10 (option 5) and 1 per cent (option 6) of product value. The first option indicates the bare minimum gains from harmonization, when no certification costs are counted for any other operation than the production process, and no indirect costs are present – both assumptions being rather unrealistic. Even in this case, the welfare gains are around 2 per cent of total trade. When the supply chain is included the welfare gains increase to US$ 3.5 million, or over 3 per cent (option 2). When indirect costs are included as equivalent to the direct costs, the gains from harmonization increase again – to over US$ 6.7 million without supply chain certification costs (option 3), and almost US$ 8 million with costs to the supply (option 4). The last two options in the table show the effect of harmonization when the indirect costs are related to returns from farming, assuming an indirect cost of 10 per cent of farm returns in option 5, and 1 per cent in option 6. The results vary between US$8.8 million, or over 8 per cent of total trade, and US$ 3 million, or close to 3 per cent.

Table 2: Summary of gains through harmonization in organic coffee trade

Option	Direct costs		Indirect costs		Total welfare	
	Producers	Supply chain	Minimal	%Value	(US$'000)	%
1	1	0	0	0	2'418	2.2
2	1	1	0	0	3'511	3.2
3	1	0	1	0	6'784	6.2
4	1	1	1	0	7'873	7.2
5	1	0	0	10	8'800	8.1
6	1	0	0	1	3'055	2.8

Note: 0 = not included in analysis, 1 or any other value = included in analysis

Source: GSIM simulations

The largest part of the gains from harmonization would go to coffee consumers, not to producers. However, elasticities have been used that apply to conventional agriculture. If the elasticity of demand for organic coffee is indeed higher than that for conventionally-grown products, more of the benefits would flow to producers. But even with an assumption of a four-fold increase in elasticity (which is not likely) producers in option 4 would still only increase their welfare with US$ 1.6 million after harmonization. A higher elasticity of substitution than used in this model, would prove detrimental to producers. There is no reason to assume that this would be actually the case in the organic coffee market. In this analysis the effects of private logos have not been shown.

Conclusions

With conservative assumptions, the extra welfare in the organic wheat trade, due to harmonization of organic standards and certification, is estimated at over US$ 0.4 million, or 1.3 per cent of the total organic wheat trade (Table 1, option 6). This estimate increases to over US$ 2 million, or almost 7 per cent of the organic wheat trade, if the indirect costs are assumed to be 10 per cent of the total output (Table 1, option 9), with gains going to both producers and consumers in equal parts. For coffee, the conservative estimate of welfare gain is close to US$ 8 million per year - or over 7 per cent of the traded value of organic coffee (Table 2, option 4), increasing to over 8 per cent assuming indirect cost of 10 per cent of output (Table 2, option 5), with most gains going to consumers.

Translating these figures into values for the whole of the organic sector, with the assumptions of farm-gate values being one third of retail values and conservative estimates of indirect costs, would lead to a range in annual gains between US$ 8 million (extrapolating from wheat only) or US$ 550 million per year (extrapolating from coffee only). This is a rather large range. It is difficult to know whether, if all commodities were included, the answer would lie somewhere between or outside those values. In addition, the effect on consumers and producers is different between the two – wheat producers capturing a much larger part of the gains made with harmonization than coffee growers.

These costs of harmonization are calculated on the basis of present trade, and would be higher if the trade had been larger – as can be expected if harmonization had been in place. In fact, it may well be that the real costs of non-harmonization are those of totally lost trade through, for example, experienced exporters not wanting to get involved in the complications of trade in organic products. The numbers are, therefore, more indicative than definitive. Though care should be taken when drawing implications from these results, the magnitude of the figures is such that harmonization of the organic compliance system may well be pursued gainfully.

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MARKET ANALYSIS: IMPROVING KNOWLEDGE ABOUT MARKETS AND THEIR ACTORS

HOW TO BUILD UP INTERNATIONAL STATISTICS ON ORGANIC MARKETS

Prof. Dr. Ulrich Hamm

University of Kassel, Steinstrasse 19, 37213, Witzenhausen, Germany, +49/5542/981285, hamm@uni-kassel.de, www.uni-kassel.de/fb11cms/alm

Key Words: Organic markets, international statistics, data harmonisation

Abstract

There is a strong need and demand from market actors and policy makers for data on organic agricultural markets on all levels from production to international trade to consumption. Market actors need reliable data to plan investigations and policy makers to govern (market) policy measures. However, up to now, there is hardly a country in the world in which up-to-date and valid statistical data exists that goes far beyond simple data on the number of organic farms and their organically managed area. The aim of this contribution is to analyse different strategies for building up a harmonised information system on organic markets leading to data that are comparable between different nations and allowing an overall view of the situation and development of the world market for organic products.

Introduction/Problem

World-wide, markets for organic products are developing fast. Every year, thousands of farms are converted to organic production (Willer and Yussefi 2004). On the other hand, there is also information (e.g. from Austria, Denmark, Italy and the United Kingdom) that some hundreds of organic farms have reverted to conventional farming due to marketing problems for organic products (Hamm and Gronefeld 2004). While conversion to organic production methods is supported by national governments in many countries, at the same time a national programme has been introduced in The Netherlands supporting the re-conversion of organic pig holdings to conventional farming. Re-conversions of organic farms that had previously been financially supported during the conversion period cause losses of welfare, not only of private investments but also of public money. One of the main reasons for the re-conversion of organic farms is that organic farmers have difficulties in selling their products as organic with a sufficient price premium above conventional prices, because there is an over-supply of some organic products in different regions. At the same time there can be a significantly greater demand than supply for the same organic products in other countries, as was the case in Europe (Hamm and Gronefeld 2004). However, valid statistical data on the amounts of organic production and consumption do not exist in nearly all countries so that it is hard for either policy makers or market actors to govern or co-ordinate markets. Thus, there is a strong need – and also a growing demand – for such market data (Michelsen *et al.* 1999).

Some attempts have been made in the past to build up statistics on organic production, demand, trade and prices, e.g. by supra-national institutions such as the FAO or EUROSTAT (the statistical office of the EU), but so far without great success. Even if a few national attempts have resulted in reliable and up-to-date market statistics, these data are not comparable between different countries.

Methodology

The contribution is based on the results of intensive market data collections and analyses in numerous European countries in the framework of three EU-financed projects ("Organic farming and the CAP-reform", "Organic marketing initiatives and rural development" and "European information system for organic markets"). While in the first two mentioned projects the focus was on data collection and analysis, the task of the third project is to develop proposals for the development, harmonisation and quality assurance of organic data collection and processing systems (DCPS). To fulfil this task, several questionnaires for different actor levels have been sent to statistical offices, certifying organisations, organic farmers' organisations, and market research institutes to get information about their DCPS. The results of this extensive survey have been discussed in a European conference (Recke *et al*. 2004a). Additionally, several personal interviews were conducted with statistical experts to discuss possible solutions for internationally harmonised data collection on organic markets (Recke *et al*. 2004b).

Results and brief discussion

While numerous countries have statistics on the organic area and the main utilisation of that area, the number of countries that provide data on the amount of organic production is much less. In a few countries in which the organic market has reached significant shares of total food consumption, some advanced market data are available from different public and private institutions. In Denmark and Germany research projects analysing household and retailer panels with data on organic consumption are supported by public funds. Moreover, Statistics Denmark has made an initial attempt to build up statistics on the sales of some organic products and product groups on the retail level (Danmarks Statistiks 2004) while the German Zentrale Markt- und Preisberichtstelle (ZMP) has provided statistics on farmer and consumer prices for some years (Goessler 2004). Some countries with significant exports of organic products, e.g. Argentina and Australia, also publish data on export amounts by product groups and destination (Cámara Argentina de Productores Orgánicos Certificados 2004; Australian Government Department of Agriculture, Fisheries and Forestry 2004). However, these data are not comparable between different countries as each institution and country has developed its own recording and classification system for organic product categories.

To build up international statistics on organic markets one can distinguish between three different approaches or strategies: For countries already collecting and processing organic market data, the main task of supra-national institutions such as FAO or WTC in developing international market data information services will be to introduce a so-called **ex-post output harmonisation strategy**. In such a strategy a conversion of existing data collections is necessary to get comparable statistics on the international level. However, as has been experienced in former EU projects, this is a very complicated task and sometimes is possible only if vague assumptions of market experts are included.

For countries that have not yet built up a comprehensive system of data collection on organic markets, there are two strategies which can be followed. The ideal strategy is an **input harmonisation strategy**. This strategy means that all countries and institutions follow the same approach in data collection and processing, which must have been elaborated beforehand. Assuming that no or only very few data collection systems exist for the organic market and that many institutions or nations are willing to build up statistics, such a strategy leads to fully comparable data. As laws, political interests, and the willingness and ability to pay the costs for such data collection are very different among nations, long discussions can occur before an international agreement on the kind of data collection and processing process can be reached. However, there are some indications, especially in European countries, that many countries prefer this strategy of an international institution preparing a proposal for a low-cost solution for harmonised data collection and processing method for statistics on the organic market. A second-best strategy could be to follow an **ex-ante output harmonisation strategy**, which means that the harmonisation process is part of the planning of data collection, but taking national differences into consideration. The advantage of such an approach is that each national statistical agency then will develop its own procedures to suit its own circumstances. However, it may take several years until most countries have built up their own modified data collection systems.

The highest degree of comparability of data from different countries can be reached by an input harmonisation strategy. As many countries in the world have not yet invested too much money in building up their own statistics on organic markets, the so-called strategic window to follow such a strategy may still be open. However, far-reaching decisions on how to build up statistics must be then made very quickly, because an international agreement on collection and processing of statistical data will be all the more difficult, the more countries that have built up their own systems in the meantime.

Not only the strategy of data collection but also possible data content and the amount of the data collection on different actor levels have to be discussed. To obtain data on the quantity of production of organic products in different product groups, different data sources can be used. The most accurate database for the quantity of production could be the data of controlling/certifying bodies, as organic production underlies a certification process in nearly all countries of the world. However, in the majority of countries certifying bodies are private firms and in many countries there are several such bodies, making it complicated to obtain data on a national basis in a uniform system. Only a few countries, e.g. Denmark, have only one certifying organisation. To oblige certifying bodies to deliver their data to national or international statistical offices in a unified data reporting system imposes an additional workload on them, and there remains the question of funding and quality assurance for such a system. Another possibility to obtain data on the amount of production followed by a few countries in Europe is to use data from different official sources. This can be data on the utilisation of the area and the number of animals in organic farms coming from sources such as farm structure surveys (FSS) or statistics on support schemes for organic production combined with data on average yields of organic farms coming from bookkeeping statistics such as the farm accountancy data network (FADN) in Europe. However, regarding farm structure surveys or statistics on support schemes, making a clear distinction between converted and not converted land or animal husbandry is a severe problem in most countries in which the conversion of parts of a farm is allowed. Regarding national bookkeeping statistics only a small number of organic farms are included in nearly all countries, so that the representativeness of these data is not given at all. Another weakness of data coming from national statistical offices (e.g. from FSS or FADN) is that they are often not very up-to-date, but have a delay of two or three years, so that they are not very interesting for market actors or policy makers.

On the processors' and wholesalers' level, in most countries the only possibility to receive accurate data about organic products again is certification bodies. Until now there is no country in which data on these levels are systematically collected from certification bodies. The same holds for foreign trade in organic products. In trade unions with supra-national domestic markets (such as the EU), data on the so-called intra-trade between countries of the trade union cannot be collected, as no certification body knows in which country of the trade union's the products are finally sold.

On the retailers' and consumers' level, where certification bodies do not control the flow of goods, data on organic products are only available through private market research companies running panel surveys. In a few countries with large organic markets, as e.g. Denmark, Germany, Netherlands, Switzerland or the United Kingdom, panel surveys for organic products are conducted by big market research companies such as AC Nielsen or GfK. However, even if one of these companies runs panel surveys in several countries, the classification of products is different from country to country. Taking this into account, as well as the high cost of panel surveys, it seems unlikely that panel surveys on the retailer or consumer level can be used as international information systems on organic markets in the near future.

Another important field to increase market transparency for organic market actors is to build up price statistics on different levels of the supply chain. However, on a supra-national level, this is a very difficult task as experienced for conventional and organic products in different EU projects (Hamm and Gronefeld 2004, Kristensen *et al.* 2004). In most countries no valid data exist on the processor or wholesaler level. Even if detailed data are available on a national level, e.g. on organic producer prices in Denmark and Germany, they are not comparable because of different product classifications and/or pricing methods. For the latter a simple example can illustrate the problem of price comparisons between countries: In some countries, only preliminary basic prices are paid to organic farmers when they sell their products to farmers' marketing organisations, processors or wholesalers. Depending on the marketers' sales revenues, an additional price premium is then paid to farmers at the end of the year. These price components are often not included in statistics on producer prices. Thus, a lot of expert knowledge is needed for building up international price statistics. As representative data on prices can only be collected in expensive price surveys, it seems too ambitious to build up international price statistics in the near future.

Conclusions

There is a strong need for better statistics on organic markets. As long as national governments subsidise organic production, and in some European countries the demand for organic products too because of the environmental benefits of organic production systems, policy makers must know whether supply and demand of organic products are in balance or not. If the stimulation of supply results in an over-supply of organic products and additional price premiums over conventional products cannot be expected by organic farmers, they will re-convert their organic farms to conventional agriculture, as long as governments are not ready to pay for all additional costs of an organic production system. The lack in market transparency for organic products causes losses of welfare every year, not only in individual nations but also world-wide, as international trade cannot be developed by market actors in a proper way. Thus, the reporting of organic market data needs to be mandatory, with the methodology and definition of product categories fully harmonised so that international statistics for organic products can be provided.

Since in all countries organic products undergo a certification process during which data on production and processing are collected, an easy system to collect some market data would be to oblige all certification bodies to deliver their data to national statistical institutions in a systematic way (input harmonisation strategy). Some resistance of certification bodies can be expected, as they then have additional costs for processing their data in a uniform way and delivering these data to a central national agency. Certification bodies should therefore be funded for their extra workload. To keep the additional workload for certifying bodies as small as possible, uniform electronic data collection tools should be developed by international organisations. With the help of data collected by certification bodies it would be possible to obtain data on organic production, processing, and international trade. Market experts could then try to estimate national consumption using data on production and international trade. However, without additional information on the amount of organic products sold on the conventional market, satisfactory estimations on consumption will not be possible, as high percentages of some organic products are still not sold as organic (Hamm and Gronefeld 2004).

For the near future, international statistics on consumption or prices cannot be expected, as the necessary surveys are very expensive. However, in some countries with big organic markets there are private market research institutes offering these services, but at a high cost. A further ambitious step could be the introduction of an identification system that gives one identification number to all market actors dealing with organic products in every country. Such a system already exists in Denmark for all private firms, organic and non-organic.

A uniform system of data collection and reporting for organic markets all over the world would have huge advantages: First, market transparency would be enormously improved for all market actors and policy makers, so that their decisions would be made under higher levels of certainty. Secondly, a remarkable result would be that it would be much easier to detect cheating in international trade by comparing production and trade data between different nations.

Acknowledgments

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Assessing the Effectiveness of Sales Promotion on Organic Products

Ulrich Hamm & Sandra Wild

Dept. of Agricultural and Food Marketing, University of Kassel
Steinstrasse 19, 37213 Witzenhausen, Germany, +49 5542 98 1287, swild@uni-kassel.de,
http://www.uni-kassel.de/fb11cms/alm

Keywords: market research, food retail, sales promotion, organic products

Abstract

This paper presents and comments on basis data for point of sale marketing on organic products. The research on promotions to date has been directed only towards conventional products. Therefore, the main issue of the study is to offer an overview of sales promotion instruments as well as evaluating different kinds of sales promotions and improving their effectiveness for organic products. The research addresses the optimal design of a series of promotions, which especially approach non-customers and occasional customers of organic products. This study is based on a quantitative empirical method which allows the comparison of sales promotion effectiveness for organic food in food retailing and specialised organic food retailing. Besides that, the study provides producers as well as retailers with an appropriate performance rating of their organic product sales promotion.

Introduction

Latest studies in Germany show that an increasing demand for organic products can only be achieved through a targeted address of occasional customers (ZMP 2003) as well as winning potential new customers. Promising methods to bind occasional customers and introduce potential new customers to organic products are sales promotion activities in retail shops (Shimp 1993). Sales promotion consists of all marketing activities that attempt to stimulate quick buyer action and promote immediate sales (Gedenk 2002). Whereas for conventional products a number of sales promotion effectiveness studies exists (e.g. Hoch et al. 1994, Schmalen et al. 1996, Ailawadi et al. 2001), there are currently no comparable, comprehensive surveys for the organic food segment. Because conventional findings cannot be transferred directly to the organic market, the basic approach of the study is the collection of data to show which sales promotion activities in specific organic product categories reach ascertained sales quantities and turnovers. This quantitative data collection has been carried out in conventional food retailing as well as in organic food retailing. Furthermore, a main goal of the approach is to evaluate the relevance of these sales promotion activities for the segment of occasional customers. For that reason an accompanying survey was carried out, in which in addition to the quantitative sales data collection, customer perception and customer attitude concerning in-store sales promotion were ascertained.

Methodology

Based on empirical findings on conventionally produced food, the study is designed to investigate the effects of price and communication elements of sales promotion as well as tasting actions at the point of sale. The analysis took place simultaneously in 24 conventional and 11 organic food retail shops over a period of 18 weeks to measure short-term and middle-term sales impacts. A detailed examination of the following combined sales promotion activities took place:

- Promotional tasting activities with or without the assignment of promotion personnel
- Sales promotion activities with or without price reductions up to 10% (considering price thresholds)
- Sales promotion activities with or without using promotional material such as displays, posters and/or additional product placement.

These sales promotion activities were combined and tested in a rolling system in the participating retail shops. Bases of the test are the buying acts, which were recorded by merchandise information systems (scanner data) over a period of 18 weeks. The identification of the relevant performance data was carried out on the quantitative and value sales development, not only for the period in which the sales promotion activities took place but also before and after the activities were undertaken. This allows statements of short-term impacts as well as sustainable impacts on sales development. To achieve valid objectives, the study had been limited to analysing three organic products which customers buy in relatively frequent intervals. Additionally, the following criteria were fundamental:

- The organic products had to be obtainable both in conventional and organic food retailing.
- The test products had to be originally from Germany.
- The chosen organic products had to be produced from raw materials, for which at least occasionally the supply exceeds the demand.

Based on these terms, organic frankfurters, unfiltered organic apple juice and organically produced vanilla yogurt were chosen as test products. Besides the analysis of possible sales impacts on the three test products, the study evaluates substitute and cannibalism effects inside the equal product categories as well as equal conventional and organic competing products. From this, implications follow on applicability of sales promotion activities to increase total sales and total turnover.

In addition to the quantitative data collection, the study contains post-purchase consumer interviews. This allows differentiated insights into sales promotion perception and customer attitudes towards sales promotion activities. In doing so, a distinction is drawn between regular, occasional and non-organic customers to deduce specific measures from these results to bind occasional customers and win previous non-customers.

Results and brief discussion

The statistical evaluation and the data interpretation are currently being undertaken. For that reason, only a short overview of the promotional impact on the averaged product sales for the test products in the 24 conventional retailers can be given. The regression results as well as results which show the impact of sales promotion activities on sales of competing or substitute products are currently not available, but will be for the conference. Table 1, row 1 summarises the increase of sales as a percentage of sales in the weeks before and after the sales promotion activities took place. As indicated in this table, the short-term incremental sales volume that was generated in the promotion week was immense. The results show that sales promotion had a significant impact on product sales for all promoted organic products. An average comparison over all 24 test shops shows clearly higher weekly sales with the assignment of sales promotion. The volume of goods sold during the promotion increased up to 841% for unfiltered apple juice, 2250% for frankfurters and 1282% for vanilla yogurt.

Table 1: Averaged sales increase of promotional tasting measures as a percentage of sales in the weeks before, differentiated in activities with or without the assignment of promotion personnel

	total sales increase	sales increase of promotional tasting activities with the assignment of promotion personnel	sales increase of promotional tasting activities without the assignment of promotion personnel
unfiltered apple juice			
sales promotion week	841	1525	457
post sales promotion period	45	75	14
frankfurters			
sales promotion week	2250	3250	1250
post sales promotion period	100	100	100
vanilla yogurt			
sales promotion week	1282	1650	650
post sales promotion period	64	54	63

Source: own elaboration (number of conventional retailers = 24; data = sales increase in percent, based on the pre sales promotion period)

An issue that arises in connection with such sales promotion data is the relative advantage of scheduling promotions to coincide with seasonal periods. Within this study, seasonal periods as well as weather conditions had been considered as disturbance variable. Scatter diagrams for every single test shop and over all 24 test shops showed that such disturbance variables can be excluded. Furthermore, additional sales promotion activities for the three test products during the period of this study can be excluded. Therefore, sales increases are caused by the tested promotion combinations.

Besides the consideration of the total sales development over all 24 conventional food retailers, the main purpose of this study is assessing the effectiveness of individual sales promotion elements. Table 1 (row 2 and 3) displays sales increases differentiated in promotional tasting activities with or without the assignment of promotion personnel. As indicated, promotional tasting activities with the assignment of promotion personnel show a higher impact on the sales development as tasting without personnel support at least within the promotion week. The sales growth for organic frankfurters differs from 1250% for tasting activities without the personnel support up to 3250% for sales promotion activities, which contain the element of the personnel supported tasting. Both other test products show similar results. For organic vanilla yogurt the sales growth lies between 650% and 1650%, for unfiltered apple juice between 457% and 1525%. The results show significant differences between those two promotional elements.

Less distinctive effects appear on examination of the middle-term effects of sales promotion. The data analysis of the post-promotional period indicates a sales increase of up to 100%. According to this, sales promotion directly effects the middle-term sales development in a positive trend. In contrast to the sales effects of the promotion week, no distinctive differences exist between personnel supported or non-supported activities. Middle-term sales effects for organic frankfurters are equal for both types of activities measured. The post promotional sales development for organic vanilla yogurt indicates a higher impact of non-personnel supported sales promotion. The sales growth for organic unfiltered apple juice differs however from 14% for tasting activities without the personnel support up to 75% for personnel supported sales promotion.

The additionally accomplished post-purchase consumer interviews allow an evaluation of background information about sales promotion perception and customer attitudes towards sales promotion activities. Over the period in which sales promotion activities took place, 1113 customers were interviewed. 626 of them were category buyers which means that they bought products in one of the product categories which correspond to the test products. 176 of the 626 customers bought one of the test products. Only 38% of the category buyers perceived sales promotion activities for the three organic products. Table 2 indicates differences in sales promotion perception depending on consumer organic purchase patterns and displays the percentage of category buyers, who changed their buying intention after perceiving sales promotion differentiated after organic purchase patterns.

Table 2:Differences between regular, occasional and non-buyers of organic products with regard to sales promotion perception and number of test product buyers

perception of	All category buyers (%)	Category buyers which are regular organic buyers (%)	Category buyers which are occasional organic buyers (%)	Category buyers which are non-organic buyers (%)
perception of sales promotion for the organic test products	38	46	37	30
perception of sales promotion for the test products, but not of the organic quality	1	1	2	0
perception of sales promotion activities, but not for product category or brand	3	0	5	1
no perception of sales promotion	58	53	56	70
test product buyers, who changed their buying intentions after perceiving sales promotion	25	37	25	12

Source: own elaboration (number of interviewees = 626, data = in percentage of all category buyer)

46% of regular organic customers perceived sales promotion for organic products. In contrast to that, 37% of the occasional organic customers and 30% of non-organic customers have been reached by sales promotion activities. Even though only 37% of the occasional organic customers and 30% of the non-organic customers were reached by sales promotion at all, one can conclude that sales promotion activities are more promising measures to address customers within this target group than other marketing activities. Therefore, sales promotion can tend to result in binding occasional and winning previous non-customers. To deduce specific measures to bind occasional and non-organic customers, a differentiated view of sales promotion perception is needed. 60% of the category buyers were able to name tasting activities with or without personnel assistance as one of the promotional measures in an unaided recall. 10% of the interviewees perceived the communicational elements and only 4% indicated that they have realised price reductions for organic products in these conventional food retailers, where the corresponding measures were carried out. The quantitative data, shown in Table 1, reflects this high perception of tasting activities with personnel support. The varying sales impacts of promotional activities with and without personnel support are allegeable with the estimation of these two promotional measures. Another important result of the additional consumer survey showed, that most of the interviewees identified "no tasting personnel" as one of the points they most of all disliked within the promotional activities. Besides the evaluation of the sales promotion perception, this study analyses the effects of sales promotion on customer purchase decisions. 23% of the interviewed category buyers had no intention of buying frankfurters, unfiltered apple juice or vanilla yogurt before entering the participating food retailer. 33% intended to buy products from the corresponding product category and 38% indicated purchasing a different brand. Only 4% planned to purchase products of organic quality. 86% of the 176 test product buyers changed their buying intention after perceiving sales promotion. Their valuation of being able to taste organic products before making a purchase decision was exceptionally high. This indicates the high impact of promotional tasting activities on total sales and its influence on customer purchase behaviour.

Conclusions

The approach presents the possibility and the advantage of quantifying sales promotion effects on bases of scanner data. Additionally, the post-purchase consumer interviews allow an evaluation of background information about sales promotion perception and customer attitudes towards sales promotion. The study's findings show that sales promotion directly influences sales increases of organic products by attracting customers, especially by attracting occasional and non-organic customers. An average comparison over all 24 conventional test shops shows clearly higher weekly sales with the assignment of sales promotion, the volume of goods sold during the promotion week increased up to 2250%. Besides the positive short-term development, increasing middle-term sales were recorded. Distinctive conclusions to what extent a certain sales promotion element affects a certain middle-term effect cannot be drawn without further analysis. First results from the post purchase consumer interviews show a high perception of sales promotion for organic products especially within the target group of occasional and non-organic customers. A conjunction between quantitative and qualitative data indicates that especially promotional tasting activities with the assignment of promotion personnel contribute to shopping enjoyment and awareness of organic products. Both factors positively influence the purchase decisions made by occasional and non-customers of organic products in conventional food retailing and due to this fact positively influence the sales development. Based on these research findings, one can conclude that marketing activities, such as sales promotions, are an important key to enlarge sales of organic products in conventional food retailing.

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ORGANIC MARKET INITIATIVES AND RURAL DEVELOPMENT – PERSPECTIVES AND POTENTIAL

Otto Schmid and Juern Sanders (1), Peter Midmore (2)

(1) Research Institute of Organic Farming (FiBL) , Ackerstrasse, CH-5070 Frick, Switzerland
Email: otto.schmid@fibl and juern.sanders@fibl.ch, www.fibl.org
(2) School of Management and Business, University of Wales, Aberystwyth, Email: pxm@aber.ac.uk,
www.irs.aber.ac.uk/OMIaRD

Key words: market initiatives, organic agriculture, rural development

Abstract

In the three year project "Organic Marketing Initiatives and Rural Development (OMIaRD)" the analysis of 67 OMIs (Organic Marketing Initiatives) showed that internal business-related factors are generally much more decisive for success than external, context-related factors. The detailed analysis of the impact of OMIs on rural development in four case-study regions (AT, FR, IT, UK) showed that not only are economic factors (e.g. employment effects and capital flow in the region) relevant but "soft" factors are as (or even more) important. However, policy-makers, especially at regional level, need to become more aware of the valuable benefits of OMIs for sustainable rural development and must take this sufficiently into account when enhancing support measures.

Introduction

Since the early 1990s, organic farming has experienced rapid growth in Europe due to increased financial support, rising market demand and growing consumer awareness. Over the last 30 years, collective initiatives of organic farmers have become a common form of marketing in the organic food sector. At the outset these initiatives were often essential in order to find markets for organic products, but now farmers participate in them to pool ideas, capital and skills and to increase the added value of products and their market power within the supply chain. As marketing problems increase for small producers in less-favoured areas, such initiatives will gain even more importance in the future.

Methodology

These collective marketing approaches were the main focus of the Organic Marketing Initiatives and Rural Development (OMIaRD) project, a shared-cost research project funded by the Quality of Life and Management of Living Resources Programme within the European Union's Fifth Framework Programme for Research and Technological Development. It ran from January 2001 to February 2004 and involved 10 partners and 11 subcontractors from a total of 19 European countries, both within and outside the EU. Deeper insight into the conditions in which OMIs operate successfully comes from a detailed analysis of OMIs from 67 case studies in 35 European regions, involving OMI managers as well as external experts. Selected using common criteria, these regions were grouped into LFAs (less favoured areas) and non-LFAs (of which some had favourable conditions and others unfavourable).

Results and brief discussion

The assessment of the OMIs surveyed showed that internal business-related factors are more decisive for success than external, context-related factors. Yet in some cases external factors - such as special demands in a small limited ("niche") market, policy support measures - can improve their potential. The analysis made clear that the vision of the founders, their strategic options and their management choices primarily determine an OMIs success, in particular the adaptation of strategic objectives to changing market and political environments during different phases of development. Also, maintaining the motivation of members and other internal and external cohesion factors are major challenges to achieving not only economic but also wider social, environmental and political goals (Fig. 1).

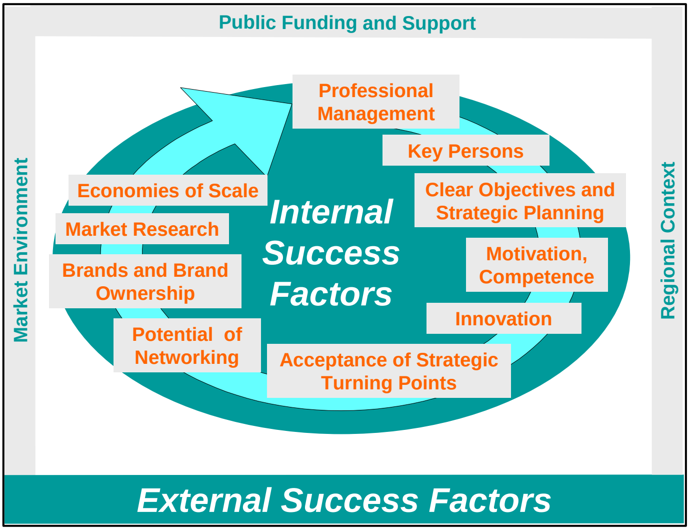

Figure 1. Internal and external success factors

A basic assumption of the analysis is that the choice of different objectives has a crucial impact on the OMI's strategies and consequently on their successful development. It became apparent that OMIs aiming for social or environmental objectives tend to underestimate financial needs. In particular, such OMIs lack competency in financial management, in contrast to those with clear economic objectives. On the other hand, OMIs focusing mainly on economic objectives tend to neglect both human relations and regional networking. One of the key challenges is how the OMIs operate in different life cycle phases: the right decision on a strategic level as well as on the operational level might be quite different at different phases of the initiative's development.

Detailed analysis of the impact of OMIs on rural development in four case-study regions, using qualitative interviews with 15-20 different actors and stakeholders in the regions, showed that not only economic factors but also "soft" factors are relevant. The OMIs in all case studies (two pasta projects in Italy, a vegetable box scheme in the UK, a dairy in Austria and a meat initiative in France) achieve their social and environmental (and sometimes also political) objectives effectively, though on a rather small scale, for example by enhancing the status of farming, preventing abandonment of the countryside and improving the image of the region. However, policy-makers, especially at the regional level, need to become more aware of the valuable indirect benefits of OMIs for sustainable rural development and take this sufficiently into account when designing and enhancing support measures.

Although OMIs have considerable potential to contribute to sustainable rural development, this is far from being realised. A range of approaches can help OMIs both to prosper and to increase their contribution to achieving such general aims. The policy framework can facilitate development and expansion of the producer-led marketing of organic products in order to achieve integration and additional benefit. CAP reforms in 2003 provide new resources for Rural Development Plans of member states, allowing them to support quality enhancement by groups of farmers (specifically identifying organic farming as eligible). However, financial support for joint action by farmers to improve quality in marketing and processing of their products is a necessary, but certainly not a sufficient; condition for OMIs to perform successfully. Policy support for the development of OMIs is limited to actions that remove barriers to development, or improve the conditions in which they operate. For consistent and sustained development, the ideas and effort must come from organic producers themselves and the communities in which they are embedded.

However, success is seen in more general terms as combining effectiveness (formulating and achieving strategic objectives in line with initiators' expectations) and efficiency (achieving objectives while maximising output or minimising costs). This relates to the capacity of OMIs to set and achieve relevant economic, social and environmental objectives, and to manage internal resources in a manner which minimises costs for a given output (or maximises output for a given cost), taking into account changing market and policy conditions.

Conclusions

A range of factors should be considered by policy-makers as well as OMI managers when formulating strategies to exploit potential more effectively and overcome limitations: considering market potentials and limitations; retaining and strengthening the ethical basis when growing; dealing with increased competition; reducing supermarket dependency through diversification; deciding for or against export; responding to the growing demand of convenience food; improving the price / cost relation. Other key factors to take into account are communication policy and supply policy with regard to product quality management. Some simple options OMIs should consider include: improved decision-making processes and management skills; realistic finance policies; cooperation with conventional agriculture and other supply chains as well as with organic food and farming organisations; improved vertical networking along supply chains; and horizontal networking in regions.

The recommended policy support measures are: improved market transparency; support for knowledge transfer and advice; financial support for OMIs and organic farmers; consumer information and education; more public procurement of organic products; facilitation of cooperation and networking; research and development projects (Fig. 2). Table 1 outlines possible support measures (Schmid, et al., 2004).

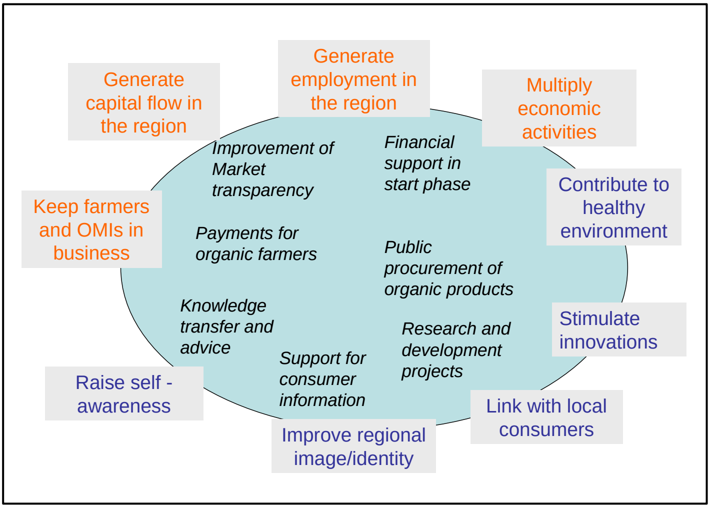

Figure 2. Appropriate policy support measures for OMIs

To conclude, several OMIs, by improving their business activities and the environment in which they operate, can go further to achieve social and ecological goals and become a model for sustainable rural development. For both market-related and rural development-related activities, there is interesting and challenging potential for development and this can present real opportunities for OMIs.

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Table 1 **Suggested support measures**

Supporting knowledge transfer/ advice	Knowledge building among OMI and training measures for managers: exchange programmes and visits to increase awareness of national/international benchmarks. Facilitate the development of an entrepreneurial culture, e.g. co-finance coaching activities, sending trainers around the various OMIs. Funding initial business consultancy services to ensure that support is based on sound analysis of market opportunities. Agricultural schools training on: business management skills, organic food marketing. Vocational training for farmers, especially for OMIs with networking facilities.
Facilitating cooperation and networking	Public funding: encourage and facilitate OMIs to build up vertical alliances/cooperation along the food chain. Regional development agencies and consultancy services: assist OMIs and producer organisations in networking in the region and along the food chain. Support via regional policy: assure coexistence of organic and GMO farming. Regional territorial approaches to organic agriculture: integrated into national organic action plans (e.g. as in United Kingdom and Spain).
Support for consumer information	More consumer information: confusion concerning organic and non-organic products. Consumer education campaigns: appropriate information material, farm visits, events Transmit to the consumer the intrinsic/added value of the OMIs' products and the ethical dimensions of organic farming. Schools: raise awareness/enjoyment of organic food and the rural development dimension of organic farming. Support for good school programmes on farms Promote local organic products using regional logos/labels or support for local projects.
Research and development	Targeted support for research projects: e.g. for small-scale processing, developing high quality organic food. Establish trans-national network of producer initiatives that market organically produced primary products: "organic food and farming observatory" to coordinate efforts.
Procurement of organic products	Public procurement of OMI products: increase public awareness, open new sales channel for OMIs. Developing organic catering in public and private schools Limiting transport miles/distances by means of taxes: encouraging local sourcing.
Financial support mainly in start phase	Clear objectives and clear criteria (e.g. multiplier effects, degree of innovation, self-financing capacities). Condition: appropriate business plan <u>and</u> a networking plan (ensuring active involvement of stakeholders / regional actors). Different support: research and development, marketing communication measures, networking, risk management and investment. Generally be limited to the start-up phase. Use tax and VAT reduction strategies and Eco-taxes to promote organic food. Less bureaucracy:–I Introduce a "fast-track" (efficient and quick) support policy for OMIs: motivating and not de-motivating!
Improving market transpar-ency	Harmonise standards without being over-prescriptive: account for regional variation Improving the regulatory framework: increase trace-ability, create more transparency (at national and even more at trans-national level). Clearer regulatory framework on labelling: make OMI products more visible. Market transparency: enhanced by consistent and stable statistical systems over the whole food chain (international, European and national level). Inspection and certification: facilitate more risk-based systems because of the small size of OMIs (reduced workload and lower costs).
Financial incentives for organic farmers	Organic farming support schemes: coordinated with a long-term perspective, better balanced between supply and demand. Compensate "real" public good and services of farmers: e.g. payments for landscape and biodiversity measures, high animal welfare, etc.

THE FACTORS OF SUCCESS FOR ORGANIC MARKETING INITIATIVES IN EUROPE: A RESOURCE BASED APPROACH

Sylvander B. (1), Le Floch-Wadel A.(1), Couallier C. (1)

(1) INRA, Chemin de Borde Rouge, 31326 Castanet Tolosan Cedex, sylvander@toulouse.inra.fr

Key Words: Organic Farming, strategic management, marketing, resources based view

Abstract

This paper explores the factors of success for Organic Marketing Initiatives in Europe. It is based upon the results of the OMIaRD project, which aimed to assess the impact of the Organic Marketing Initiatives on Rural Development1. The results show that many studied OMIs meet strategic problems linked to their ability to face an increasing of collected, processed and marketed volumes. Those problems can be considered as a strategic turn point and might lead them to perceive the necessity to better manage their growth.

Introduction/Problem

The market for Organic Farming (OF) is growing both at the world and the European level. In most of the European countries, consumer demand is still growing. In northern Europe, the political institutions and professional bodies provide financial support to farmers and promotion campaigns. However, several southern countries – excepted Italy - have a lower growth rate, due to weaker political support (Spain, France, Portugal). Import is often necessary to compensate this low production. There are strong evolution potentials, based mainly on public policies (strategy push) and marketers strategies (strategy pull) (Hamm et al. 2004). However, several hinders have been identified : too high price premium at consumers' level, lack of availability of the products and lack of information. This is confirmed by most of the market surveys (Zanoli, 2004). In the present framework of the today's OF sector, it seems quite important to better understand it's development conditions and, thus, better understand the factors of success of the OMIs.

A subpart of the OMIaRD2 project was devoted to analyse the success factors of the Organic Marketing Initiatives, which are often small and medium enterprises. The aim of this communication is to present the main results of this study.

Methodology

Organisational economists of the 1950s, seeking to define the circumstances under which economic optimum and social welfare could be achieved, developed the Structure-Conduct-Performance paradigm (SCP). The aim was to identify and stamp out anti-competition practices such as the imposition of entry barriers or monopolies. For a long time the firm had remained out of the research field, although the basic postulate advanced by Coase (1937) had altered the way we view the firm, which was defined as an organism whose internal structure and relationship with the outside world change over time. During the sixties and seventies, this new conception of the firm has developed rapidly. In emphasising the importance of the firm's decision-making capacities Simon is emphasising the importance of its internal resources. Similarly, Barney and Hesterly (1996 :133) claim that the SCP paradigm gives too much weight to the firm's environment: "However, the attractiveness of an industry cannot be evaluated independently of the unique skills and abilities that a firm brings to that industry". The research in management experienced the same evolution. Penrose (1963) stressed that the internal skills was a determinant factor to explain firm strategies, followed by Wernerfelt (1984) who launched the stream of a "Ressource Based View " of the

[1] An OMI is defined as an "organisation of actors, privately or cooperatively owned, involving participation of organic producers which aims to improve the strategic marketing position of the products by adding value to the raw product through processing or marketing".

[2] The Organic Marketing Initiatives and Rural Development project is a shared-cost research programme, funded by the Quality of Life and Management of Living Resources Programme, part of the European Union's Fifth Framework for Research and Technological Development. It was taking place from 2001 to 2003, and involved 10 partners, who studied (in certain cases by subcontracting) 19 European countries, within and outside the EU. See the website : www.irs.aber.ac.uk/omiard.

firm. This movement stands clearly in opposition with the porterian view, which focuses on market and competition for accounting of the firm's strategy.

The first survey aimed to identify and characterise the OMIs through an extensive survey all over Europe, gathering as many firms as possible in all countries. From the 196 identified OMIs, we selected 35 regions and 81 OMIs, where an intensive survey was carried on, analysing the relevant variables to explain economic and social success (Sylvander and Kristenssen, 2004). Out of this sample, 67 relevant OMIs has been kept for further research. A questionnaire has been filled by the partner teams in order to assess if the success factors are or not linked to external market and policy conditions or rather to internal competencies and resources. The present communication is based on the second survey.

The purpose of this paper is to test the following hypothesis : is the success more linked to external conditions (national, regional, market context) or to firms' internal competencies (including managers' competencies in networking and the OMIs characteristics). We made assumptions on the main "factors of success", on the basis of previous research (Barjolle and Sylvander, 2002) and wanted to ascertain whether these factors are correlated with success. All variables (including success) were estimated by the investigators on a Likert scale. We distinguished external and internal factors ; External factors relate to the overall institutional context, to the sector and the market conditions (organic sector and sub-sector to which the OMI belongs) and to specific regional context1. Internal factors relate to the OMI itself, that is, the OMI's own capacity to conduct an effective and efficient development policy (marketing, supply, processing and logistics, finance, organisation and networking).

Success is defined as the achievement of both ethical objectives (environment, animal welfare, landscapes) and economical ones (profit making). This variable, directly deduced from the survey, consist of four success groups, which played as variables in the further factor analysis. *Success group 4* is made up of the OMIs achieving clear ethical and economic objectives. It is the largest group with 29 OMIs, or 44% of the population under study. *Success group 3* is made up of OMIs achieving clear ethical objectives and which break even or make a loss. This grouping is consistent insofar as the economic objective is not paramount for the OMI. However, we can distinguish two sub-groups: one for which economic survival is not an issue and the other for which the OMI's position is a source of concern, even if economic objectives are not among the stated priorities for the OMI. *Success group 2* is composed of OMIs achieving mostly economic objectives and whose financial situation is balanced or positive, which corresponds to the objectives set and achieved by these OMIs. *Success group 1* is made up of OMIs achieving neither clear economic objectives nor clear ethical objectives. In addition, these OMIs are very largely in the "break-even" category and in one instance "loss-making", which is consistent with their stated objectives.

As we had to process discrete variables, we performed a factor analysis using as variables : the success groups, the external and the internal factors[2], with OMI characteristics as passive variables. This enabled us to identify the determinant variables for success.

Results and brief discussion

The explained variance is 32% on two axis (axis 1: 17%; axis 2: 14%). The factor analysis enables us to determine which the determinant variables for success are.

1. Axis 1 orders the success factors mainly focused on internal policies, quite common in business management. Among them, we can underline the role of processing and logistics policies first of all and secondly of supply policies ahead of environmental variables where market conditions for raw materials feature clearly. In addition, the only OMI characteristic appearing as a passive variable is the age of the OMI, which asserts itself as an additional factor. This shows that the other characteristics, even if they have some influence, are comparatively insignificant. This axis contrasts success group 4 (OMIs achieving their economic and ethical objectives, on the left, positive scores) and success group 3 (OMIs achieving only ethical objectives, negative scores). For OMIs in group 4, which are often in intermediate areas, success is, nonetheless, not determined by the region. An OMI's success has little to do with its location, because it sets

[1] This regional context is related, among other aspects, to the Less Favoured Areas (LFA), as shown in the figure 1.

[2] We excluded marketing and product policies, which are not discriminatory, and the "special cases" success groups which are deviant.

objectives and implements resources that are able to offset the drawbacks of difficult regions and to make the most of the assets of favourable areas.

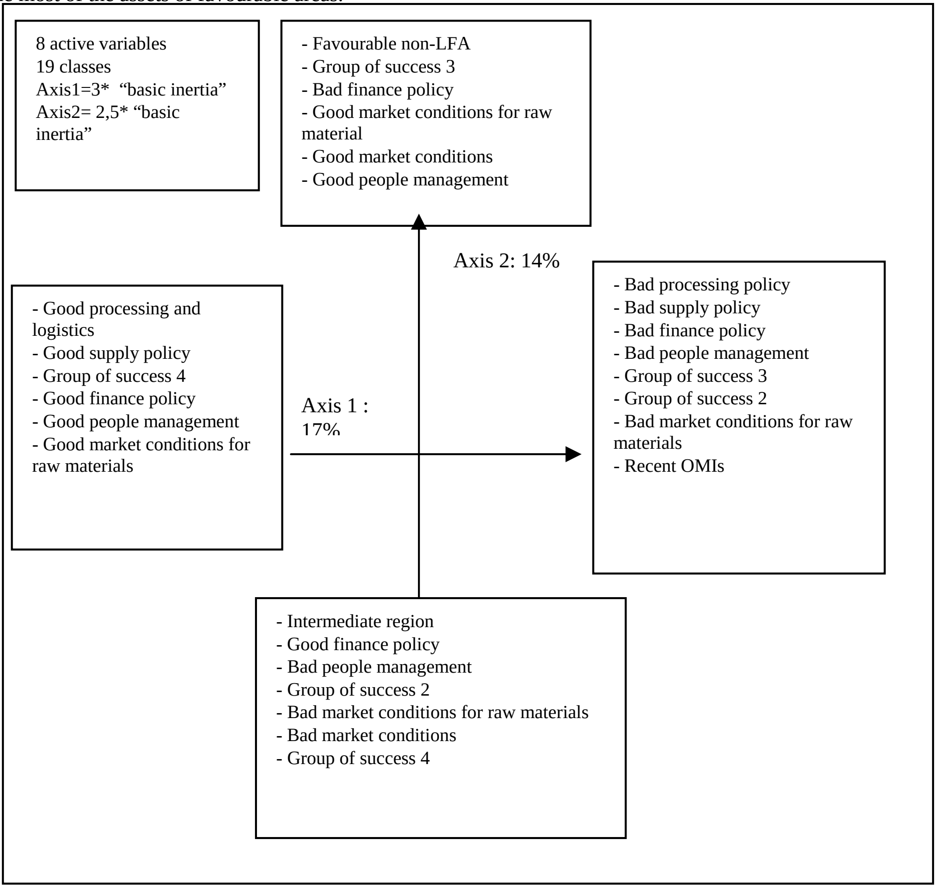

Figure 1 : factor analysis on success factors

Even though the markets for the different sectors of Organic Farming and the countries under study have to cope with different situations, it can be seen that OF is growing throughout Europe. The prominent image of organic products with consumers means that the market can exert "marketing pull" and the technical and economic impediments to expanding output help emphasise the qualitative and quantitative problems of supply for firms. In addition, there are many factors to explain the importance of the logistics issue: low output and marketing levels, remoteness from consumer regions, freshness of many organic products that are marketed (milk, fruit and vegetables, meat), requirement for some OMIs to manage varied assortments (multi-products) and high distribution costs. Finally, processing seems a crucial point: it helps to regulate the quantities available upstream, to stabilise fresh products and generate added value (as with dairy produce and meat). It is unavoidable for some products: drying aromatic herbs, drying and storing cereals, sorting and grading fruit and vegetables, etc. After setting up OMIs, which are often founded on a philosophical and political vision of the world and sometimes on direct contact with the consumer, managers realise that the technical management of supply (in quality and quantity), of processing and of distribution are fundamental. Those OMIs with the competencies to identify this problem and solve it have better chances of succeeding. This is what this first factor axis shows.

2. Axis 2 qualifies the influence of internal policies by rectifying the influence of the region, but in a way that was unexpected compared with the project's objectives. It is the favourable non-LFAs (reference regions as described here) that are home to most OMIs achieving ethical objectives while intermediate regions (unfavourable non LFAs or favourable LFAs) are home to most OMIs achieving economic objectives. This axis also shows that ethical OMIs (group 3), which are often recent business partnerships in direct contact with consumers, enjoy a good market environment and have better human resources and organisational policies than financial policies whereas "economic" OMIs (group 2) are in the opposite position. The latter are often medium-sized businesses engaged in upstream activities and achieving success despite an unfavourable context, which further accentuates the importance of internal policies that manage to make up for a unfavourable context. This result displays the consistency of some of the OMI strategies studied. For a strategy based on ethics (under the constraint of economic equilibrium, of course) to succeed, it is organisation, the management of human resources and the strength of the network that are decisive. In the opposite instance, where an economic strategy is pursued, it is good financial management (source of funds, independence, low debt ratio) that is decisive and networking that is less decisive.

Let us discuss that result. In fact, market conditions in the different areas are generally favourable and OMIs are distinguished more by their capacity to implement efficient procurement policies in terms of quantity (when raw material is in short supply because of rapid average growth of the downstream market, as with fruit and vegetables or cereals) or in terms of quality (when the market is more stable and quality becomes a significant criterion). It is primarily internal competencies related to the policies employed that account for the success of OMIs. Capacity to control processing and logistics frees OMIs somewhat from the constraints and fluctuations of the upstream market allowing them to produce added value (by processing) and to cut transport and distribution costs (if logistics are carefully organised). This is particularly important in a branch handling small volumes where scale economies cannot readily be made. Both these factors have a marked influence on cost effectiveness.

Again with regard to internal policies, the required conditions for achieving ethical or economic objectives are the capacity to manage human resources and the capacity to manage financial matters. These abilities are closely correlated to the type of objectives set and accomplished: with ethical objectives there is a tendency to overlook the financial aspect and favour people whereas with economic objectives the financial aspect takes precedence over the human one.

Conclusions

At the firm level, the survey showed that most OMIs come up against a limit in their strategies and find themselves at the crossroads. The initial vision developed by the initiators in not sufficient enough any longer and new strategies and management methods have to be implemented. There come revitalization points, in which the managers need to do critical decisions and put effort to develop the concept so that a new growth period can be achieved, without forgetting their ethical objectives. Actually, the "moment of truth" met by the OMIs may lead them to think again about their objectives and to reformulate their strategies.

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SUPPLY CHAIN MANAGEMENT - IMPROVING THE COOPERATION BETWEEN MARKET ACTORS

COST DRIVER IN THE ORGANIC MEAT MARKET IN GERMANY – SPECIFIC PROBLEM OF THE ORGANIC SECTOR

Christoph Beukert (1), Dr. Johannes Simons (2), Prof. Dr. Monika Hartmann (3)

Institute for Agricultural Policy, Market Research and Economic Sociology,, Nussallee 21, 53115, Bonn, Germany. Internet: http://www.agp.uni-bonn.de
(1) Tel. ++49 228 737752, E-mail: beukert@agp.uni-bonn.de;
(2) Tel. ++49 228 733549, E-mail: simons@agp.uni-bonn.de;
(3) Tel. ++49 228 733538, E-mail: hartmann@agp.uni-bonn.de.

Key Words: organic meat market, cost driver, economies of scale

Abstract

High prices for organic meat and meat products in Germany are caused especially by small scale production schemes and the special behaviour of the market participants. Special requirements for organic production systems play a minor role. The German market for organic meat is a co-ordinated market with restricted access, as an analysis based on expert interviews shows. Prevalent forms of co-ordination are contract production and the pooling of output and prices. Due to this situation, the margin between the producer and the consumer price is higher than on a competitive market. But the conditions on organic markets are changing as it becomes more difficult to restrict market access. For the future, the generation of demand could help to overcome the problems of this market. Existing networks in the organic meat market could be used to co-ordinate necessary activities.1

Introduction/Problem

High consumer prices for organic meat and meat products are often regarded as the core obstacle for a growth of market share in Germany (Hensche and Kivellitz 2001, Meier-Ploeger *et al.* 1997, Schölzel 2001, Spiller 2001). The higher prices for organic compared to conventionally produced meat products can, however, not primarily been explained by the higher prices for the respective raw product, organic animals, but are mainly due to larger margins in the marketing chain for organic meat. But what are the reasons for higher margins in the organic sector? The study attempts to find answers to this question by identifying cost drivers along the value chain for organic meat and meat products in Germany and by evaluating the behaviour of the market participants.

Methodology

The identification of factors affecting higher margins in the organic meat chain is based on the theory of transaction costs, the principal agent theory and supply chain management methods. These theories especially focus on the co-ordination and co-operation mechanisms among enterprises, and consider the specificity of organic products in the theoretical framework. In accordance with this framework, the stages of the value chain which potentially have an impact on the margin, were defined and questionnaires were tailored for the analyses of the respective steps. In-depth, face-to-face interviews (n=31) were carried out with experts from farmer co-operatives, slaughterhouses, processors, butchers and supermarket-chains in Germany. Additionally accessible data on production costs, cost drivers and the market structure were taken into account.

Results and brief discussion

The analysis points out three categories of reasons causing higher consumer prices for organic meat: (1) specific organic production systems (2) small scale production schemes and (3) the behaviour of the participants within the marketing chain.

COSTS ARISING FROM SPECIFIC ORGANIC PRODUCTION / PROCESSING SYSTEMS

[1] As this study was conducted on the German market for organic meat, the results cannot describe the market situation for other countries yet. Further research must show if the basic findings can be adopted to other organic meat markets as well.

The main cost driver on farm level is the specific organic production system. Concerning the production of pig meat, prices for piglets and fodder are about twice as high as for comparable conventional inputs. In addition, a lower feed conversion ratio in organic husbandry amplifies the effect of higher prices for fodder. As piglets and fodder stand for about 50 % of the total production costs of pigs (Schubert 2002), they have a major impact on the overall production costs. Moreover, compared to conventional farming, organic husbandry requires more spacious fattening units and is even more labour intensive, so that higher costs arise due to farm buildings and labour, too (Schubert 2002, Löser 2004).

With respect to processing organic meat, additional costs evolve from the compulsory certification as a prerequisite for organic processing and due to the separate handling of organic animals and meat. Furthermore raw material of higher quality must be used for organic meat products as the use of additives is restricted in organic meat processing. However, those factors explain only a small part of the difference between the margin of organic and conventional meat and meat products.

COSTS ARISING FROM SMALL SCALE SYSTEMS

A second category of cost drivers on all levels of the organic meat chain are the, compared to the conventional sector, small production schemes in the organic sector. On farm level, animal density is limited more restrictively compared to conventional farming by legal requirements (EG-Öko-VO 2003). In addition, organic farming requires more differentiated production systems so that it is more difficult to realise economies of scale. This problem concerns especially small farms. In proportion to their size, a relatively differentiated production system must be implemented against the background of limited capacity of labour and capital. Conventional farmers can meet that problem by specialisation, which is more difficult to realise in organic farming.

With regard to the marketing chain of organic meat, the size of enterprises is the most important factor for higher costs compared to the conventional sector. Small scale slaughtering and meat processing enterprises not only cope with higher average fixed costs, but are also affected by increasing legal standards, too, which require additional investments. Another factor for higher costs in organic meat processing is the lack of specialisation. Comparable to the situation on farm level, processors have a wide product range and cannot realise economies of scale in their small enterprises. A higher product differentiation requires a higher qualification of the staff, too. The analysis shows that employees in organic enterprises normally have a vocational education whereas staff in large slaughtering or processing enterprises mostly are semi-skilled for a few activities within the production process, leading to higher labour expenses in organic meat processing.

Additionally, the lower number of enterprises in the organic meat sector leads to longer distances between these companies and thus causes higher transport costs on all levels of the organic meat chain.

BEHAVIOUR OF THE PARTICIPANTS OF THE MARKETING CHAIN

Statistics and the interviews reveal that not all organic produced meat is sold as organic meat. This is especially valid for beef: The share of organic cattle sold as organic meat merely adds up to 70 % (BÖL 2004). As for carcasses, especially those parts that are used in processed and convenient products cannot be sold on the organic market by 100%. Retailers, as the last link to the consumer, do have similar problems as they suffer from high return rates of meat products exceeding the expiration date.

At first sight this may be regarded as a disadvantage of the organic sector, because the added value decreases if not all organic produced meat is sold on the organic market and gets the respective price premium. But the question is: What would happen on a competitive market if only a part of the products were sold with a price premium? In a competitive market falling prices would stimulate demand. Compared to falling prices on competitive markets, the organic sector may benefit from a strategy that reduces supply on the organic markets and sells the surplus without the price premium. But, how do they overcome the mechanism of a competitive market? The main reasons are:

The market for organic meat is characterised by barriers for market entry. Market entry is hampered especially due to (1) high risk in narrow markets. The market for organic meat in Germany is a niche market, as only 3,63 % (47.000 tons) of beef, and 0,39 % (16.000 tons) of pig meat is produced organically (ZMP 2005). The situation on this narrow market is even aggravated as different standards of the organic farmer associations (e.g. Bioland, Demeter, etc.) lead to an additional segmentation of the market on each level of the value chain. (2) Organic production and marketing requires special knowledge. This concerns the production scheme and the sales of organic products as well. (3) Relationship management is important within the value chain and between producers, distributors and consumers. For an outsider it is difficult to become part of that network. (4) Rapid reactions due to the change in market situation are hardly possible as the legal changeover time of 24 months must be maintained (EG-Öko-VO 2003).

Contract production is the prevalent form of vertical co-ordination. By using this instrument it is possible to adjust supply to expected demand. Against the background of a narrow market and intensive relationship management, discipline can obviously be achieved. Especially in organic pig production, agreements on quantity, price, quality and the date of delivery are fixed every 6 months. Organic beef production is not co-ordinated by contract production, but by experience and trust.

In case of emergency, price pooling helps to enforce co-operative behaviour between the individual participants of the market. Pooling of produced quantities and the subsequent repartition of returns is co-ordinated by farmer co-operations in order to distribute the advantages of supply reduction equally to all producers. Thus, the participants of the organic meat market can act like a monopolist without facing the problem of deviant behaviour of the individual participant.

Due to the above mentioned reasons the market for organic meat is a co-ordinated market with restricted access. Specificity and the resulting segmentation of the market lead to oligopolistic and even monopolistic market forms. In the course of a market expansion, it becomes more and more difficult to achieve the discipline, as different sales channels emerge and the market internationalises.

Conclusions

The results indicate that the high margin between producer and consumer prices for organic meat is primarily caused by small scale production schemes and the special behaviour of the market participants, whereas specific requirements for organic production play a minor role.

A co-ordination between the different stages of the value chain is used to adjust supply to expected demand. The high price level of organic meat is achieved by controlling supply even if it leads to a surplus of organic meat. The application of this instrument will become more difficult in the future, as market conditions change.

To overcome the problem of small scale production concentration, the increase of production is necessary. But the increase in production without an adequate increase in demand leads to decreasing prices or to a rise of the surplus. In the end, a small scale value chain may enhance the credibility and the perceived quality of organic production and thereby might be, for part of the consumers, a prerequisite for an increased willingness to pay. Structural change in the organic sector therefore may reduce credibility.

Nevertheless, vertical co-ordination is still missing in many cases, inducing additional costs due to low capacity utilisation. Thus, especially in the mid-term, the efficiency of the whole organic meat sector could be increased by utilising the existing potential concerning empty fattening units.

Therefore it seems to be important to enforce demand. The network within the organic sector could be used to co-ordinate necessary activities.

For the future, a rapid structural change can hardly be expected in the short run, because necessary investments for enhancing structural changes are more risky in narrow markets and the factor specificity is higher than in mass markets. Therefore the identified cost drivers are not a specific problem of the organic meat market, but rather a problem of narrow and specific markets.

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THE ORGANIC FOOD SUPPLY CHAIN IN RELATION TO INFORMATION MANAGEMENT AND THE INTERACTION BETWEEN ACTORS

Marja-Riitta Kottila (1), Adeline Maijala (2), Päivi Rönni (3)

(1) University of Helsinki, Faculty of Agriculture and Forestry, Taivaanvuohentie 9 B 26, FI-00200 Helsinki, Tel. +358 40 581 9252, marja-riitta.kottila@helsinki.fi
(2) Helsinki University of Technology, Department of Industrial Engineering and Management, Environmental and Quality Management Unit, Saimaankatu 11, FI-15140 Lahti, Tel. +358 505 705 969, adeline.maijala@tkk.fi
(3) University of Helsinki, Faculty of Agriculture and Forestry, Virpeistöntie 59, FI-12350 Turkhauta, Tel. +358 40 563 4074, paivi.ronni@helsinki.fi

Key Words: organic, demand - supply chain, information management, communication, collaboration

Abstract

Conventional retailers play a significant role in selling organic food, and therefore, it is important to understand how the demand - supply chain of organic food works as an element of the conventional food system. The proportion of organic food in the conventional food chains is small, and this poses a great challenge to the performance of the chain. Surveys and case specific studies on consumers and supply chain actors indicate that the changes in the conventional food system have an impact on the organic chain. The main obstacles to the optimisation of the organic food chain include poor information management, insufficient communication with consumers, and the diverging objectives and needs of the actors of the chain.

Introduction

Supply chains of organic products are often considered as alternative supply chains, which are shorter, more locally oriented, and in which the producers and consumers are more tightly connected to each other than those in the conventional food supply chains. In spite of this, the involvement of retailing groups into the organic supply chain has increased the market share of organic products in many European countries (Finfood 2003a, Hamm *et al.* 2002).

Despite the rapid increase in the demand for organic products in many western countries, the market shares remain small (Hamm et al. 2002). According to consumer surveys conducted in Finland (Finfood 2003a), the potential demand for organic food is greater than its market share indicates, but the supply does not satisfy the demand in terms of quality-price ratio, availability and diversity of the product assortment. Therefore, one needs to focus on the functionality of the demand-supply chain.

The main problems of the organic supply chains identified in earlier research at European and Finnish levels are: imbalance between supply and demand, high operating costs, lack of co-operation between actors of the chain, incompatibility of values among actors of the chain, lack of information flow, and poor supply reliability (Finfood 2003b, Hamm *et al.* 2002, Baecke *et al.* 2002, Franks 2003, Wycherley 2002). These issues call for solutions that involve closer collaboration as well as more exchange of information between actors.

The objective of the research is to understand the interactions between the actors of the organic food supply chain when the distribution takes place among the mainstream retailing chains. The theoretical background consists of elements from supply chain management (Lambert *et al.* 1998), Efficient Consumer Response (Alvarado and Kotzab 2001), relationship management, as well as stakeholder management.

Methodology

The system was observed by using both quantitative and qualitative methods. The surveys were conducted during 1999 and 2003, and the number of consumers and food chain actors were 1009 ±134 and 439±130, respectively. The data was analysed during spring 2005. Explorative factor analysis and K-Means cluster analysis were used. Several groups of actors and consumers were identified, each of them having a clearly distinguishable attitude profile in relation to organic food.

To deepen the understanding of the demand - supply chain of organic food, case studies were carried out with a qualitative approach. The focus was kept particularly on the information management as it presents the key to improved performance. The flow of information between the actors of the chain co-ordinates the other flows, such as the product flow (Coughlan et al. 2001), and is an essential element of the inter-organizational relationships (Anderson and Narus 1990). In this system, the model of information flow is based on a preliminary literature review, and is adapted and refined according to the results of the case study.

Two chains were selected by taking into account the requirements of comparability, representativeness and diversity. The products chosen for the case represented typical daily food of the Finnish consumers. The cases differed from each other in terms of product characteristics (fresh product vs. industrial product with a long shelf-life), marketing concept (private label vs. own brand), as well as the size of the marketing company (small processor marketing the products on its own vs. small processor whose products were marketed by a big company). Both products were sold by the same two retailers, which are the largest grocery retailers in Finland.

To describe the chains, the viewpoint of the organic processor was chosen for two reasons. Firstly, processors concentrating exclusively on organic are critical in developing organic products for the market, and secondly, it is assumed that they are highly committed to organic food. From that focal point, the product was followed downstream through actors involved in distributing, marketing and selling the organic product to consumers, but also upstream to a couple of farms producing the raw material. Apart from the focal organic processor and its suppliers, the proportion of organic food is small in the chains, as in conventional food chains in general.

The data was gathered by interviewing the actors along the chain. The selection of the interviewees is based on their position and responsibilities in the company. Interviewees are either managers of the companies (small firms and farms) or are involved in decision making processes concerning the assortment and promotion of the products. In total, 28 interviews were conducted. The chains as well as the amount and position of interviewees are depicted in figures 1 and 2.

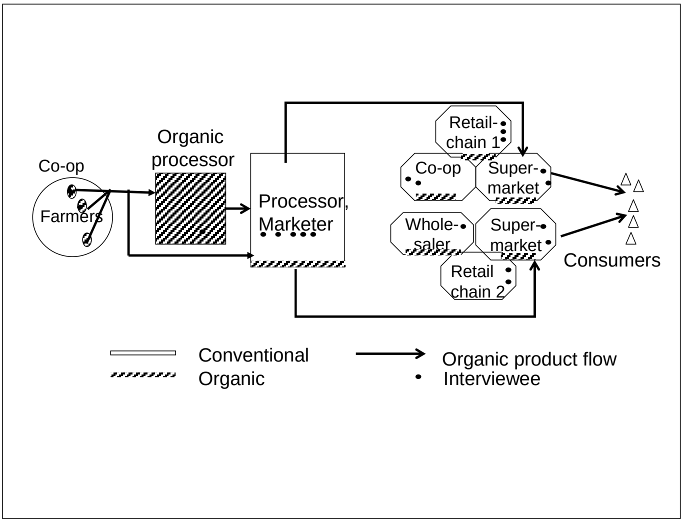

Figure 4: Description of case 1 (Fresh product)

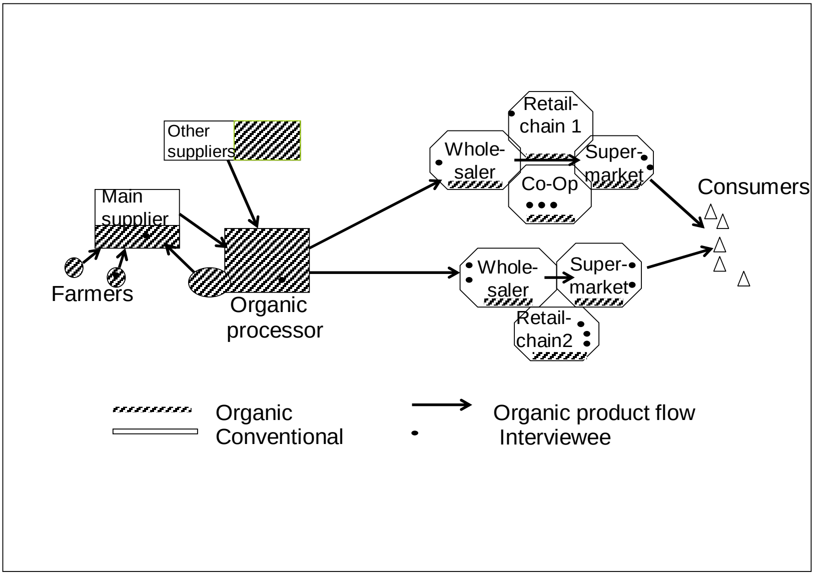

Figure 5: Description of case 2 (Cereal product)

Each interview took one to three hours and was semi-structured. Nine specific issues were covered: actor's position in the chain, commitment to organic production or marketing, the network of organic information, the means and the content of information exchange, the efficiency of information flow, as well as the relationships between the actors and the performance of the chain.

All interviews were recorded and transcribed. The interviews were conducted between November 2004 and March 2005. In addition to interviews, secondary material such as financial reports, marketing research done by the actors, annual reports and internet pages of the companies were evaluated. Transcriptions were analysed by summarising and comparing the views of different actors in the same chain. Preliminary propositions are revised and finally tested in all case-chains. The preliminary propositions are:

1. The information flow is inadequate and inefficient.

2. The actors' conception of the situation is inconsistent.

3. Some actors of the chain, or stakeholders outside the chain, possess or have access to information which could be used to improve the performance of the whole chain.

4. Actors know little about the needs of the other actors of the chain.

5. Communication between the actors of the chain is insufficient.

6. Commitment to organic would improve the performance.

7. Experience of organic presents a key to proper performance.

Results and brief discussion

Interviews with the actors along the studied chains shed light on the significance of organic to the actor, the type of information actors exchange and/or need, the significance of stakeholders outside the chain, the relationships between actors, as well as the factors affecting information sharing. Together with the existing theories, the identification of factors affecting the performance - in particular conflicting objectives - is enabled, and thus, the corresponding opportunities and means for the improvement of the system can be found. The share of organic in the turnover of the actors varies greatly depending on the size of the company and the position in the chain (Figures 1 and 2). Because the strategic role of organic products is different for each company, there may be contradictions and difficulties to share a common goal between the decision-makers within a company or between customers and suppliers. The preliminary results indicate that the information concerning organic is poorly managed by the actors in the chain. Management of the conventional food chain is based on product categories. Because organic products exist in various categories, information of organic products is a negligible part of each conventional product category. This complicates the management of the information and the marketing of organic products.

In the first analysis of the data, it was found that information flow to consumers from the chain actors is deficient. The mutual view of the chain actors is that the brand owner is responsible for delivering information to consumers. Due to the limited resources and conflicting needs of the brand owner and its stakeholders, the package of each product is the only significant means of providing information to consumers. Due to the poor information management and the information delivery to the consumers, the information concerning the environmental and ethical value of the organic product is not flowing among the chain actors. However, the information system coordinating the logistics of organic products is similar to that of the conventional products, and therefore, the information could flow just as efficiently for organic products as for conventional products.

Conclusions

In order to understand the needs and possibilities for system improvements or changes, research at the chain level is necessary to complement the studies concentrated on one actor group of the chain. Due to the deficiencies of the information flow by the chain actors, the performance of the organic food chain could be improved with the involvement of the stakeholders outside the chain. The role of the actor from outside the chain would be to support the organic chain by managing and delivering information concerning the ethical, ecological as well as societal value of organic food. Interesting questions for further discussion are the role definition between the stakeholders inside and outside the chain as well as the interaction between them.

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STRATEGIES TO SUPPORT DOMESTIC ORGANIC MARKETS IN COUNTRIES WITH EMERGING ORGANIC SECTORS

Toralf Richter, Annamaria Kovacs

Research Institute of Organic Agriculture (FiBL), Ackerstrasse, CH-5070 Frick;
email: toralf.richter@fibl.org; annamaria.kovacs@fibl.org; www.fibl.org

Keywords: emerging organic markets, market development strategies

Abstract:

This paper presents the current state and prospects of domestic organic market development in selected countries with emerging organic markets: The Czech Republic (CZ), Poland (PL), Hungary (HU), Ukraine (UA), Mexico (MX) and India (IN). While governmental support for organic farming varies across all countries studied, the organic sector is focused mainly on export markets in every country represented. The results of a two-step expert consultation indicate that development of the domestic market is mainly hampered by a lack of processing and distribution infrastructure, as well as the relatively low purchasing power of domestic consumers. Experts recommend that political support should prioritise national market development programmes for organic food (above all regional producer initiatives, vertical networks, establishment of a national organic logo). With regard to marketing measures, market development can be fostered by expanding the available range of domestic processed and convenience food, changing the price image and improving communication strategies that focus on health and quality aspects. In addition, distribution should not focus exclusively on conventional retail chains.

Introduction

Countries with emerging organic markets differ in terms of the governmental support provided to the organic sector. For instance, in recent years, most of the new EU member states have introduced support schemes for organic farming that focus on the supply side (Stolze 2004). In other countries with emerging organic markets, where almost no public support is available, farmers have converted to organic agriculture on the basis of positive (export) market expectations. Due to a lack of domestic demand (Richter and Halpin 2001), the bulk of organic food produced in these countries is for export (Willer and Yuseffi, 2005; Reuter and Schade 2004; DZI 2004). In countries that were not able to build export networks or to develop a domestic market, organic food is mainly sold as conventional food. This is the case for example in the Ukraine, where just 5% of the organic production volume can be sold as organic product (DZI 2004). Because the organic land area in most Central and Eastern European countries (CEE) is growing very rapidly without equivalent domestic demand, a growing volume is exported to Western European countries. At the same time, due to the lack of domestic processing infrastructure for organic produce, many organic products are imported to these countries from abroad (Kovacs/Richter, 2004). The phenomenon of imbalanced domestic organic market development seems to be a general problem for countries with emerging organic markets.

Objective

The objective is to discuss internal strengths and weaknesses, as well as opportunities and threats, for the organic sector in countries with emerging organic markets, in order to stimulate stronger domestic organic demand and identify action points for policy makers and market actors.

Methods

The study used a two-step approach. In the first step, a desk review and a consultation of market experts was carried out. In the second step, a standardised written expert survey was conducted in six countries with emerging domestic organic markets. In total, 17 responses were included in the analysis. The countries studied were divided into two groups:

- Countries with relatively strong governmental support for organic farming [Hungary (4 respondents), Czech Republic (3), Poland (3)],

- Countries with no or weak governmental support for organic farming [India (1 respondent), Ukraine (5), Mexico (1)].

The key questions of the study were: Which internal strengths and weaknesses and which external factors mainly influence the development of the domestic organic sector? What are priority areas for governmental support to stimulate the domestic market? What possibilities exist to increase consumer interest in organic products in the country? Which marketing measures are appropriate to develop the domestic market in countries with emerging organic markets?

Results and brief discussion

Desk review

The results of the desk review and expert consultation indicate enormous differences with regard to organic supply (5.97% organic area in the Czech Republic versus 0.05% in India, see Table 1). However there seems to be no clear evidence that political support is a strong determinant of the proportion of organic farming in any case.

Table 1: Comparison of countries studied with regard to their proportion of land area under organic cultivation (February 2005)

	Countries with relatively strong governmental support for organic farming			Countries with no or weak governmental support for organic farming		
	CZ	HU	PL	UA	MX	IN
Share of land area under organic management (%)	5.97	1.94	0.30	0.78	0.37	0.05

Source: WILLER and YUSSEFI 2005

In all countries studied, supply is growing faster than domestic demand. The growing supply is driven mostly by the economic situation of the conventional agriculture sector, which is affected by declining prices and a lack of financial resources to invest in intensive conventional production. The organic production structure in the countries studied is mostly concentrated on a few raw materials with high demand abroad (cereals, oilseeds, tea). Unprocessed organic raw materials and the small domestic product range do not provide attractive organic assortments for the domestic market. At present, the small number of domestic products is mostly distributed via farm shops or farmer markets (Kovacs and Richter 2004).

Expert survey

The written expert survey did not take a quantitative approach. In countries like Poland, Mexico or India only few persons have sufficient information about the national organic sector. Insofar the quality of the expert sample is more important than its size. For each country, the experts interviewed have been closely involved in the development of the national organic sector for many years. Starting with an analysis of strengths, weaknesses, opportunities and threats, experts spontaneously named different internal and external factors for their countries which promote or hamper the development of the domestic organic market (see Table 2).

Furthermore, experts indicated the current state of public support for the organic sector as well as the main challenges in the future for policy and market actors to stimulate domestic organic markets. The results also indicate different priority areas of governmental organic support in the countries studied. In the new EU member states, the organic sector is mainly supported by land-based payments for conversion to and maintenance of organic farming. Besides research and advisory service, activities dedicated to organic farming are pointed out by the experts as current areas of political support. However in all six countries there is presently no governmental support for domestic organic marketing activities. In countries like Ukraine, Mexico and India, support for organic farming is not given a high priority. This means governmental support for the organic sector is not provided or is only just beginning. For Mexico and India, experts stated that without governmental support organic farming will not become more viable over the long term or, worse still, will stop.

For Hungary, Ukraine, India and Mexico, experts noted that organic farming structures are mainly influenced by export market prospects. Experts believe that in Ukraine, India and Mexico the proportion of organic area would definitely decline if foreign demand were to drop. However, for India, Poland and the Czech Republic, experts believe that domestic wholesalers would increase their activities for domestic market development if demand on export markets were to decline.

Table 2: Analysis of strengths, weaknesses, opportunities and threats for the development of domestic organic markets in the countries studied (spontaneous expert statements)

	Countries with relatively strong governmental support for organic farming (CZ, HU, PL)	**Countries with no or weak governmental support for organic farming (UA, MX, IN)**
Strengths of the domestic organic sector	▪ Regulation and certification systems for organic farming and products exist–HU, CZ ▪ Huge supply potential for organic production–HU ▪ Excellent producer skills for organic production–HU ▪ Stakeholder willingness to cooperate–CZ ▪ Organic farming association functioning well–CZ	▪ National capacity building of organic agriculture starts to be developed–MX, IN ▪ Organic farmers interested to develop the local market–MX ▪ Huge supply potential for organic production–UA ▪ First organic farming association constituted–UA
Weaknesses of the domestic organic sector	▪ Lack of capital and know-how in the domestic processing sector–HU, CZ, PL ▪ No regulation of the retailing of organic products–HU ▪ Less information about organic production and food available–HU ▪ Lack of marketing initiatives for organic food–HU ▪ High price premium for organic food as key barrier to domestic demand–HU ▪ Small volumes of organic products available for domestic markets-CZ ▪ Lack of skills in strategic decision making, marketing, PR, lobbying-CZ ▪ Lack of producer skills for organic production–PL ▪ Low degree of national organisation of organic producers –PL	▪ In many regions no market structures for organic products exist–MX, UA ▪ Low market and production transparency–UA ▪ No governmental organic standards–UA ▪ Only organic plant production–UA ▪ Low quality of available organic products–UA ▪ Lack of capital resources in the domestic farming sector–UA ▪ Low degree of national organisation of organic producers-UA ▪ Lack of capital and technology resources in the domestic processing sector–UA ▪ Absence of organic farming skills–UA ▪ Absence of organic advisor network–UA ▪ Lack of public services for the organic sector-UA ▪ High price premium for organic food–UA ▪ Small volumes of organic products available for domestic markets–MX ▪ Organic market scattered and isolated-IN
Opportunities to develop national organic markets	▪ Conventional retailers increase organic assortments –HU, CZ, PL ▪ Increasing consumer demand for 'health products'–HU, CZ, PL ▪ National organic farming regulation–CZ, HU ▪ National action plan for organic farming released-CZ ▪ One national organic logo does exist–CZ ▪ Government starts to support local organic initiatives and organic products–CZ ▪ Increasing consumer purchasing power-CZ ▪ Increasing numbers of organic retailers–HU ▪ Organic food and production is frequent reported in media-HU ▪ Governmental financial support for organic production–PL ▪ Networking with international	▪ Government starts to support local organic initiatives and organic products (e.g. on trade fairs)–MX, UA ▪ Increasing consumer demand for 'safe/health products'–UA, IN ▪ Information campaigns about market opportunities motivate organic producers to develop the domestic market-MX ▪ Export promotion agencies support organic food development also for the domestic market–MX ▪ Consumer readiness to pay higher prices for organic food-UA ▪ Processors and retailers are interested in organic food–UA ▪ No refusal of policy makers and conventional farmer associations to organic farming–UA ▪ Media are interested in organic farming–UA

	experts–PL	
Threats to develop national organic markets	▪ Refusal of conventional farmers to organic farming–PL, CZ ▪ Growing share of imported organic food–CZ, HU ▪ No governmental concept and support for domestic organic market development–CZ, HU ▪ Limited scale of market channels–CZ, HU ▪ Low consumer awareness and knowledge of organic products–CZ, PL ▪ Limited interests of small retailers in organic fresh food–CZ ▪ Uncertainty about organic production support after EU accession–HU ▪ Environmental awareness of consumers weak–HU ▪ Lack of local advisory support–PL ▪ Media less interested in organic farming–PL	▪ Absence of organic support schemes for the organic sector–UA, IN ▪ Low consumer awareness and knowledge of organic products–MX, UA ▪ Low consumer purchasing power–UA ▪ Low market transparency–UA ▪ High demand for organic products in the export sector–MX

Source: FiBL expert survey 2005

For Hungary, the Czech Republic, India and Mexico, experts see recently a growing demand for organic food on the domestic market. For Ukraine, India and Poland experts believe that consumers tend to prefer organic food from domestic production over imported organic food. However, due to the lack of processing capacities, consumers have no access to a broad range of domestic organic food. Only for Poland do experts state that the processing quality of domestic organic food is comparable to products from abroad. For other countries quality aspects are seen as a further barrier preventing the stimulation of domestic organic markets.

With regard to policy support activities, experts recommend prioritising the following areas to stimulate the development of domestic organic markets: Support the establishment of networks among vertical market actors as well as among organic producer initiatives and local tourism sectors; support marketing activities of regional producer cooperatives; establish a unique national organic logo (in contrast to regional organic logos); and support the establishment of local and regional processing infrastructure for organic food. However, most experts do not agree that the new policy support areas should be financed by a reduction of support measures on the production side.

With regard to marketing measures to stimulate domestic organic markets, experts recommend:

- Product policy: Increase the share of domestic organic food in retailer assortments and increase the organic share of (semi-)processed and convenience products.
- Price policy: Reduce the prices for organic food generally or at least improve the price image by making frequent cut-price offers.
- Distribution policy: Place organic food in special organic product blocks in conventional retail chains, increase competition between conventional retailers, but do not prioritise conventional retailers exclusively as the key distribution channel for organic food.
- Communication policy: Improve consumer recognition of existing organic brands, focus communication on the needs of households with high purchasing power, achieve broad penetration of information via all media (mainly consumer trend journals), improve communication at the point of sale, and highlight the health and quality attributes of organic products through advertisements.

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KNOWING HOW CONSUMERS THINK AND ACT TO IMPROVE MARKETING

AN INTERDISCIPLINARY APPROACH TO ANALYSE PRODUCTION, MARKETING AND CONSUMPTION OF ORGANIC PRODUCTS

Maria Fernanda Fonseca (1), John Wilkinson (2)

(1) PESAGRO-RIO, Rua Euclydes Sólon Pontes, No.30, C.P. 97503, Centro, Nova Friburgo – RJ, Zip Code 28601-970, Brazil. Tel: 55 021 21 36039238 ffonseca@netflash.com.br
(2) CPDA/UFRuralRJ, Av. Presidente Vargas, No.419, 6th Floor, Centro-RJ, Zip Code 20071-003, Brazil Tel: 55 021 21 22248577 jwilkins@uol.com.br

Key words: organic agrifood systems, socio-economic analysis, economy of conventions

Abstract

This paper analyses the networks of production, marketing, and consumption of organics products understood as specific quality products, using an interdisciplinary approach to understand how institutions are constructed, how standards and rules are established and implemented, and which values and habits are negotiated, enforced, and regulated. Governments and Civil Society are both important for coordinating the organic agrifood systems, given the diversity of cultures, ideas, policies, territories, habits and regulatory systems. Transaction Costs Theory, French Convention Theory, Social Network Analyses, and Actor-Network Theory are all approaches that help to analyse the diversity of relations established between actors in agrifood systems designed to protect the environment and defend issues of social justice.

Introduction

Over the past three decades the organic food system has evolved from a loose assortment of independent local networks of producers and consumers to a global, formal, and regulated trade system. Market activities are not purely economic relationships. They encompass social norms and institutions that mediate their effects. Governance evolves and reflects conventions developed between key social, political, and economic players engaged in developing and enforcing particular ideas and practises (Raynolds, 2004). Since its formation in 1972, IFOAM's role in the governance of the organic food system has focussed largely on the international promotion of certification systems, established largely by Northern producers and organisations to regulate and guarantee the organic qualities. Current efforts to define and enforce 'certified-organic' quality specifications inadvertedly promotes the superiority of 'certified-organic' labelled products over all others, bolstering industrial and commercial conventions (based on efficiency, standardisation, bureaucratisation, and price competitiveness) at the expense of an organic movement oriented by domestic and civic values (personal trust, local knowledge, ecological diversity and social justice), practises, and institutions. Since the 1990s, one of the main objectives of the Agroecology Movement for Latin America and Caribbean (MAELA)1 has been to promote participatory guarantee systems (PGSs) established by Southern producers and organisations to regulate organic quality and promote local markets. They promote social control methods and support domestic civic conventions.

Historically, the Soil Association in 1967 established the first local organic standard. In 1981, IFOAM established the first international organic standard and France established the first organic technical regulation. Today, after 30 years, we have more than 60 countries with regulations (implemented or under discussion) and more than 380 certification bodies (CBs). But, whilst national government regulations bolster the authority of organic certification systems and define the world market for certified organic products, other control systems are trying to be recognised as quality guarantee systems and define a global, socially oriented fair trade of organic products (Fonseca, 2004).

Methodology

To analyse the production, marketing, and consumption of organic products we followed two steps. First we based our interdisciplinary approach on currents from economic and social theories to explain the different

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[1] At the end of the eighties, an IFOAM Latin American group was created, which became known as MAELA in the beginning of the nineties, creating its own platform, sometimes quite different from that of IFOAM, as on the issue of guaranteeing the organic qualities only by the means of certification.

forms of governance and forms of coordination constructed by organic product networks during its institutionalisation, drawing on authors from Transaction Costs Theory, French Conventions Theory, Social Network Analyses, and Actor-Network Theory.

Second, to understand the forms of coordination existing in the marketing of organic products, instead of limiting ourselves to the Organic Guarantee System from IFOAM, the Codex Guidelines for OA and implementation of organic technical regulations where the guarantee is based on certification, our analysis focuses on markets that accept different procedures of conformity assessment to guarantee the organic qualities, known as PGS.

Results and discussions

Interdisciplinary Approach

A central issue faced by economic agents is to establish and enforce OA principles and norms to obtain a quality product and a desired quantity (Reardon & Farina, 2001). In an environment where agents have limited rationality and are inclined to opportunism, for transactions to have outcomes that most approximate the hoped-for scenario (organic qualities), incentives are necessary for the adoption of standards (price premium), for the establishment of controls (auditing, verification), and eventually for the provision of public goods and services (technical advice, mutual recognition agreements). For the Transaction Cost Theory (Williamson, 1985), quality standards, certification and accreditation systems are technical mechanisms (exogenous variable) to lower the costs of negotiating uncertainty in the market of organic products. Other ways to guarantee the quality of the goods to consumers include the development of reputation by trustworthy behaviour over time, the fixing of commercial brands through publicity, and an efficient judicial system to solve disputes between contractors.

However, standards are not merely technical mechanisms, but also imply the definition and selection of what is good, in turn involving exclusion processes. In this sense, standards embed values and interests, and quality is no longer an exogenous variable. The Economy of Conventions focuses on this coordination aspect of how to explain the qualifying process (quality definitions) of OA products. The issues of coordination between agents are based on quality conventions with the perspective of an endogenous construction of these quality concepts obtained by effective use of participation by the agents and the creation of collective institutions that establish the rules and provide the means to respect these rules.

Coordination mechanisms such as technical controls for negotiating the quality concept are insufficient to express all the qualities of an organic product. The issue of coordination, differently from economic theory of standards, isn't based on the simple choice of a solution within a set of pre-defined possibilities, but implies constructing along with others the solutions judged to be satisfactory. In this sense, one can recognise of local linkage arrangements between actors, where communication is based on the proximity of actors, which of itself allows, for the expression of disagreements, negotiations, and the resolution of conflicts. At this point, the Economy of Conventions converges with the social networks approach theorized by Granovetter (Wilkinson, 1996).

In the case of OA, empirical observation shows how what the French call "dispositives" emerge (standards and specific institutions for each type of quality product), initially on a voluntary basis and afterward subject to formal regulation (Fonseca, 2005). These dispositives restrict the direct inter-relation between the economic actors, defining types of qualities, and, institutionalizing a "certification" and specific controls. As stated by Sylvander (1995, 1997), the Economy of Conventions approach allows us to perceive in the networks of the organic products the change of values related to social conventions (rooted in personal trust relations, in ecological diversity, in local arrangments and in social justice) in the direction of values linked to industrial mercantile logic (rooted in efficiency, standardization and competition by price, certification and auditing).

Network analysis is convergent with Polanyi's argument (1957) that activities of marketing aren't just purely economic, but are embedded in social standards and institutions that intermediate their effects. Today, information flows are seen as critical in shaping our "network society" (Castells, 1996; Capra, 2002). Research in socio-economy analyses how individuals, firms, government authorities and nongovernmental organizations (NGOs) are involved in economic transactions, and how these different actors shape as much as they are shaped by networks of social relations, basing their theoretical reference on the social construction of institutions (Mark Granovetter, 1985). The analysis of agrifood networks for OA products highlights the potentially important role of individual and collective consumers, as well as economic and politic actors, researchers, and farmers, in shaping the means and practices of OA networks.

With the institutionalisation of OA through the establishment of voluntary (private standards) and later mandatory standards (technical regulations), first by local and then by international organizations, NGOs and governments, we can draw on the approach of social-technical networks (Callon, 1991). This approach serves to explain how actors from each network of organic products establish referentials based on distinct types of artifacts that assure the links in the course of transactions, making possible the agreements. It is important to understand how the complex network of relations (humans and nonhumans) are established and managed, connecting material, social, political and economic actors (rules, controls, logos, visits, inspectors, farmers, consumers...) in an articulated organic network.

Diversity and Identity – Global Exchanges (information, goods) and Local Production

It was in the context of a lack of harmonisation and equivalence among organic standards and technical regulations around the world, with an increasing market for organic products in high income countries and the importance of PGSs to guarantee the quality of organic products for local markets in low-income countries, that IFOAM took the initiative to propose the realization of a Workshop to evaluate the status of PGSs around the world. During five days (13^{th}-17^{th} april 2004), in Torres, Rio Grande do Sul State - Brazil, 48 people from 20 countries and all five continents, representing NGOs (43) and government (5) organisations, participated directly in discussions about alternatives to internationally recognized certification systems.

The participants and organizations at the workshop represented 25 initiatives around the world that began as early as the 1970s, at the onset of the organic agriculture movement, i.e. community supported agriculture schemes (CSAs) in the USA; the Teikei system in Japan and COOLMEIA Ecological Fairs in Brazil, together with initiatives that appeared later in the 1990s and in the first years of this century, mainly as alternatives to large anonymous markets and national regulations on organic labelling. The systems they represent involve mainly small farmers and small enterprises who want to distinguish their products for local consumers as deriving from a system that accounts for social and environmental aspects that are important for sustainable living. They include schemes in 7 countries with implemented organic regulations (Argentine, Costa Rica, India, Japan, Philippines, Thailand, USA), 3 with organic regulations which have been finalized but not yet fully implemented (Brazil, Chile, Mexico), 4 with a draft regulation/standard (Peru, Lebanon, Uruguay, New Zealand), and 3 where no regulatory developments have reportedly taken place (Palestine, Paraguay, Uganda).

The type of organisations involved in PGSs were diverse, including farmer associations, consumers cooperatives, clubs, marketing organizations, informal and formal nongovernamental organizations (NGOs). A common label, logo or seal is normally used, but often there is also a written statement (affidavit). Means of promotion variy, including mouth-to-mouth communication, publications (brochures, newsletters) direct mailing, farmers markets, training sellers' staff, and webpages. Schemes can be on a local, regional, national as well as continental scale.

Although made up of different types of actors and working in different geography, climate, and ecosystems, as well as different development histories, the PGSs present at the workshop share many common features. Most use standards based on the IFOAM Basic Standards (IBS), Codex, private CB standards, and national regulations adapted to their local socio-ecological conditions, small-scale production and processing, and local marketing. Procedures are simple. There is minimal bureaucracy to maintain low costs to farmers or time spent filling out papers. Most rely on an educational process and social control involving all actors in the productive chain but focusing on consumer participation to uphold their organic quality system. Transparency is maintained through stimulating active participation within the networks.

Participatory Conformity Assessment Procedures

The PGSs use different types of conformity assessment procedures to guarantee the organic qualities:

- First-party assessment, e.g. Certified Naturally Grown-CNG and Northeast Organic Farmers Association-NOFA–NY (USA), Tierra Viva (Chile); where farmers take a pledge and sign an affidavit.

- Second-party assessment, e.g. El Rincon Organico (Argentina), NOGAMU (Uganda), COOLMÉIA (Brazil) where the organization that markets the products backs the scheme with its reputation or where the organization that supports the activity (development project) gives its reputation to the product, e.g. Qaraon Project – American University from Beirut (Lebanon), Alter Vida – APRO/ECOAGRO (Paraguay).

- Third-party assessment, e.g. GreenNet (Thailand) and ANPE (Peru), where the farmers organizations belonging to an internal control system implemented for export of their main crop want to sell side crop products in the local market (individually and as a group).

- Network assessment, i.e. Organic Farm (New Zealand), ECOVIDA and ACS (Brazil), IIRD (India).

The PGS constructed by ECOVIDA Network (Brazil) is based on an assurance given by a network of individuals and organizations involved in the production, distribution and consumption/use of the product/service with co-responsibility for guaranteeing the quality system. The production is normally diverse and marketing is not always centralized.

The farmers' objective in organizing themselves include food security and food sovereignty as well as a fair price. The focus is on training all persons (farmers, workers, consumers) involved in the process of production, distribution and consumption of organic food. Peer review visits are done by extension workers and farmers who have practical knowledge in organic producion and include supporting activities. Consumers also take part on the visits and share responsibility for the quality of the organic guarantee system. The certification decision-making is decentralized.

Besides being based on technical conformity, PGS also relies on social conformity enhanced through procedures and social conventions, such as common group purpose, group standard-setting, co-responsibility of conformity assessment procedures, membership codes, interaction, interdependence, and long-term relations.

Strengths and Weaknesses to PGSs

Official recognition is a common challenge for all the PGSs present at the workshop. In countries with organic labelling regulations already implemented, an alternative employed by PGSs is selling products without labeling them "organic" but, for instance, as "certified naturally grown" in the USA. Another option is to lobby for government "extra-official" recognition of PGSs managed by farmers associations in partnership with NGOs, universities and/or agriculture research institutes (public and private), as a guarantee system for sales in local markets but not as a CB (Costa Rica, México, Líbano). In countries where regulations are yet to be implemented, PGSs are lobbying to be recognized within the legal framework (Brazil, New Zealand).

One characteristic to discuss about PGSs is that most if not all currently involve little downstream processing and little or no introduction of raw materials from beyond the producers involved within the system. The possibility of facilitating trade between distant countries and distant conscientious consumers would be a major challenge for such systems. Formal recognition of such systems will enhance further development of their procedures as a credible assurance system.

Conclusions

For the analysis of markets for specific quality products such as OA products, both Transaction Cost Theory and the Economy of Conventions, equally focusing on the implications of "asymmetry information" and on the problems of collective action, provide important analytical tools. Although beginning from distinct presuppositions, efficiency on the one side and values on the other, these approaches are at the same time complementary for understanding the governance structures of a quality market.

The nature of the quality in question, the possibilities of standardization, and the features of quality conventions have a relevant role in modelling the governance structure of value chains. The key issue therefore isn't simply the way in which the quality can define different forms of coordination at different points of the production chain (and even within the same segment), but how quality conventions (and "cultures" of business relations) facilitate the combination of these forms of coordination inside patterns of global/total governance, itself contested and submitted to change, re-definition or renegotiation (Ponte, 2004).

Social movements are as important as state authorities and economic organisations in fueling and regulating international trade. There continues to be a series of tensions in the global trade of organic products within mainstream industrial-commercial conventions. Market values rooted in efficiency, standardization, and price competition are chipping away at domestic-civic conventions linked to personal trust relationships, ecological diversity, and social justice. Globalisation has, to date, extended market conventions more rapidly than social commitments. The existence of PGSs is a promising sign of new initiatives that can revitalise social norms and practices in organic food networks globally. They are a reality to be stimulated and supported, alongside current formal certification systems.

Considering that to harmonize is not to make uniform, we have to search for living in harmony but respecting diversity of people, culture, climate, territory, policy, standards and regulations, production systems, commercial chains, and consumers habits. To think and to act respecting those principles mean that we have to use an interdisciplinary approach to understand the functioning of social-political-economic-technical networks of production, marketing, and consumption of organic products. Doing that we might achieve a global policy network approach to understand and support the construction and reconstruction of quality markets.

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CONSUMERS' KNOWLEDGE OF ORGANIC QUALITY MARKS

Simona Naspetti (1), Raffaele Zanoli (2)

(1) Università Politecnica delle Marche, Via Brecce Bianche, 60100 Ancona, Italy, Tel. +392204648, E-mail simona@agrecon.univpm.it

(2) Università Politecnica delle Marche, Via Brecce Bianche, 60100 Ancona, Italy, Tel. +392204929, E-mail zanoli@agrecon.univpm.it,

Key Words: Organic consumer, means-end chain, quality sign, trust builders

Abstract

The study was conducted as part of a EU-wide qualitative survey on consumer perception of organic products, carried out in 8 European Countries (Austria, Denmark, Finland, France, Germany, Great Britain, Italy and Switzerland). It aimed to investigate consumer motivations and barriers related to buying organic products, in order to better understand the consumer decision-making process. In particular, the proposed paper focused on:

- the role of quality marks and certification labels on consumers' knowledge of organic products;
- those aspects which determine and facilitate consumers confidence towards organic products;
- opportunities for the improvement of the communication and distribution strategy of these products.

Introduction

Consumer interest in organic food products has grown rapidly over recent years. Nevertheless, consumers show a generalised lack of trust in the working of the food chain and on organic inspection and certification system (Zanoli, 2004).

Given that the consumer feels unsure about organic quality, quality signs – acting as both search and credence product attributes – are obvious instruments to be used in communication to encourage consumption and reduce perception of risk. Consumers suffer a generalised lack of organic product knowledge: there is a lot of confusion still on what organic products exactly are, what characteristics they have, how are they produced and what are the consequences associated with their use (Zanoli & Naspetti, 2002). Even among current organic consumers, there is still a lack of information about product characteristics, certification bodies, labels, etc.

Organic brands and labels are differently developed in Europe as tools to provide consumers the possibility of making choices among products with similar visual appearances. Only in Northern European countries are they widely used and recognised by consumers. Mentioned among extrinsic quality cues, they serve as quality signals, before any other quality experience occurs. They act as trust-builders, and are related to the consumer's level of product experience (Bredhal, 2003). For this last reason it is not possible to characterize any significant relation between brand and consumer for all consumers neither for all the categories of product. Such relations reflects the level of the consumer's involvement (situational and intrinsic self-relevance) towards the product and consumers attitude to that brand and/or product (Peter and Olson, 1999).

Existing literature has analyzed consumer perceptions of brand (Bredahl, 2003; Grunert *et al.*, 2004), as well as attitudes towards both PGI/PDO products (Barjolle and Sylvander, 2001; Carbone and Sorrentino, 2003; Zanoli *et al.*, 2003) and organic ones (Brunsø *et al.*, 2002; Fotopoulos *et al.*, 2003; Sylvander, 1998). Nevertheless, none of these studies has tackled the issue of consumer confidence in food quality marks.

In this paper, we aim to investigate the role of quality marks and certification labels on consumers' knowledge of organic products, and those aspects which determine and facilitate consumers confidence towards organic products. These aspects are going to be analysed in order to find new opportunities for the improvement of the communication and distribution strategy of these products.

Methodology

Our conceptual framework draws most heavily on means-end chain theory (Gutman, 1982; Olson and Reynolds, 1983). The objective of means-end chain theory is to understand what makes products relevant personally to consumers by modelling the perceived relationships between a product (defined as a bundle of attributes) and consumers themselves (regarded as holder of values) (Pieters *et al*., 1995). We extend the notion of means-end chain structures of consumer's product knowledge to symbolic signs such as quality marks. We use the soft-laddering technique, which is used to construct means-end chains (Reynold and Gutman, 1988; Grunert and Grunert, 1995), 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 800 in-depth interviews were carried out in Europe as part of a larger EU-funded project (OMIARD). Consumers interviewed vary according to their gender, age, frequency of purchase of organic products, level of knowledge of organic products and residence (rural vs. urban).

In order to identify their cognitive structures, consumers 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 and their consequences in order to reveal their underlying beliefs, feelings and desired ends.

Interviews were conducted in native languages and a first coding was performed by native language speakers. Subsequent coding was performed centrally by the authors, who actually merged and newly recoded the material which was used for national analyses. The results of a means-end chain analysis is a hierarchical value map (HVM) or consumer decision map (Reynold and Gutman, 1988). Coding of consumer responses and mapping was performed using a specialist software package developed by the authors (MecAnalystPlus).

Results and discussion

The HVM on quality sign shows a unique nodal point (*have trust)*, so the map is like a spider, with a large number of linkages from attributes and functional consequences to a smaller number of psychosocial consequences and values. European consumers, substantially link organic food perception to the health (*Healthy and long life*) quality dimension. In agreement with previous cognitive studies (Zanoli and Naspetti, 2002), when making reference to general motivations for buying organic products, Italian consumers above all mention aspects associated with health and well-being. With respect to all other motivations, health is clearly the most relevant for consumers.

Results clearly indicates that a trustworthy label should rely on clear standards (*clearly defined standards*), like those usually followed by the *existing labels* – those mainly circulating in Europe: the EU logo for organic products, the German BIO-Siegel, Ecoland, the French AB, the Dutch Skal-EKO, the Swiss "Bud". In this sense, consumers request a quality sign that gives information about the certification body, about how seriously they conduct inspections and about product standards (*Information about label/control/standards*). This knowledge, allowing more *transparency*, could be the only way to allow consumers to *trust*, make them *feel safe* and *avoid been cheated* about organic produce.

Besides, consumers ask for many types of information to be placed on the label: *information about the producer, about a product's place of production and origin, about the product itself and the way of production,* showing a strong request for product traceability. At the same time they understand the need for compromise between such a wide range of requests for written information and the aesthetics of the quality sign. Consumers seem not to forget that a label usually has a limited size (*Clear/attractive symbol/label appearance*), that it needs to be legible (*easy recognizable/to understand*) and suggest labels providing only "objective and understandable information" to trust.

The need to know the origin of the product is also connected to the desire (at the attribute level) that the products be produced locally or nationally (*produced nationally, regionally, locally*), that can improve transparency given potentially one *can personally verify*. The good reputation of organic farmers or producers (*Reliable people/organisations*), as well, can lead to trust. Consumers seem also to ask for a unique label, issued controlled by an independent organisation or a governmental institution. The large number of certification bodies, and different labels that appear on the market contribute to confusion and lack of trust in existing quality sign for a quite high number of UE consumers.

Conclusions

In the context of increasing competition and growing interest in organic food, it is of primary importance to take into consideration factors affecting trust in organic sector and in its regulations. This research identified three dominant/central facets in the context of quality sign: consumer's knowledge, organic sector reliability and relationship trust.

Results suggest, once again, the complexity of the quality concept and the difficulty that consumers have in standardising their decision-making process concerning product quality, with specific reference to organic products. The main findings of the research provide evidence that the majority of existing organic labels and logos fall short of providing a credible quality assurance scheme. The resulting consumer goals structures indicate that existing marks (both public and private) are scarcely informative, while they suggest a change in the approaches to organic quality signalling throughout Europe. Consumers will be more motivated in purchasing organic products by being informed on producers and handlers (improved traceability) and by having more transparency of the inspection methods and results.

Since quality perception is mostly a problem of "information environment" (Brunsø *et al.*, 2002), communication that take place between subjects – involved in the quality perception process – is fundamental. It represents the point of departure of the relational dimension of quality. It also defines the quality perception process and creates an atmosphere of confidence towards the product (Vanoppen *et al.*, 2001). The core problem is that such communication, simply because it regards a relation between individuals, is neither homogenous nor easily standardized, and therefore needs special marketing efforts to be truly effective. Promotion could be used to educate and involve consumers. Considering people usually fully learn 80% from what is experienced – against 20% from what is heard, and 30% of what is seen (William Glasser) – experiential promotion should be used to improve product knowledge and products/brand positioning. Sampling, special tasting events and demonstrations are just examples to improve communications and distribution of existing organic products.

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CONSUMER COMPETENCE AND LOYALTY IN A HIGHLY UNCERTAIN MARKET: A NOVEL LEARNING MECHANISM IN RELATION TO ORGANIC FARMING

Bertil Sylvander (1), Martine. François (2) , Vanessa Persillet (3), Lucie Sirieix (4)

(1) INRA-SAD, Chemin de Borde Rouge, 31326 Castanet-Tolosan, sylvander@toulouse.inra.fr
(2) GRET, 213 rue Lafayette, 75009 Paris, francois@gret.org
(3) INRA-LERECO, rue de la Géraudière, 44316 Nantes Cedex 03, persillet@nantes.inra.fr
(4) Agro Montpellier, UMR MOISA, 2 Place Viala, 34060 Montpellier, sirieix@ensam.inra.fr

Key Words: Consumer behaviour, consumer attitudes, learning, organic farming, organic market, communication

Abstract

This study presents a novel learning process for consumers in relation to organic farming. The conditions for the development of consumer loyalty were studied against a background of great uncertainty about this market in relation to changes in consumer behaviour. Consumer competence with regard to organic farming was evaluated through cognitive and experiential experiments (labelled 'myth' or 'management'). Group effects and learning effects ('complete' or 'incomplete' learning) were variously observed in the different tests. Indeed, both the cognitive phase, directed at 'management', and the experiential phase contributed to an improvement in consumer competence. However, improvement was not lasting in all respects. The study provides some insight into the conditions surrounding the consumer learning process in a selected field.[1]

Introduction/Problem

Many workers have studied consumer attitudes to and concerns about organic food, identifying various purchasing motives (health, tastiness, environmental care and ethical concerns) across a range of countries (Zanoli, 2004). Most recent European studies focus on 'regular' / 'loyal' / 'strongly committed' organic consumers. However, the proportion of such consumers in the population remains small and today's market is nearing saturation (Hamm et al., 2004). It is a fair assumption, therefore, that any future growth in the organic market will depend on it extending to 'occasional' / 'new' / 'uncommitted' consumers, which may lead to the mainstreaming of organic agriculture.

Studies show that occasional consumers know little about organic farming (be it its production processes or the standard of quality they can expect of it) and reveal a mismatch between expectations (consuming organically-farmed products is perceived as a factor of good health) and actual fact (the main benefit of organic farming lies in its environmental and ethical values). This mismatch (like that with the image of beef before the 1996 BSE crisis) may pose a threat to the future of this market. And yet it seems to be maintained by the various communication campaigns designed by the industry out of concern to conform to consumer perceptions.

Methodology

This issue may, we feel, call into question a particular type of communication and more generally a type of marketing aimed at conforming to purchasers' own representations in situations of high uncertainty and where perceptions are not neutral in terms of quality. Here we set out to propose a 'conception-oriented' form of marketing. The idea behind the name is that communication should not be out just to meet expectations but also to shift those expectations progressively in a direction that is beneficial in the medium term to the sector in question.

We work on the assumption – among others – that consumers are 'learners'. In so doing we follow, along with A. Giordan (1998), a 'neo-constructivist' tradition, which postulates that individuals are actors in their

1 This paper is the follow-on from a project conducted as part of the AQS programme with financing from the ministries responsible for research and for agriculture. The scientific director was B. Sylvander (INRA) and the operational director M. François (GRET). The team also included V. Persillet (INRA) and C. Couallier (INRA). See Persillet, Couaillier, Sylvander and François (2004).

own learning processes, in a process of deconstruction (and resistance thereto) and of reconstruction at cognitive, emotional and metacognitive levels.

Marketing theory looks at relations among preferences (perceptions, expectations of a product), exogenous characteristics of consumption and product attributes in an endeavour to account for satisfaction and choices made. What comes to mind are Grunert's ideas about the connection between the consequences purchasers expect and their means of control, the work by Steenkamp (1989) on attitudes to the product, quality indicators and product attributes, or the study by Shepherd (1991) on context and individual consumer factors. For present purposes the most valuable asset is cognitive sequencing, which makes a systematic examination of connections between product attributes, consumer expectations and consumer scales of value. In this area consistency among factors counts for more than the question of causality, which does not seem central although there is explicit involvement of consumer 'purposes'. Conversely there is a question of delving quite deep into the structure of consumer action. The laddering technique takes us a good way into the examination of the hierarchy of values.

These approaches present a limit in the perspective of a learning process about product quality. For one thing they go quite far into the question of hierarchies of objectives, which, for educationalists, come into play in the learning process and are necessary in any event for furthering the knowledge of consumers-cum-citizens about the future of farming. For another thing they fail to set enough store by experience. Admittedly the central paradigm developed by Hirschmann and Holbrook (1981) takes a close look at this, but it does not really tie in experience with a process of radical change of preferences.

In the context of this paper we test the hypothesis of consumers' ability to learn (and so to increase their level of competence). To do this, we test out a learning mechanism. This mechanism is formed from three groups (a control group, a 'myth' group, which is given idealised information, and a 'management' group, which is given more complex and more objective information).While the control group is given no information throughout the experiment, the other two groups are given first cognitive information (appealing to the intellect) and subsequently 'experiential' information (involving a real-life experience: a trip to a farm). The experiment – the relevance of which is under test here – aims to measure changes in consumer conceptions and competence through questionnaires and quality score cards.

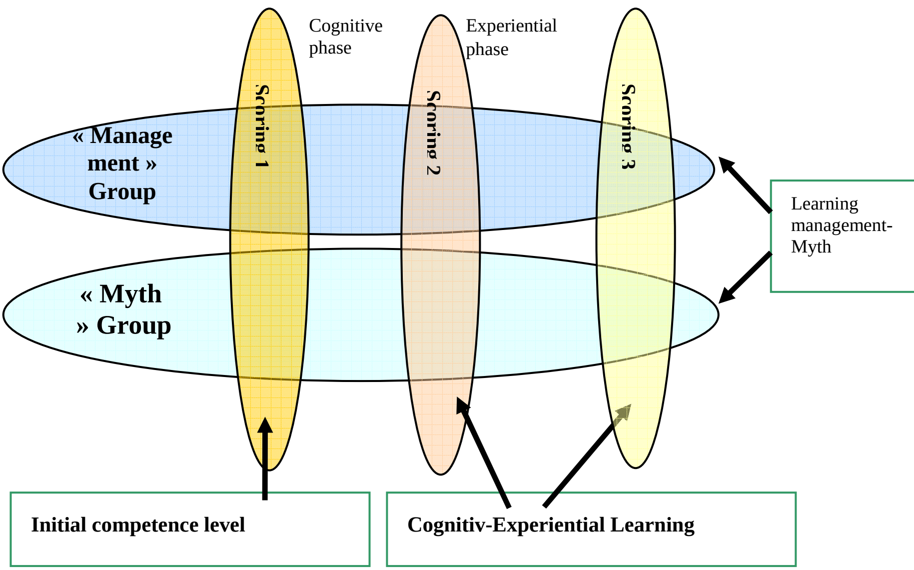


Figure 1 : methodological device for consumer learning research

Results and brief discussion

1. Consumer competence as measured at the beginning of the experiment displayed a fairly evenly balanced situation with regard to consumers' knowledge of farming in general and of organic farming in particular. The definition of organic farming was quite well grasped and the main provisions, which are both logical and covered by the press, were known. However, 'trick' questions were obviously more troublesome. We found the questions posing the greatest difficulties to consumers were those about the 'idealisation of organic farming'. This confirms our starting hypothesis, given both the difficulty of the topic and the communication policies, which, as we said at the outset, tend to opt for a representational marketing strategy.

2. On the question of learning, consumers in the 'myth' and 'management' groups addressed three themes simultaneously: theme A: conventional and organic production modes; theme C: guarantee, label and logo; theme D: environment.

3. The 'management' group differed from the 'myth' group in undergoing a complete learning process on four topics mostly related to theme A 'conventional and organic farming' (particularly animal welfare).

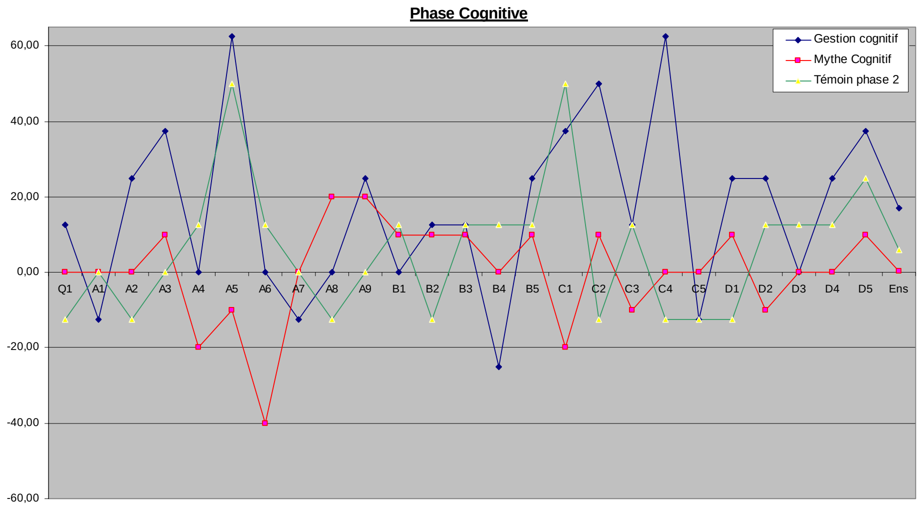
4. The incomplete learning process for the 'management' group related mainly to theme C 'guarantee, label and logo', on which consumers in this group progressed during cognitive learning and regressed after the experiential phase. The experiential phase was only beneficial for the consumer learning process on theme A 'conventional and organic production modes'.

5. Contrary to the 'management' group, consumers in the 'myth' group progressed on questions which were more about the idealisation of organic farming (for both complete and incomplete learning processes).

6. The proportion of correct answers improved for the 'management' group above all in the cognitive phase and for the 'myth' group in the experiential phase. The themes on which the 'management' group made most progress were those relating to the 'idealisation of organic farming', as consumers imagine it. Respondents were led to markedly revise their thinking on issues of concern to them and which are readily taken up by the press.

7. Unlike the 'management' group the 'myth' group did not increase its knowledge of organic farming during the cognitive phase.

8. The 'experiential' process was particularly beneficial for the 'myth' group especially with regard to livestock farming (farm visit). This shows that experiential communication can 'correct' the shortcomings in the provision of information which is very much marked by the myth of nature. The mythical process can therefore be corrected either by 'management' style communication, which is not complacent with regard to reality, or by an experiential process, allowing consumers to correct their own prejudices after having 'seen for themselves'.



The figure above is an example of the results, in the case of the cognitive approach. It shows the learning performances achieved by the consumers according to both groups ("myth" and "management". It follows the different types of questions (A, B, C, D) presented in the paragraph 2. The red line illustrates that the "management" group is learning more efficiency than the "myth" group. Thus, it seems that a communication based on facts and on consumers' cleverness, presented in a fair and attractive way, could be more efficient than simple "surfing" on consumers beliefs !

This is only a first stage in this programme and we are aware that the changes in competence will need to be validated in terms of consumer attitudes and behaviour. This first stage was to check capacity for learning and the various learning styles employed.

Conclusions

Our research shows that there is scope for learning for consumers of organically-farmed products, even on difficult themes. 'Cognitive' communication is more effective on some themes if consumers have 'managment' type, that is objective, information. Conversely 'experiential' learning allows consumers exposed to idealised information to correct their opinions. This outcome may lead to a degree of objectivity being instilled in communication if it is more informative than emotional, and also where feasible lead to the creation of experiential situations.

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ORGANIC AND LOW INPUT FOOD CONSUMERS: CONCERNS AND PERSPECTIVES FOR DEVELOPING THE ORGANIC MARKET IN THE FUTURE

Bertil Sylvander (1), Martine Francois (2)

(1) INRA-SAD, Chemin de Borde Rouge, 31326 Castanet-Tolosan Cedex, sylvander@toulouse.inra.fr
(2) GRET, 213 rue Lafayette, 75010 Paris, francois@gret.org

Key Words: organic farming, consumer attitudes, consumer behaviour, low input food, quality, safety, acceptability of technologies, learning

Abstract

This contribution deals with occasional consumer attitudes to organic/low input food in relation to quality and safety issues; and presents the preliminary results of studies conducted as part of the EU Framework 6 QLIF[1] research project. The main result shows that a lack of knowledge among consumers about the production and processing techniques leaves room for a learning process on how to give pragmatic content to the demand from "caring people" and how to allow consumers to learn more about farming and processing.

Introduction/Problem

Numerous authors have studied consumers attitudes to and concerns about organic food, revealing various buying motives (health, tastiness, and environmental and ethical concerns), depending on the country (Zanoli, 2004). The same range of motives for consuming organic food is mentioned in several European countries. Certain motives tends to be more crucial, but the order of importance differs from country to country (table 1).

Table 1: Rank of the three principal motives for buying organic food by country (adapted from Zanoli, 2004)

Country	Motives		
Austria	Health	Responsibility for children	Contribution to regional development
Switzerland	Better taste	Health	Altruistic motives like environment, animal welfare, remuneration of farmers
Germany	Own or children's health	Support of organic shops and farmers	Taste
Denmark, Finland	Lifestyle choice: environmental protection	Own health	Support of and contribution to a better world (DK), conscience: animal welfare (FI)
France, Italy	Health	Taste	Respect for the living world (FR)
United Kingdom	Health	Local farming and fair trade	Environmental protection

Most recent European studies focus mainly on "regular"/"faithful"/"heavily" committed organic consumers. However the percentage of such consumers in the population remains low, and the growth rate is declining in some countries (Hamm *et al*., 2004). Therefore, it can be concluded that the future growth of the organic

[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 fork to farm approach. The project was initiated on March 1, 2004. It is funded by the European Union with a total budget of 18 million Euros. The research involves thirty-one research institutions, companies and universities throughout Europe and beyond. The results presented in this paper involve the participation of the following institutions and researchers : FiBL (T. Richter), GRET (M. François), Institut National de la Recherche Agronomique (B. Sylvander), University of Aberystwyth (P. Midmore), University of Ancona (S. Naspetti, R. Zanoli), University of Kassel (U. Hamm, H. Stolz), University of Newcastle (A. Tregear, Ch. Ritson, E. Oughton, M. Brennan, K. Brand), DARCOF (M. Wier).

market must rely on reaching “light”/”new”/“occasional” consumers , which could lead to “mainstreaming” organic agriculture.

Reaching, informing and convincing these light consumers to become more loyal towards organic products is difficult because:

(i) The supply needs to be adapted to this occasional demand while the concerns of “core” consumers have to be kept in mind. For the latter, “organic products represent the quality and safety that they seek, and have also integrated social concerns for the environment” (Midmore *et al.*, 2004). The “light” organic consumers tend to be more price and convenience sensitive and thus market expansion may rely on achieving scale economies in distribution and greater levels of processing. If light and core organic consumers tends to have different concerns, there is a difficulty to address both at the same time.

(ii) Environmental and societal concerns are growing in the world agri-food sector, reinforced by NGO movements, and in the framework of WTO negotiations. The support that governments give to their agricultural systems must nowadays be legitimated, which provides new support for “Low Input” agri-food systems, techniques and certification (integrated agriculture, for example).

(iii) Other alternatives exist and may compete with Organic Food and Farming (Origin Labelled Products, farmhouse products, direct sales, etc.)[1]. For “light” organic consumers, “organic” is not the only reference for quality products, and organic products have to be put in their competition area.

(iv) One of the pathways for the development of the organic market may involve the development of processed and pre-packaged products that may be demanded by occasional organic consumers but often rejected by regular consumers who may distrust and suspect the technologies involved.

In this framework, the QLIF project seeks to address key questions related to the quality and safety of both organic and low input foods in a broader perspective. The sub-project devoted to consumers’ expectations addresses the following questions:

1. How do consumers define and construct meanings around the concepts of quality and safety as they relate to organic and low input foods?

2. How do such concepts and meanings vary for different model commodities?

3. What are the mechanics of consumer perception and behaviour for organic and Low Input foods? And what role do quality and safety characteristics play within this?

The research framework considers the gap between the quality of the product, as it is designed by the actors in the processing chain, and the quality as it is perceived by the consumer.

Here the “learning process” takes place. The consumer can learn about production and processing techniques, understand the producer’s constraints, be more conscious of what is at stake in the production and processing process, and make food choices according to his knowledge.

The research aims at enlightening how this “learning process” takes place in the mechanics of consumer perception and behaviour. Then, the question raised by the research is how this concept of “learning process” can contribute to a renewal in the design of appropriate communication and information about organic agriculture and food ?

Methodology

On the basis of a comprehensive literature review and in accordance with the previous statements, the first step in the research involves four focus groups (FG) in five countries (France, Germany, Switzerland, Italy and the United Kingdom), concentrating on four products (bread, yoghurt, tomatoes, and eggs; two for each FG).

We focus on occasional and higher involved consumers of organic products[2], which are compared with low input and conventional products, and we deal with quality and safety attributes and with production and

[1] See the Dolphins project (www.origin-food.org, Sylvander, 2004) and (François et al.) Agroalimentaire Paysan Européen : Caractéristiques distinctives des produits fermiers, Rapport final, www.gret.org).

[2] All consumers uncommitted to organic foods, half of the group (8-12 people) consists of 25- to 45-years-old and half of 45- to 65-years-old; at least two men per FG, all consumers buying at least one of the selected products as organic.

processing techniques. This last choice is based upon the interest of today's consumers in production techniques for assessing quality and upon an evolution of organic standards at farming and processing levels, and is strongly concerned by a set of "critical technologies" (Schmid *et al.*, 2004).

The following questions are handled in the FGs: buying criteria for food, possible disappointment with the purchased products, the influence of production and processing techniques on quality, and willingness to pay for the product. As most regular consumers perceive organic food as inherently safe, we intended at the beginning to analyse the conditions under which reducing the perception gap could be envisaged. At first, we could only limit the focus to consumers' knowledge of consumers of agricultural and food technologies and their expectations/acceptability of use or non -use of "critical" technologies.

Results and Brief Discussion

As the FGs were conducted during the autumn of 2004, we can only report some preliminary results at this point. The complete report of the research will be available in September 2005.

For fresh or lightly processed products, organic is seen as a guarantee of the naturalness and "pureness" of the food (without pesticides, hormones, antibiotics, etc.). Organic is associated with freshness and a minimal level of processing. Organic is thus linked to short distribution channels, on-farm production, and self-production. There might be a confusion in the consumer's mind, between "Organic" and any product purchased through short distribution channels. When there is a general distrust in the long production, processing and distribution food chain, "*Knowing the producer*" is an important factor in the trust building process for the consumer. At the same time, some consumers turn to self production or processing of food (home made bread in the United Kingdom, Germany, self production of vegetables in France, home preservation of vegetables in France,…).

Furthermore, for some consumers, organic can also be considered to be an assurance of food safety for processed foods when farming or processing techniques are suspected. For example, high spatial concentration of hens in egg production can be associated with bad quality or even create disgust for industrial eggs "*I cannot even think of eating an egg coming from industrial production*".

In that case, "free range eggs" or "barn floor eggs" may be a cheaper alternative to organic for "light" organic consumers. For some consumers, the BSE crisis has lead to mistrust in the conventional beef commodity chain, but also in the whole industrial production – processing and distribution food chain. For commodities such as frozen burgers, organic can be seen as a guarantee of pureness and freshness.

Consumers' knowledge of agriculture, food technology and processing seems very weak. Most of the technologies used in processing "simple" foods (such as the use of ripening agents for fruits and vegetables, hydroponic culture, additives in animal feeding, or milk processing, crop production techniques to shorten the ripening are unknown. Furthermore, the consumers do not associate immediately the crop production techniques and the product when it is processed: For example wheat and bread, milk and yoghurt. Some consumers are seeking information in the newspapers, looking at TV reports. At the same time, some other consumers feel overwhelmed by the quantity of information they should gather to make their food choices. "I cannot be an agronomist ! ". Then, they only are aware of major disrupts in the food chain: pesticides alerts (UK), BSE crisis, ….

Both attitudes can lead to reinforcement in the organic consumption. The latter wish to have a label "*not to have to think when I buy my food*" which provides insurance in food safety and quality, without personal investment.

The others learn about conventional and organic agriculture. Some conventional techniques are strongly rejected, like battery poultry production, use of hormones as ripening agents, use of antibiotics in animal feeding, etc. Therefore, reference to conventional industrial techniques might be a strong incentive to buy and eat organic food for some consumers.

Thus, the question raised here is how to take advantage of the consumers' "willingness to learn".

Conclusions

The main question raised by this approach is building consumers' trust in the product, which seems to be linked with the consumers' trust in the actors along the supply chain, which in turn is based, in the minds of the participants, on an incompatible conflict between a profit-seeking attitude and quality building.

This conflict refers to the concept of “care”, strongly linked, in the minds of consumers with quality/safety: “people who care” are also presumed to take care of the product (and of other people!). Long commodity chains, industrial agriculture and processing, retailing through supermarkets is strongly linked, in the consumer’s mind, to profit-seeking as a major goal of the organisation, and leads to a lack of responsibility of people at work. “*even if they wish, they cannot put quality at the first place*”. Industrial methods and profit-seeking are linked with disrespect towards human beings, and poor ethics. Certainly, not all low-input foods have to be associated with “careless industrial methods”—hence, in this perspective, the consumers’ high interest in the technical and economic conditions that prevail in supply chains (including the ability to “take care”), which legitimates the attempt to address the “learning hypothesis” in our research agenda (Sylvander et al., 2004).

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SOCIOLOGY

THE CHALLENGE OF ECOLOGICAL JUSTICE IN A GLOBALISING WORLD

Hugo Fjelsted Alrøe

Danish Research Centre for Organic Food and Farming (DARCOF), P.O. Box 50, 8830 Tjele, Denmark, +45 8999 1679, hugo.alroe@agrsci.dk, http://hugo.alroe.dk

Key Words: ecological justice, fairness, commons, globalisation, organic agriculture, trade, development

Abstract

Ecological justice is a challenging concept in relation to the current development of agriculture, including organic agriculture, because it positions social and ecological interests against market liberalism and economic growth. Ecological justice concerns fairness with respect to common environments, and it is therefore closely connected to the idea of commons. The concepts of commons and ecological justice are particularly relevant to organic agriculture, which builds on close cooperation with ecological systems and cycles, and they may suggest ways to resist the pressures of globalisation and structural and technological developments.

Introduction

Like mainstream agriculture, organic agriculture is faced with the all-pervading trends of globalisation and the ensuing challenges of sustainable development. These current trends in mainstream agriculture are to some degree shared by organic agriculture. In areas that are not, at present, covered by regulations, organic agriculture tends to follow the mainstream path towards large-scale, efficient productions that use modern technologies and global trade, and organic processing, marketing, and sale is incorporated into large conventional companies (e.g., Rigby and Bown 2003). This ‘modernization’ and ‘conventionalisation’ of organic food systems has been an important factor in the recent growth of organic productions and markets. On the other hand, this development can lead to unwanted social and environmental impacts due to reduced landscape diversity, increases in food miles, greater distance between producers and consumers, unfair competition from large players, reduced food diversity, etc. And it can also put pressure on the integrity of the organic agro-ecological production systems by imposing constraints on the selection and diversity of crops, varieties and breeds.

In a wider perspective, globalisation and the mainstream approach to sustainable development have generated great resistance from many stakeholders, most noticeably developing nations, local communities, advocates of civil society, and environmentalists. Although diverse, there is a general philosophical theme that unites this resistance, that of the cause of *ecological justice* (Low and Gleeson 1998, Byrne et al. 2002). Ecological justice promotes fairness in relation to the common environment for both present and future generations and for both human and other living beings. It is thus a more comprehensive form of justice than the well-known form from political liberalism, extended to incorporate the idea that individuals have a claim on their environment and the idea that justice and fairness concern not only humans, but animals and other living organisms as well. The latter extension does, notably, not go against the traditional goals of liberalism – there is a space for a liberal ecologism that does not put the causes of non-human nature above those of humans, but see the first as intimately connected with the latter (Bell 2003, see also Baxter 2005: ch. 7).

Methodology

This paper investigates the role that ecological justice may have in relation to the present challenges for organic agriculture (see also Alrøe et al. 2005). The investigation has two interacting elements, a philosophical analysis of ecological justice in relation to other relevant concepts, such as sustainability and commons, and a discussion of how the key concepts can be put into practice to meet the challenges.

Results and brief discussion

The comprehensive, integrated view of nature and ethics that is characteristic of organic agriculture is evident in one of the original key ideas: that “the health of soil, plant, animal and man is one and indivisible,” in the words of Lady Eve Balfour (Woodward et al. 1996). This view entails a certain perspective on sustainability, which is perhaps best captured by the notion of sustainability as ‘functional integrity’ as opposed to ‘resource sufficiency’ (Thompson 1996).

Functional integrity sees humans as an integrated part of nature, based on an ecological view of nature. Humans and nature form vulnerable socio-ecological systems that have crucial elements, such as soil, crops, livestock, ecosystems, cultural values, and social institutions, which must be regenerated and reproduced over time. Functional integrity emphasizes resilience and recognizes the limits of scientific knowledge and the possible risks connected to new technologies, thereby incorporating the concept of precaution. Sustainability as resource sufficiency is an ‘accounting’ approach that focuses on how to fulfil present and future human needs for food, and on how we can measure and calculate the proper balance between present resource use and future needs based on the relation between input and output from the system. Nature is seen as ‘robust’ and separate from society, and environment and nature are considered a resource for humans.

Functional integrity has the potential to stand up against some of the present trends in mainstream agriculture and sustainable development. But functional integrity concerns the workings of the system as a whole, and such notions seem to have a limited impact in current discourses. Ecological justice, on the other hand, concerns individuals in relation to the system, and in recent years this concept (together with the related, more human-centred concept of environmental justice) has emerged as a forceful reaction to the current global trends (Low and Gleeson 1998, Byrne et al. 2002, Shrader-Frechette 2002, Baxter 2005).

Ecological justice can in particular be applied to three, related, aspects of the present trends: the commodification of hitherto commons, the externalisation of environmental and social costs, and globalisation as the erosion of barriers to distant trade and ownership.

The basis for speaking of justice with regard to the environment is that the environment is, in some sense, common to us all. The concept of ecological justice is thereby closely connected to the general idea of ‘commons’. This idea is traditionally found in relation to common lands used for grazing or gathering and debates on their commodification by way of enclosure and private property, but it has recently been used in a much broader sense (e.g., The Ecologist 1993). The question is what aspects of the environment are to be considered commons and in what respects, and what that means for ecological justice: the scope of ecological justice depends on what rights individuals and communities have on their environments.

Organic agriculture is more dependent on the environment than conventional agriculture, because it bases agricultural production on a close cooperation with natural ecological systems and processes and because it has fewer technological remedies available to counteract depletions and malfunctions of these systems. What we may call ‘ecological commons’ therefore have a special importance in organic agriculture. Nature plays a key role in the provision and reproduction of ecological commons whereas public goods are produced by human actors. This distinction is important because the provisions by nature tend to be overlooked in policy analyses directed towards the challenges of globalisation.

The question of whether something is to be considered as a commons is determined by ethical and political criteria, not by empirical criteria such as whether the benefits from the resource are excludable (can be withheld from others, e.g. the enclosure of land) or rival (are depleted when used). Technological and structural developments keep shifting the ground for such empirical criteria, and technically and economically excludable resources may well be considered commons from the ethical perspective of ecological justice.

The degradation and depletion of commons through over-use has been the topic of the ‘tragedy’ discourse that followed from the influential article by Garrett Hardin (1968). The tragedy of “The tragedy of the commons” is that is has been taken as a demonstration of the inability of ‘common property’ regimes to manage commons, even though Hardin did, in effect, not consider such regimes (McCay and Jentoft 1998). Hardin’s case was a case of free usage and no regulation, and the only alternative regimes that were fostered by the ‘tragedy’ discourse were the privatisation and nationalisation of commons, and thereby this discourse effectively disguised the potential of ‘commons regimes’ to manage commons.

The concepts of commons and ecological justice can be put into practice in different ways that can be seen as commons regimes, which institutionalise the usage of common environments. Examples are sustainable production methods, local community institutions of co-management and cooperative food networks; certification and labels that involve the consumers as a responsible actor; state or supra-state regulations of the market; and global institutions under the mantle of the United Nations. Organic agriculture has little direct influence on the latter, but it can play a key role in the first. It can do this in two different ways, through certified and non-certified organic agriculture.

There is a tendency in today's globalised markets towards liberating the products from the production processes and manufacturing alternative, attractive, but fictive, stories to go with the product. Organic and fair trade certification are two examples of alternative forms of trade that go some way towards meeting the aims of ecological justice by way of incorporating the production process context into the market based on certification standards and procedures - standards that may be targeted to work against commodification and externalisation of costs. Such alternative forms of trade have the potential to work across globalised food networks in distant trade relations. But the current forms of organic and fair trade fall short of meeting the aims in some respect. Fair trade is lacking in ecological considerations, organic trade lacks social considerations, and both omit considerations of external costs connected to distant trade, for instance. In general, the different forms of alternative trade put the responsibility for ecological justice on the consumer, and the question is to what degree the consumers can bear such responsibility in a situation of cheap conventional goods that do not carry their own environmental and social costs, and under the pressure of everyday economic constraints.

The organic movement also works to promote alternative forms of farming and food networks that are not necessarily certified in the standard market way (e.g. local community networks, local markets, and participatory guarantee systems). The concept of 'non-certified organic agriculture' designates forms of production and processing that accord with the ideas and principles of organic agriculture without being certified. This form of organic agriculture has a potentially very important role to play in the promotion of ecological justice in large parts of s the low-income countries, where food production is based on low-yielding agriculture, subsistence farming, and local food markets. In such areas, organic production methods have the potential to give higher and more stable yields than the existing agriculture, based only on local natural resources and the necessary inputs of knowledge and extension services to assist the establishing of self-reliable organic food systems. Non-certified organic agriculture may therefore be promoted as an alternative solution to food security problems, which is more sustainable and ecologically just than the mainstream high-input solutions. A solution that is furthermore open to the later inclusion of certified organic trade as an added option for economic development. But this solution can only be realized fully if there is understanding of and support for the value of sustainable low external input agriculture, such as organic agriculture, within development organizations and related research institutes.

Conclusions

Ecological justice is a more comprehensive form of justice than the well-known form of political liberalism, extended to incorporate the idea that individuals have a claim on their environment and the idea that justice and fairness concern not only humans, but animals and other living organisms as well. The idea that we share environments is basic to ecological justice. Alternative forms of trade such as organic and fair trade constitute one way to implement ecological justice in agriculture and food systems. But both organic and fair trade, in their current forms, need to be amended from the perspective of ecological justice, and such alternative forms of trade put great demands on the awareness and responsibility of the consumers. In addition to such reforms of the market based food systems, ecological justice suggests the promotion of 'non-certified organic agriculture' as a path to development of local sustainable communities.

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FACILITATING ORGANISATIONAL CHANGE IN AN ORGANIC DAIRY CORPORATION IN DENMARK

Dorthe Christensen[1] and Nadarajah Sriskandarajah[2]

The Royal Veterinary and Agricultural University, Danish Research Institute of Food Economics, Unit of Learning, Rolighedsvej 25, 1958 Frederiksberg C, Denmark,1) doch@kvl.dk; 2) sri@kvl.dk

Key Words: Organic dairy farming, dairy industry, learning organisation, systems thinking, action research

Abstract

This paper focusses on the notion of sustainable development as the challenge of creating self-referential systems that are continually learning how to persist in a complex and ever-changing environment. Drawing on systems theory and practice, a process of organisational change was facilitated within a small organic dairy that had great difficulties surviving the competition in the contemporary Danish food system. Peter Senge's discipline of creating a shared vision was incorporated into an experiential learning methodology; here it acted as the major catalyst for the organisational learning and change achieved. The findings imply that in order to survive and create the future that it desires, a small organic processing firm needs to learn to be mentally agile with respect to change and innovation within, as well as outside, its existing boundaries. For this learning to be accomplished, facilitating it with a systemic perspective may be an option available to an organisation.

Introduction

In recent years organic milk production in Denmark has exceeded consumer demand. This put economic pressure on dairies and farmers and increased competition between the dairies. One of the smaller dairies that had great difficulties surviving in this competitive environment was the organic dairy corporation named ORDA in this study. The objective of this paper is to evaluate the process and the outcomes of a facilitated organisational change in this organic dairy, towards assessing the potential of systems theory and practice applied to similar organic agricultural contexts.

Theoretical and methodological framework

The systems theory and practice applied comes primarily from the 'soft' school of the systems movement. Overall, this means that it becomes important to focus on the 'wholeness' of a situation as the people constituting the situation, both in terms of existing reality and in terms of improvements, subjectively appreciate it. The crucial task of the systems researcher is therefore one of acting as a facilitator of a learning process, within which people can share their multiple perspectives on reality and engage in a debate about them, in a way that will lead to desirable change. This means that systems research becomes action research, which is a participatory approach having the dual aim of pursuing both action (change) and research (understanding). Action is always taken together with people to address issues of pressing concern to them. This is done in a way that increases understanding for the researcher as well as for the participating stakeholders. As a parallel outcome, actual change in the stakeholder situation is accomplished. In terms of the research part, the understanding gained by the researcher may be relevant to a wider aim of developing existing theories and practice. Specifically, this study draws on the systems theory and practice of Peter Checkland and his colleagues at Lancaster University (e.g. Checkland, 1981; Checkland & Scholes, 1990) and the work of Richard Bawden and his colleagues at the University of Western Sydney, Hawkesbury (e.g. Sriskandarajah et al., 1991; Bawden, 1995). Further, inspiration is taken from Peter Senge (e.g. Senge, 1990) and, in particular, from his views on creating a shared vision for an organisation.

In the facilitated process with the dairy ORDA, the wheel that made the systemic action researching towards organisational change go round was made up of sequential experiential learning cycles consisting of four basic learning styles: diverging, assimilating, converging, and accommodating (Kolb 1984). This experiential process can be viewed as a way in which a system can consciously organise and guide its activities towards profound change as sequential cycles of planning, action, observation, reflection, planning, action, observation, reflection and so on. As Checkland & Scholes (1990) outline it, in this way, a change process can become doubly systemic: 1) the research methodology in which systems ideas are used to initiate and orchestrate the debate about purposeful change, without rigour being abandoned, and 2) the operation or creation of a cyclical iterative learning system to use experiential learning and other systems ideas. The latter is justified by the belief that a system's ability to persist and achieve long-term self-mobilisation and stability can be correlated to double-loop learning – i.e. to its ability to adopt new worldviews and learning to learn (Bawden, 1995). Ideally the goal is therefore that the learning process continues beyond the time the researcher is part of the organisation. The endeavour with the dairy ORDA developed through the completion of four such experiential learning cycles. A fifth planned cycle was never completed, because the dairy was suddenly sold to a much larger dairy co-operative.

Methodological overview

1. Establishing the project
2. Finding out about the present situation of the organisation/system
3. Creating a shared vision of an alternative purposeful activity system
4. Evaluating the envisioned system, evaluating and prioritising ideas
5. Creating the first action plans to bring about desired improvement (this cycle was only planned, never completed)

Findings and discussion

The observed changes happening within the organisation are described as modifications in actual behaviour or in potential behaviour of the organisation, resulting from the learning the participating ORDA stakeholders derived throughout the facilitated process. Change in potential behaviour is described as learning what to do under particular circumstances and learning how to do it. Change in actual behaviour, then, is what is achieved when the potential behaviour is enacted in a given situation.

As the shared vision constructed in many ways challenged the prevalent images or mental models ORDA stakeholders had of their present situation and in this way 'mentally transformed' the system, the vision can be seen as a change in potential organisational behaviour. The wider values and procedures under which the organic organisation was operating at the time were questioned and possible changes suggested based on new ways of seeing things. This indicates that double-loop learning was happening. In addition to this mental transformation, the process of facilitation brought about a 'relational transformation' of the system. Stakeholders' sense of community, their sense of feeling connected in an important undertaking, was strengthened and given new life. This change was partly a modification in potential behaviour, partly in actual behaviour. There was a clear relationship between this relational transformation and the establishment of the over-arching long-term goal, accomplished through the visioning process. This finding confirms the important effect of creating a shared vision emphasized by Senge (1990) – that it binds people in the organisation together by common aspiration and caring. For Senge, the power of shared vision lies not in the vision as such, but in what it does to the people creating it in terms of empowering them to achieve their greatest aspirations collectively as a community. This viewpoint is supported by Flood (1998), who points out that one of the valuable insights that come with Senge's learning organisation is that, when attended thoughtfully, it can be potentially empowering in this way. The renewed feeling of community, empowerment and sense of commonality in terms of aspirations seemed to be the major reason that ORDA stakeholders during the process requested a change from the original plan in terms of stakeholder participation. Accordingly, the desire to have all stakeholders within the organisation involved in the work towards change steadily increased as the process advanced. It culminated with the participants starting to question the existing passive role of the dairymen within the organisation. The desire to involve the whole organisation in strategic planning and management was a clear change from usual ORDA procedures. As concrete steps towards realising increased stakeholder participation were planned throughout the facilitated process, this change was not merely a change in potential behaviour, but in part also a change in actual behaviour. Therefore, one could say that a 'methodological transformation' of the system also took place. ORDA stakeholders were starting to question and adopt completely new ways of going about things.

In discussing and evaluating the facilitated process leading to the changes described, Senge's discipline of creating a shared vision stands out as the major catalyst for the organisational learning accomplished. Following mainly Frantz (1998), the specific technique used for visioning was to first suspend or transcend the existing reality and leap ten years into the future by way of guided imagery. This was followed by sharing of individual experiences and intensive dialogue. The intention with using this procedure was to allow space for ORDA stakeholders to free their creative imaginations from the constraints of current reality, leap out of their present worldviews forming the way they saw ORDA, its environment and themselves at the time, and dream dreams about the future that reflected their deepest aspirations. As Senge points out, it is the fact that a shared vision reflects the 'intrinsic' desires of each individual making up the organisation, which helps constitute in organisational consciousness a willingness to change. It is this, along with the fact that shared vision binds people in the organisation together by common aspiration and caring, that creates commitment, fosters the necessary risk-taking and experimentation, and empowers people to act. Guided imagery, followed by individual reflections on individual experiences during the imagery, allows for the 'inner' visions of the individual to emerge before a collective visioning session is held. In the facilitated process with ORDA, drawing on this 'inner' source of learning seemed important, not only for challenging existing worldviews, enhancing creativity, and establishing deep organisational meaningfulness, but also for capturing the wholeness of the of the desired future situation.

When all this is said and done, it is important, however, to acknowledge that there are many ways of creating shared visions of future systems, and it is difficult to say what will work and what will not work in a given situation with a particular group of people. The most important thing is to get started with visioning. As Senge (1990) points out, it is not possible to have a learning organisation without a shared vision. This viewpoint builds on the idea that a central feature of visioning lies in its power as a tool for facilitating learning into an unknowable future. On this matter Senge follows the structure of processes of learning, which have been suggested by other system thinkers like Ackoff (1981) and later also Banathy (e.g.1998). Here, the key aims and benefits of visioning are not so much to forecast the future and make fixed plans accordingly, but that the organisation, through the visioning process, becomes mentally agile with respect to change and innovation within as well as outside its existing boundaries, and continuously learns its way into the future in this way. Flood (1999) speaks of this as 'learning with scenarios'. The central argument here is that the new purposeful system created acts as the major catalyst for learning. This was in fact the essential function of the shared vision created in ORDA. Had the dairy not collapsed, but maintained its identity, the vision may also have acted as the major catalyst for creating a learning organisation learning to persist, achieving long-term self-mobilisation and stability through the integration of different forms and sources of learning.

Within an organic agricultural context all this complies with a notion of sustainable development as the challenge of creating self-referential systems that are continually learning how to persist (e.g. Bawden, 1995). However, although the findings indicate that at least potentially the organic dairy showed characteristics of becoming and also wanting to become such a self-referential learning system, the dairy ended up doing completely the opposite of what it intended: it collapsed and was taken over by a much larger dairy co-operative. This 'undesirable' organisational change raises a number of questions about the future prospects for facilitating change in small organic food processing firms in the way it was attempted in this piece of research. The overall question remains whether all this learning, action researching and visioning can really make a difference for a small organisation that is operating in the reality of today's food market. In order to assess this, a longer-term study would be appropriate. In such a study, in particular the system's ability to learn to continuously close the gap between its current reality and its intrinsic desires (its shared vision) should be evaluated. As an organisation's intrinsic desires as well as current reality keep moving all the time, it would mean that such an evaluation would include the organisation's ability to revisit and adapt action plans aimed at closing the gap, as well as its ability to terminate or start new ones when this is necessary. Included into this could also be an evaluation of the organic organisation's ability to manage the inevitable creative and emotional tension, and the structural conflicts and constraints that Senge (1990) warns of.

Conclusions

The evaluation of the facilitated organisational change process and its outcomes led to the conclusion that Senge's discipline of creating a shared vision could be easily incorporated into the methodology of sequential experiential learning cycles, where it acted as the major catalyst for the organisational learning and change achieved. Leaping into the future by way of guided imagery, followed by sharing of individual experiences and dialogue, was an effective visioning technique for bringing out a shared vision that apparently reflected the organic organisation's deepest aspirations and core values, challenged the prevalent images its stakeholders had of their current situation, and captured the wholeness of their desired future situation. These organisational change processes all required collective efforts, guided by a facilitator. This opens up for a new professional role: the facilitator of change as an intervenor in organic agricultural contexts. In order to survive and create the future that it really desires, a small organic firm, positioned in the contemporary reality of the Danish food sector, needs to be proactive. Learning to be mentally agile with respect to change and innovation within as well as outside its existing boundaries will be a helpful approach here. For this learning to be accomplished, facilitating it with a systemic perspective may be an option available to an organisation.

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WHAT WILL THE NEXT GENERATION DO WHEN THEY SUCCEED THEIR PARENTS ?

Bernhard Freyer (1), Heidrun Leitner (2), Thomas Lindenthal (3)

(1, 2, 3) University of Natural Resources and Applied Life Sciences Vienna, Inst. for Organic Agriculture, Gregor-Mendelstr. 33, 1180 Vienna, Austria, +43-1-47654-3750, www.boku.ac.at/oekoland/
(1) Bernhard.Freyer@boku.ac.at (2) Heidrun.Leitner@boku.ac.at (3) Lindenth@edv1.boku.ac.at

Key Words: Organic farming, agricultural education in high schools, attitudes, intentions

Abstract

In autumn 2003; a survey was carried out in six Austrian agricultural high schools in order to obtain an overview of students' attitudes towards organic farming. 25.5% of students from conventional farms have a negative attitude towards organic farming (27.5% hold a neutral attitude, 47% a positive attitude). Significant impacts of land use systems and social norms can be determined. Gender-related differences are highly significant, differences between the schools as well.

Introduction

Austrian agricultural schools train a large section of future farmers in theoretical as well as practical knowledge of farm management. Thus, they should play an important role in promoting organic farming – which is also emphasized in the Austrian Organic Action Plan (BMLFUW 2001).

Relevant factors that either support or obstruct the conversion to organic farming methods have been investigated in various scientific studies (Darnhofer *et al*. 2005, Schneeberger *et al*. 2002). Similar studies that are, however, based on surveys among pupils and students attending agricultural high schools are not known to the authors.

The overall objectives of this paper were (1) to identify students' attitudes towards organic farming and their intentions with respect to converting or not converting their parents' farms into organic farm management, (2) to define the main factors in the related decision process and (3) to examine the influence of schools and teachers on students.

Methodology

Some of the most recognised models in Environmental Psychology and Behavioural Science were analysed to extract factors that could be relevant to the formation of students' attitudes and intentions in the context of organic farming and their decisions when taking over the farm management: the *Theory of Reasoned Behavior* (Fishbein & Ajzen 1980), the *Theory of Planned Behavior* (Ajzen 1985), the *Model of Ecological Behavior* (Fietkau & Kessel 1981, cit. in Schahn 1993) (see fig. 1) and a *Model of Predictors of Environmental Behavior* (Hines *et al*. 1986/87). A written, standardized questionnaire registering attitudes, intentions, opinions, wishes, social norms, knowledge etc. was handed out to 259 students in six Austrian agricultural high schools[1] in autumn 2003. 154 students from conventional farms form the focus group of this study.

[1] Secondary vocational schools offering a five-year education with practical and theoretical contents to pupils aged between 15 and 20, general qualification for university entrance after passing the final exams. The study was carried out among pupils in final classes (mostly 19 and 20 years old).

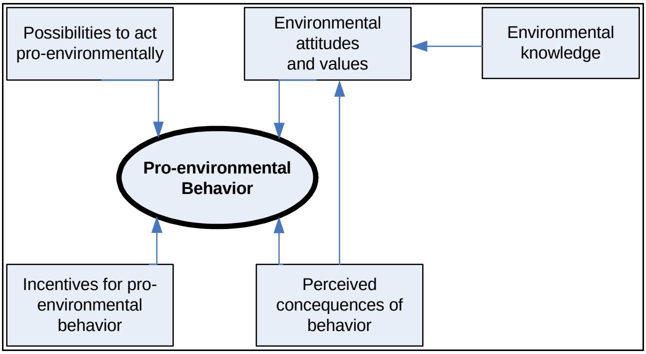

Figure 6: Model of Ecological Behavior (Fietkau & Kessel, 1981, cit. in Schahn 1993)

Results and Brief Discussion

32.5% of the questioned students are from forage growing farms, 26.5% from mixed farms (see fig. 2). 68.6% of the farms are managed as full-time farms and 31.4% as subsidiary part-time farms. The average surface amounts to 47.5 ha with 50% of the farms between 20 ha and 50 ha.

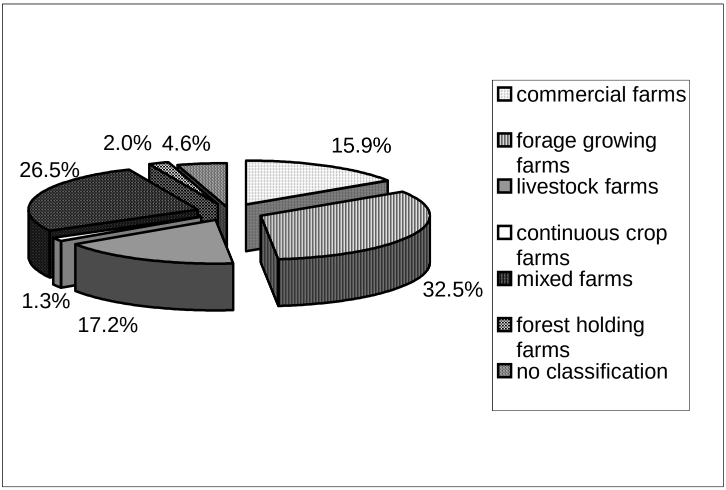

Figure 2: Land use systems (n=154: pupils whose parents are conventional farmers)

25.5% of questioned students from conventional farms expressed negative attitudes towards organic farming, combining their objections with "*pro-conventional*" intentions regarding the management of their parents' farms (92.1% of students with negative attitudes). 47% of students, however, hold positive attitudes, but the majority of them (71.1%) would not adopt organic farming methods on their parents' farms themselves. 27.5% of the students articulate a neutral attitude, which can be interpreted as students being either indifferent or incurious about organic farming. They are, on the contrary, more clear about their intentions: 94.9% express the intention to continue farming in a conventional manner. Breaking the sample down to analyse the attitudes and intentions of those who are going to succeed their parents in farm management (at least 50.7% of the students and possibly some 11.8% more who are not sure about the farm transfer yet), the proportion of students with negative (31%), neutral (27.6%) and positive attitudes (41.7%) almost remains the same. A higher number of students with positive attitudes but expressing the willingness to convert to organic farming methods (33.3%) becomes evident.

Attitudes and intentions are subject to differences between the schools – highly significant Chi-Square values are measured in both cases: the relationship between the factors *school* and *attitudes* ($p<0.004$**) and *school* and *intention*s ($p<0.002$**) (comp. tab. 1).

Table 6: Attitudes towards organic farming and intentions in Austrian Agricultural High Schools (n=154: students whose parents are conventional farmers)

			Schools						
			1	2	3	4	5	6	Gesamt
Attitude towards organic farming	negative	number of pupils	14	1	12	3	5	3	38
		expected number	11,2	3,8	8,4	5,1	3,8	5,6	38,0
		% of school	31,8%	6,7%	36,4%	15,0%	33,3%	13,6%	25,5%
		standardized residuals	,8	-1,4	1,2	-,9	,6	-1,1	
	neutral	number of pupils	14	2	11	1	6	7	41
		expected number	12,1	4,1	9,1	5,5	4,1	6,1	41,0
		% of school	31,8%	13,3%	33,3%	5,0%	40,0%	31,8%	27,5%
		standardized residuals	,5	-1,0	,6	-1,9	,9	,4	
	positive	number of pupils	16	12	10	16	4	12	70
		expected number	20,7	7,0	15,5	9,4	7,0	10,3	70,0
		% of school	36,4%	80,0%	30,3%	80,0%	26,7%	54,5%	47,0%
		standardized residuals	-1,0	1,9	-1,4	2,2	-1,1	,5	
Total		number of pupils	44	15	33	20	15	22	149

			Schools						
			1	2	3	4	5	6	Gesamt
intentions regarding conversion to organic farm methods	conventional	number of pupils	44	8	25	9	12	17	115
		expected number	37,0	10,2	22,8	14,2	11,8	18,9	115,0
		% of school	93,6%	61,5%	86,2%	50,0%	80,0%	70,8%	78,8%
		standardized residuals	1,1	-,7	,5	-1,4	,1	-,4	
	organic	number of pupils	3	5	4	9	3	7	31
		expected number	10,0	2,8	6,2	3,8	3,2	5,1	31,0
		% of school	6,4%	38,5%	13,8%	50,0%	20,0%	29,2%	21,2%
		standardized residuals	-2,2	1,3	-,9	2,6	-,1	,8	
Total		number of pupils	47	13	29	18	15	24	146

High Schools: 1-Wieselburg, 2-Elmberg, 3-St.Florian, 4-Pitzelstätten, 5-Ursprung, 6-Raumberg

Parents' attitudes towards organic farming (father as well as mother) and students' attitudes and intentions are significantly related (both: Chi-Square $p<0.001$***). Any significant relations between teachers' opinions towards organic agriculture and the attitudes as well as the intentions of students can not be found. 76.7% of the students believe that their teachers' attitudes towards organic farming are *very positive* or *rather positive than negative*. 73.5% of students indicate that the opinion of their teacher is important 68.3% of students estimate their colleagues' attitudes to be *rather negative* or *negative* but there are some variations between the schools: thus in Wieselburg and St. Florian pupils experience their colleagues' attitudes towards organic farming as relatively more negative than students in other schools do.

A highly significant Chi-Square ($p<0.006$**) indicates that there is a relation between students' attitudes towards organic farming and the land use systems of their parents' farms (comp. fig. 3). Almost all commercial farms (15.9% of the whole sample) are concentrated in those two schools (Wieselburg 54.2%, St. Florian 37.5% of commercial farms) situated in areas of intensive agricultural production (mostly arable farming), where students express the most negative attitudes towards organic farming (see also tab. 1).

On the contrary, Elmberg, a school situated in this area as well, shows its focus on students from forage growing farms (50%), only 8.3% are commercial farms.

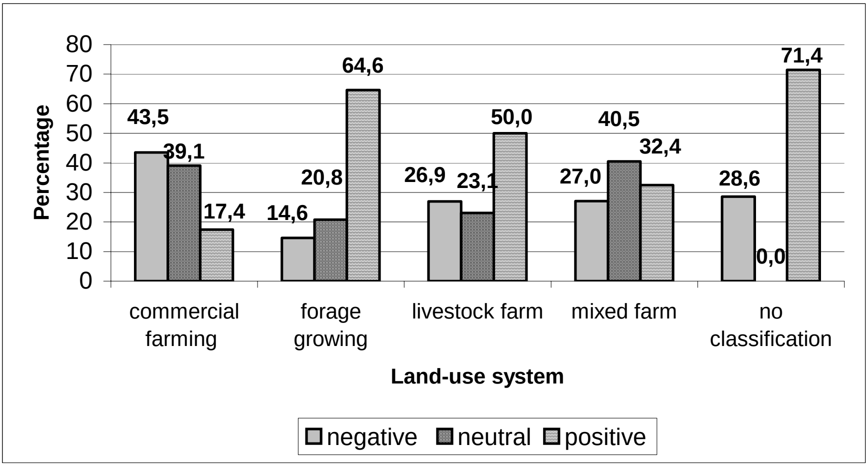

Figure 3: Attitudes towards organic farming and land-use systems of their parents' farms (n=154: students whose parents are conventional farmers)

The high rate of students from forage growing farms in Raumberg (56.6%) and Ursprung (46.6%) reflects the importance of grassland farming in the Federal states Styria and Salzburg and corresponds to significantly more positive attitudes towards organic farming.

It can be concluded that students are split up in "*pro-conventionals"* - regarding their attitudes towards organic farming - mostly from commercial farms (43.5% from n=23) and "*pro-organics"* from forage growing farms (64.6% from n=48) and livestock farms (50% from n=26).

Furthermore differences in attitudes and intentions between girls and boys became apparent: girls show a more positive approach towards organic farming. Gender-related differences are supposed to play a key role when it comes to positive attitudes of students in the schools Elmberg and Pitzelstätten - schools that are mainly attended by girls due to a focus on *agriculture and food economy* whereas the other schools offer a purely agricultural education.

The Chi-Square test indicates a highly significant relationship between sex and attitudes ($p<0.001$***) due to an over-represented contribute of girls with positive attitudes and an under-represented part with neutral attitudes.

The Spearman's rho measures a highly significant correlation between students' attitudes and intentions ($r=0.476$ ***, $p<0.001$; Chi-Square $p<0.001$***) although the correlation of attitudes and intentions as stated in the *Theory of Planned Behavior* (Ajzen 1985) can be found confirmed in the present study as well.

The relationship between attitudes, intentions and land use systems corresponds to the observed development of organic farms, concentrated in the mountainous areas of (western) Austria that are predominantly dairy farms (Eder 2003). In the eastern and northern parts of Austria, where land use is dominated by arable land, conversion has proceeded at a slow rate (Schneeberger *et al*. 2002).

Conclusion

Although a significant relationship between *schools* and *attitudes* towards organic farming and *intentions* can be stated, the missing link between the attitudes of teachers and students' opinions and intentions may indicate that there are other factors than education that may be essential: Students are influenced in their attitudes towards organic farming by a large variety of factors. Therefore, it is wrong to consider only the importance of the agricultural education in pushing the conversion to organic farming. Factors like land use systems, sex, social norms (e.g. attitudes from parents, friends, colleagues) are highly significant influential factors. We have pointed out the complexity in the decision process and that simple teacher-student models are too short-reaching. To analyse and understand those factors and their interactions, a rigid analysis (e.g. in-depth interviews with students and teachers) proved very instructing.

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ADOPTION OF CERTIFIED ORGANIC PRODUCTION: EVIDENCE FROM MEXICO

Caroline E. Hattam and Garth J. Holloway

Department of Agricultural and Food Economics, University of Reading, PO Box 237, Reading, RG6 6AR, UK, Tel: +44 (0)118 931 6775, e-mail: c.e.hattam@reading.ac.uk/garth.holloway@reading.ac.uk

Key Words: Organic agriculture, adoption, market access, policy intervention.

Abstract

Adoption of organic production and subsequent entry into the organic market is examined using Mexican avocado producers as a case study. Probit analysis of a sample of 183 small-scale (<15ha) producers from Michoacán suggests that adoption is positively influenced by management and economic factors (e.g. production costs per hectare and making inputs), but also by social factors (e.g. membership of a producers' association). Experience in agriculture has a significant but negative effect. Effective policy design must be therefore be aware of both the economic and social complexities surrounding adoption decisions.

Introduction

Adoption of organic agriculture and organic certification allow farmers to obtain access to the fastest growing sector of the international food market and obtain a premium for their produce (FAO, 2002). However, the organic market has high entry costs. The decision to adopt requires significant changes and, although reversible, has long-term implications. Nevertheless, the organic market is promoted by NGOs, donor organizations and increasingly governments as an opportunity for producers in less developed countries to improve their incomes (FAO, 2002; Parrot and Marsden, 2002).

What remains unclear is the extent to which this dynamic market can be exploited by producers in the less developed regions and especially by the small-scale, rural poor (Harris *et al.*, 2001). To ensure that the rural poor do benefit from this opportunity, there needs to be understanding of the multifarious aspects (social, economic, technical and institutional) that impact the adoption decision. The search for this understanding is the subject of this exercise. Using small-scale (<15ha) avocado producers in Michoacán, Mexico, we explore the factors determining the adoption of organic production with a view to determining the types of interventions that are likely to encourage conversion. In what follows, we briefly detail the nature of avocado production in Mexico; describe the survey and data used in the probit investigation; outline the methodology used to implement the model; present the results and close with a discussion and conclusions. Extensions are discussed.

Avocados in Mexico

Mexico is the world's largest producer of avocados, almost 90 percent of which come from one state: Michoacán. At the end of 2004, the avocado zone of Michoacán covered 87 359 ha, producing 847 653 tonnes of fruit and involving over 6000 producers (SIAP 2004), yet only 8-10 percent of this is exported (Torres *pers. comm.*). The vast majority of producers are small-scale with low yields, poor quality fruit and sell almost exclusively to the national market (Stanford, 1998). Organic avocado production began in the 1980s as a response to falling prices and increasing costs, but at this time there was no recognised organic market for the produce. The first commercial efforts began in 1997, coinciding with the opening of the US market to Mexican avocados. Adoption, however, has been slow and today only approximately 100 producers and 1265 ha are certified as organic. Of these 100 producers, about half are small-scale organic producers, although some of these also have large scale conventional operations.

The survey data

Data collection was completed in two stages. Initially, in early 2004, 32 semi-structured interviews were conducted with key economic actors, including organic and conventional avocado growers, members of avocado producers' associations, buyers and packers of avocado, organic certification agencies, researchers and government officials. This was followed by an in depth household survey of 233 small-scale avocado producers, 186 conventional (non-adopters) and 47 certified organic (adopters). The survey collected information on household demographics, attitudes to organic production, avocado production and yields, assets and access to credit and information. The definition of "organic" is important. Here, "organic producers" are those who are fully certified as organic and selling on the organic market, and producers who are in the so-called "transition period", the period in which an adopter has committed to enter the organic market, but has yet to receive full certification.

Modelling the decision to adopt organic production

Briefly, the economic model underlying the empirical investigation presupposes expected utility maximisation and the notation $E\left(U_{ij}\right)$ where $E\left(U\right)$ denotes expected utility, $i\left(=1,2,...,N\right)$ denotes an individual in the sample and $j\left(=1, \text{ if the agent adopts, } =0, \text{ otherwise}\right)$ denotes action. Using this notation, individual *i* adopts organic production if the expected utility from adoption exceeds the expected utility from non-adoption, or, in other words, if $E\left(U_{i1}\right) \geq E\left(U_{i0}\right)$. This is a standard interpretation of the binary responses in a structured survey (Feder *et al.*, 1985) and a standard set of techniques is available for investigating the factors that influence the adoption decision (Greene, 2003). The probit model is implemented by defining $y_i^* = U_{i1} - U_{i0}$ as the unobserved (latent) difference in expected utilities, assuming that the respective actions depend on observed covariates $x_i = \left(x_{i1}, x_{i2}, ..., x_{iK}\right)'$ and random error, ε_i, and by assuming, in turn, that the random error is normally distributed. Accordingly, with $\beta = \left(\beta_1, \beta_2, ..., \beta_K\right)'$ a set of corresponding (unknown) adoption coefficients, $y_i^* = x_i'\beta + \varepsilon_i$ models the adoption decision and we observe $y_i = 1 \text{ if } y_i^* \geq 0$ and observe $y_i^* = 0$, otherwise. Estimates of the location and scales of the unknown coefficients are retrieved using a standard procedure (Albert and Chib, 1993) and indicate the direction in which the explanatory variables influence the adoption decision, their relative importance and their statistical significance.

Results and discussion

Due to missing data, the model was run on a reduced data set of 147 conventional producers and 36 organic producers, representing 77 percent of small-scale organic producers in Michoacán. The results of the probit analysis are summarised in Table 1. Four of the selected variables have a significant impact on the decision to adopt organic agriculture. The other variables included in the model, while being significantly different between groups, are not significant, however they can be used to complement the model output (Hair *et al.*, 1998).

The result that making inputs and, to a lesser extent, exporting fruit and registering costs positively influence the decision to adopt organic production is as expected, but could be construed as a consequence of being an organic producer. The only market for organic fruit where it obtains a premium is the export market; registering costs and transparent administration are necessities for obtaining organic certification, and making inputs forms part of the organic ideology of closing the agricultural system. However, having experience of such activities will make the transition to organic production and entering the organic market a much easier venture. Learning and experience are important factors in the adoption process (Feder and Slade, 1984; Lindner *et al.*, 1979).

Table 1. Binomial probit results for the adoption of organic agriculture

Variables $\left(x_i\right)$ [1]	β estimates	Highest posterior density interval (95%)	
Experience in agriculture (years)	-0.029	-0.056	-0.003
Orchard size (ha)	0.024	-0.091	0.134
Export fruit (1=yes, 0=no)	0.443	-0.283	1.186
Number of full time contracted labourers (not family)	-0.126	-0.488	0.233
Register costs (1=yes, 0=no)	0.489	-0.325	1.326
Register harvest volume (1=yes, 0=no)	0.034	-0.812	0.865
Management plan (1=yes, 0=no)	0.385	-0.290	1.079
Other crops (1=yes, 0=no)	0.565	-0.057	1.215
Other sources of income (non farm) (1=yes, 0=no)	0.618	-0.029	1.295
Information source other than agronomist (1=yes, 0=no)	0.469	-0.161	1.111
Membership of association (1=yes, 0=no)	1.032	0.402	1.678
Age (scaled by 10)	-0.105	-0.385	0.172
Education	-0.295	-0.636	0.031
Most educated family member	0.035	-0.254	0.326
Total costs/ha (inputs, administration, rental of farm machinery) (in thousands of pesos)	0.034	0.000	0.068
Make own inputs (1=yes, 0=no)	1.774	1.061	2.517

[1] Variables in bold indicate significant β estimates (calculated with a Gibbs sampler run for 25 000 iterations) confirmed by the highest posterior density intervals not crossing zero. The sign of the β estimates indicate the direction of the impact of the variable.

The insignificance of age suggests that organic production is suitable for all, but at the same time, producers with more experience in agricultural work are less likely to adopt. This finding agrees with the literature that organic producers are newer entrants to farming (Padel, 2001; Burton, 1999). The literature also states that smaller land holdings are the norm among organic producers (Padel, 2001), contrary to mainstream adoption theory (Feder e*t al.*, 1985). Nevertheless, the data presented here show orchard size to be unimportant to the adoption decision, indicating that any orchard size within the class of "small-scale producer" is feasible for conversion.

In contrast to adoption and diffusion theory (e.g. Rogers, 1983) and previous research into the adoption of organic production (e.g. Burton *et al.*, 2003; de Souza *et al.*, 1999), education is shown to have a negative and insignificant influence on the adoption decision. This is in fact an encouraging result, especially for Michoacán, where 59.9% of the population has only primary education or less (INEGI, 2001) and for less developed countries as a whole, suggesting those with limited schooling may convert with success. Having educated family members is also not significant to the adoption decision.

Costs per hectare have a positive significant effect on the decision to adopt organic production, implying higher costs for organic producers. As Table 1 shows, alternative sources of income have a positive influence (although insignificant), which may be particularly important in providing extra income to aid adoption. Likewise cultivating other crops positively influences the decision. This could be interpreted as making optimal use of space within the orchard, but in actual fact, the "other crop" is usually a commercial one, such as peaches, grown conventionally on another plot of land, again suggesting the importance of additional income. Furthermore, being an organic producer and growing other crops indicates a greater demand for labour (Lampkin and Padel, 1994), but the results show that the number of full-time contracted employees is insignificant to the adoption process. This may mean that organic farmers rely more heavily on family labour, but more probably reflects some risk or uncertainty in the labour market.

Membership of a producers' association increases the likelihood of conversion to organic production, aided by obtaining management information from more diverse sources. This coincides with other studies (Rigby *et al.* 2001, Burton *et al.* 2003) which suggest that normal channels of information flow (via agronomists) are not suitable for organic producers. However, other sources are available and associating with other producers may improve their flow. Avocado producers' associations are also concerned with fruit sales and bulk purchasing of inputs. These roles are critical for the small-scale organic producer whose individual production may not be sufficient to supply demand, but also because of the relative scarcity and cost of locally available "ready to apply" organic inputs.

Conclusions

If organic production is to be promoted, then understanding the key factors affecting the adoption decision is paramount to designing projects and policies. Using probit analysis, this work demonstrates that interventions should focus on the social capital of producers, strengthening producers' associations and networks for information flow, and increasing the availability of more diverse information sources. However, introducing organic production into mainstream information channels (i.e. training agronomists in organic production) can also be expected to be beneficial.

Fortifying producers' management, planning and accounting skills should also increase adoption by encouraging a more commercial outlook to avocado production, especially export orientation. Promoting the elaboration of homemade inputs will also positively influence adoption, while at the same time help to reduce the costs of organic production. These results clearly demonstrate the simultaneous need to deal with both the social and economic factors affecting adoption if small scale producers in developing countries are to reach the certified organic market.

The findings presented here will be extended in two ways. First, we will assess the relative contributions of each of the significant variables to the adoption decision by computing marginal probabilities of entry (Greene, 2003), and second, we will evaluate the posterior odds of a model that includes only economic factors against one that includes only social factors and the one above, which considers that both economic and social factors are significant in the adoption decision.

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WHAT DO AGRICULTURAL PROFESSIONALS THINK ABOUT ORGANIC AGRICULTURE AND BIOTECHNOLOGY ?

Sarah Wheeler (1)

Centre for Regulation and Market Analysis, University of South Australia, City West, North Terrace, Adelaide, SA 5000 Australia, sarah.wheeler@unisa.edu.au

Key Words: Organic agriculture, paradigm, knowledge, attitudes, agricultural professionals.

Abstract

Traditionally, agricultural professionals have had a pessimistic view about the future and viability of organic agriculture (OA). Such views may be because OA represents a new 'paradigm' in agriculture. This study assessed the current state of views of Australian agricultural professionals in public bodies towards OA and biotechnology and considered how increased OA knowledge and experience influences attitudes. One of the key findings was that professionals who have increased OA knowledge are more likely to be positive towards the innovation, as well as being more likely to be negative towards biotechnology. Overall, views towards OA amongst professionals seem to be slowly changing, indicating that organics as a new 'scientific paradigm' may be becoming more accepted.

Introduction

Organic farmers have often complained about agricultural professionals' negative attitude towards, and lack of knowledge of, organics. The limited research that has been done into the state of knowledge and attitudes held by agricultural professionals provides support for these claims to some extent (ie Morgan & Murdoch 2000, Harp & Sachs 1992, Busch & Lacy 1983). One of the reasons often cited for negative attitudes is that OA is a 'new paradigm' in agriculture (Wynen 1996, Beus & Dunlap 1990) and therefore one should expect that it would be subject to ridicule from some and increasing acceptance and understanding from others. The market, size and organizational support for OA around the world has been rapidly increasing and, given the role that professionals play in influencing farmer adoption choices, it is important to ask what exactly are professionals' attitudes towards OA? Have they changed and/or are they evolving? Also, how do they compare with another major innovation in agriculture – biotechnology (specifically genetic engineering - GE)? Does having increased knowledge and experience in OA affect professionals' views?

Previous research has looked at consumers' views and attitudes towards OA and GE (i.e. Lyons *et al* 2004) and scientists' views of GE (ie Lawrence & Norton 1994). Some studies have sought to explore how knowledge of GE affects consumers' views, and found that consumers who have the highest perceived (rating their knowledge themselves) understanding of biotechnology tend to be more positive towards GE food (i.e. Baker & Burnham 2001, Koivisto *et al* 2003). However, Koivisto *et al* (2003), Hossain & Onyango (2004) and Costa & Mossialos (2003) found that when they assessed actual knowledge of GE, knowledge was no longer a factor in influencing views. Other studies have found that providing increased knowledge of GE to consumers tends to reinforce current views, as well as strengthening currently held attitudes (ie Frewer *et al* 2003).

Methodology

A telephone survey was conducted in the middle of 2004 on agricultural professionals' (namely extension officers, scientists, researchers and academics in public bodies) views and knowledge of OA and GE. An agricultural professional was defined as either providing agricultural advice to farmers; conducting agricultural specific farm research on agriculture; or teaching agricultural courses at university. The survey was made up of two samples – a random sample of the general population of agricultural professionals based in South Australian public bodies (119 surveys conducted), and a random sample of a targeted population of professionals who have had actual OA experience in Australian public bodies (66 surveys). The targeted population database consisted of scientists, extension officers and academics in public bodies across Australia that had written/researched and/or provided extension advice about OA. The survey consisted of five sections: (a) background; (b) GE knowledge; (c) OA knowledge (d) actual research/practical experience with GE/OA; and (e) GE/OA attitudinal questions. An overall response rate of 96% was achieved, with 185 professionals surveyed.[1] The high response rate, the random sampling method and the statistically significant sample size suggest that the surveys had no response bias and truly represent agricultural professionals' OA and GE views.

Results and Brief Discussion

Direct comparisons between the two samples of agricultural professionals indicate that background characteristics of the respondents were generally similar, in terms of their age, working age, area of agriculture and gender. However, there were significant differences in their views towards OA and GE. Respondents from the general population were much more likely to be positive towards GE (ie believe there were net social benefits) and much more likely to be negative towards OA (ie believe there were net social costs). Targeted respondents were much more likely to positive towards OA but negative towards GE. Table One below highlights some results from the two samples.

Table One: Survey Results

Questions on Agricultural Innovations	Biotechnology Answers		Organic Answers	
	Random Sample	Targeted Sample	Random Sample	Targeted Sample
Average perception of knowledge (Scale 1 to 5)	3.0	3.2	2.9	3.7*
Plans to learn more about the innovation in the future	83%	80%	76%	89%
Believes that benefits outweigh costs/risks	45%	23%*	37%	73%*
Believes that benefits do not outweigh costs/risks	25%	44%*	34%	11%*
Too hard to call if benefits outweigh costs/risks at present	30%	33%	29%	17%*
Views becoming more favorable over the past 5 yrs	25%	20%*	35%	46%
Views becoming less favorable over the past 5 yrs	16%	32%*	13%	6%*

Note: Totals may not add due to rounding.

* Indicates that the results for the two samples were statistically different at a 95% two-tailed t test.

In terms of knowledge about GE, both the random and the targeted sample rated themselves as having a similar average level of knowledge and understanding (knowledge of OA and GE was asked via a five point Likert scale). In addition, asking respondents to name as many organic certifying/research bodies as possible assessed OA knowledge. The targeted sample perceived their OA knowledge as higher than average while the random sample perceived their knowledge as slightly below average. This perceived higher level of OA knowledge by the targeted sample was supported by the fact that targeted respondents were 5.5 times more likely to name OA bodies than random respondents. This indicated that perhaps random sample respondents overestimated their knowledge of OA. There was considerable qualitative evidence to suggest that many respondents in the random group believed that OA was simply conventional agriculture without fertilizers and chemicals, hence if they knew about standard agriculture then they knew about OA.

Multivariate data regression[2] was used to identify key factors that influence OA attitudes. Professionals who: were more tertiary educated; were non-European; had a higher knowledge of OA issues; were part of the targeted (experienced OA) group; had positive views on the environmental friendliness, profitability and innovativeness of OA; named a large number of major OA benefits; believed that conventional agricultural was not environmentally sustainable; and had positively changed their views in the past five years were more likely to think that OA conveyed positive net benefits. Professionals who: had a higher salary; worked for the Commonwealth Scientific & Industrial Research Organisation; named a large number of major OA costs; believed that converting to OA would result in substantial yield decreases (greater than 30%); and who cited scientific journals as their first main source of information were more likely to think that OA conveyed no net benefits.

[1] The response rates of each sample were not statistically different. The sample size of each was statistically significant at a 95% level and a 7% precision level.

[2] Ordered probit regression was used, with the dependent variable being professionals' views on the net benefits of OA. For reasons of brevity, details and statistical tests are not reported here.

The results show that professionals' who have increased OA knowledge and spent more years in tertiary education are more likely to think organics offers positive net benefits.[1] Such a result must be interpreted with care, as the knowledge variable was measured as self-perception. Another key result is professional OA views seem to be driven from separate attitudes and knowledge than their GE views because attitudes towards GE were statistically insignificant as an independent variable in the model. This goes to show that a professional that is pro-OA is not necessarily anti-GE. This result highlights that some professionals can see benefits in both innovations and obviously believe that the two innovations can be adopted simultaneously or at least co-exist.

Professional views also seem to be more influenced by the practical farming benefits of OA than its product health benefits. Factors such as environmental sustainability, innovativeness and profitability of OA were much more likely to influence agricultural professionals' OA attitudes. Professionals therefore primarily responded as information providers to farmers, not as consumers of OA products or evaluators of the health consequences of food. Also, the more professionals believe in the lack of environmental sustainability of current agricultural practices, then the more likely they are to have positive OA attitudes. This indicates that such professionals are searching for alternatives to the current agricultural system.

Three-quarters of the random sample and approximately 90% of the targeted sample plan to learn more about OA in the future, indicating that most respondents believe OA will maintain a presence on the Australian agricultural scene. As well, there is some evidence that views on OA may be changing. If OA is a new paradigm in agriculture, then a prerequisite for a new paradigm to become "normal practice" must mean that agricultural professionals have to be "converted" to the new paradigm (Kuhn 1970). Although "conversion" is not necessarily a scientific process (because scientists do not necessarily base their views on purely scientific grounds), it is hypothesized that the increasing exposure to OA (because of increased farmer adoption, increased scientific literature and discussion, etc) in Australia over the past five years should have led to an increasing number of professionals being "converted" to the new paradigm. Such a hypothesis is extremely hard to test without comparable historical data for Australia. The most comparable data is Harp and Sachs' (1992) study on the reactions of 584 US scientists to sustainable agricultural terms. Scientists were asked to rank 9 agricultural terms on a scale of 1 to 5 (from least to most favorable). The phrase 'organic farming' was ranked the least favorable after government regulation. This indicates that in the early 90s more scientists thought more unfavorably about OA than favorably. Within the current survey, more random respondents felt favorably (37%) about OA than unfavorably (34%), with the rest sitting on the fence. To assess how these professional attitudes have changed recently, a question was asked: "Over the last 5 years, have your views on OA become (a) more favorable; (b) less favorable; or (c) stayed the same?" More than a third of all random respondents stated that their views had become more favorable, while 13% stated that their views were more negative, with the remainder not changing their views. Almost half of the targeted professionals' views had become more favorable, with the majority of the remainder staying the same.

Conclusion

Overall, around a third of agricultural professionals in the randomly selected sample think that OA benefits outweigh its costs and risks. The remainder is split between being undecided and not believing benefits outweigh costs. This is in contrast to their GE views; where nearly half of the professionals randomly surveyed believe that GE benefits do outweigh its costs, and only a quarter believe that it does not. The majority of professionals within the targeted sample believe OA benefits outweigh costs, while only a quarter of them believe GE costs outweigh their benefits. Other regression modeling provides support for the theory that professionals with increased OA knowledge and experience are more likely to think favorably towards OA. However, attitudes to GE are not statistically significant in influencing attitudes to OA, indicating that other factors (such as socioeconomic, occupation, knowledge, experience, informational effects and particular attitudes on agricultural issues) play a more important role. In addition, there is some

[1] The other issue to be aware of is that knowledge may be endogenous. That is, having a positive attitude towards OA may lead to a desire to gain increased knowledge about it, and as such, the results may be of dubious value. It is believed that such a problem is not an issue, as separate regressions were run assessing factors of influence on knowledge. Overall, attitudes on OA net benefits was not a statistically significant independent factor in influencing OA knowledge.

indication that OA views are changing positively over time (albeit slowly) and that it may be becoming a more acceptable ‘paradigm’ in professional agricultural circles.

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SUSTAINABILITY OF ORGANIC FARMS

RELATIONSHIPS BETWEEN SOCIAL FORMS OF ORGANIC HORTICULTURAL PRODUCTION AND INDICATORS OF ENVIRONMENTAL QUALITY: A MULTIDIMENSIONAL APPROACH IN BRAZIL

Stéphane Bellon (1), Lucimar Santiago de Abreu (2), Pedro J. Valarini (2)

(1) INRA-SAD, Unité Ecodéveloppement, Domaine Saint Paul, Site Agroparc, 84914 Avignon Cedex 9, France, bellon@avignon.inra.fr,
http://www.avignon.inra.fr/internet/unites/ecodeveloppement/version_index_html
(2) EMBRAPA Meio Ambiente, Rodovia SP 340 Km 127,5; CP 69 13820-000 Jaguariúna (SP, Brazil), lucimar@cnpma.embrapa.br; valarini@cnpma.embrapa.br

Key Words: Small-scale horticultural organics, Forms of organisation, Environmental assessment, Indicators

Abstract

Organic farming (OF) is increasingly considered as a possible alternative for designing a "new rural" in Brazil, where OF covers a wide range of production and certification systems. However, the ways small farmers adopt OF in green belts to meet an urban demand in organic vegetables have not been extensively investigated. Likewise, the impact of such practices on environmental quality components has not been sufficiently documented. Our objective was to relate forms of organisation to environmental assessment in a watershed where organic horticulture significantly contributes to landscape and water quality. We showed how small farmers were organised or how they organised themselves to meet urban demands and develop OF. We assumed that associated practices were consistent with environmental impacts, as evaluated by indicators. Based on interviews with stakeholders, we identified four forms of organisation and associated farmers' practices. We related them to environmental assessment in three compartments: landscape ecology, water quality and soil quality. Although organisations share some objectives, namely with regard to visual quality and the "right price" of products, differences appear in their scope and internal operation, their values and relationships with consumers, and their technical and environmental contents. As for technical content, input supply, planning processes and crop diversity vary among organisations, ranging from liberal to hierarchical. Our results also showed similarities and differences among various organisations in terms of environmental impact. Such results are interpreted and discussed in the light of technical and social dimensions that account for the progressive design of new systems in Brazil.

Introduction

The relationship between organic farming (OF) and environment is somewhat puzzling. On the one hand, it is assumed that OF respects the environment or contributes to this objective, due to the compliance with OF specifications. On the other hand, in keeping with field observations and international regulatory standards, OF is expected to contribute to a solution to environmental problems such as the reduction of biodiversity, soil degradation, and water contamination. Between these two poles, we acknowledge the fact that organic farmers actually wish to contribute to environmental preservation, based on the features of their production systems and specific environmental issues, generally at the local level. One challenge for OF is to go beyond acknowledged standards and propose a better management rationale for complex ecosystems whose consequences have to be assessed with the design of research and development programmes (Sylvander and Bellon, 2002).

In Brazil, OF is increasingly considered as a possible alternative for designing a "new rural" (Campanhola and Graziano da Silva, 2000), based on a diversification of economically oriented activities and the recognition of multiple dimensions in agriculture. OF covers a wide range of production and certification systems, including certification as a group. OF is also considered as a foundation for sustainable agriculture (Brazilian Law n° 10.831/03) and a way to comply with environmental legislation (Primack and Rodriguez, 2002). However, the ways that small-scale farmers adopt OF in order to collectively contribute to new markets and to environmental preservation in Brazil are at stake.

Based on this framework, we analysed how OF develops in the large community of Ibiúna (close to São Paulo) and the potential impact of organic horticulture on territorial resources. We proposed a comprehensive description of four basic forms of organisation dedicated to OF (Bellon and Abreu, 2005) and related these OF development patterns to environmental contributions.

Methods

We focussed our study on a territory with multiple status: it is both an organic vegetable crop supply area and a tourist destination for Brazilian citizens. It also contributes to the water supply in the neighbouring metropolis of São Paulo. We assumed that OF organisations (associations, cooperatives, etc.), technical methods and environmental impacts were inter-related. Subsequently, we did not refer to so-called "conventional" farming but focused on diversity in OF *per se*. We also assumed that differences among organisations were due not only to market integration but also to specific value systems within social groups. In order to identify OF development patterns in this community, we considered OF not only as a set of production methods but also as a social practice whose goal was to renew relationships among farmers, with consumers, and with the environment.

Based on secondary data, we identified the number and location of organic farmers. The aim of our sampling method was to explore the diversity of OF situations. We gradually identified and conducted interviews with stakeholders and active OF organisations: technical and political officers (3), organic inspectors (2), group leaders (4), and farmers (20). All of the farmers interviewed were vegetable growers. A total of 18 among the 20 interviewed farmers were affiliated with four farmers' organisations. The other two farmers sold their produce directly on local markets.

The questions obviously differed according to the people being interviewed. As for technical officers, we focussed on their activities and relationships with organic farmers, as well as on their description of the OF universe. This enabled us to identify and locate various OF farmers and organisations. The organic inspectors we encountered worked either for the IBD (Biodynamic Institute for Rural Development based in Botucatu, operating at the international level) or for the AAO (Association of Organic Agriculture in São Paulo, operating at the federal and state levels).

In conjunction with OF group leaders, we analysed group dynamics and operation, marketing channels and certification processes.

These interviews also enabled us to obtain a list of farmers for each organisation and their location, in order to define a randomised sample for farmer selection.

Interviews with farmers consisted of: (i) understanding the motivations, problems and changes related to conversion to OF; (ii) characterising their production methods and results; and (iii) identifying relationships with other farmers.

Concerning environmental impact assessment, we used part of the 62 indicators of the methodology developed by Rodrigues *et al*. (2003). This method covers five dimensions: landscape ecology, environmental compartments (soil, water, air), socio-cultural values, economic values, and management and administration at the farm level. It was adapted to our purpose and applied to a farm sample (20 farms), adjusted to the number of farmers present in each organisation. The breakdown is as follows: H&A (10), APPOI (3), APPROV (2), CV (3).

Results

Most of the organic farmers are located in the same water catchment basin of the community of Ibiúna. This is due to the past initiative of a private enterprise (H&A), which includes 60 organic farmers in the catchment basin out a total of 110 organic farmers in this community.

Individual and direct selling forms persist in OF and do not require certification, provided that monitoring is feasible in the form of traceability and access to operating data (Brazilian Law n° 10.831/03). Therefore, organisations are strongly encouraged. Four basic forms of organisation were encountered in Ibiúna.

* H&A operates vertically, with an effective planning at the regional level, specialised technical staff, and certification for city supermarkets and export markets. It supplies farmers with all organic inputs and operates without transfer of product property until the products are sold ("consignment" system). It includes 60 vegetable farmers in the community of Ibiúna.

* APPOI, another organisation, includes 15 farmers, with a more flexible relationship and a greater degree of autonomy in relation to the choice of crops and inputs. This includes individual certification and the

possibility of direct sale on the market. Its markets are geared to supermarkets and the Catholic communities of São Paulo.

* APPROV, the third organisation, derived from the first one (H&A) and 12 farmers, joined an established conventional co-operative selling to medium-sized supermarkets in São Paulo state; its certification process is similar to that of APPOI.

* CV, the last one, is also an enterprise, operating in Ibiúna. It was created in 2002. Its focus is on organic inputs and sales to wholesalers as well as to large- and medium-sized supermarket chains. As opposed to H&A, product ownership is transferred from farmers to CV.

The main products sold by these groups are leafy vegetables, typically for salads, followed by fruits (tomatoes, cucurbits) and root vegetables (beets, carrots).

Interviews with group leaders made it possible to relate production processes to organic product valuation criteria. As a result, the four organisations share some objectives, namely in relation to visual quality and the "right price" of products. Differences also exist in their scope and internal operation, their values and relationships with consumers, and their technical and environmental contents.

Concerning environment, tension is due to the impact of human activities on soil or water resources and higher expectations in terms of environmental quality. In the case of environmental impact assessment, we used utility values for various compartments. These values range from 0 to 1, where 0 expresses the maximum negative environmental impact (unfavourable indicator) and 1 a maximum positive impact. A reference value of 0.7 was derived from the literature already published on the subject; values above this threshold are considers environmentally favourable. A global analysis shows critical values for some indicators, expressed in % of the total sample of 20 farms.

As for landscape ecology, global values can be ranked as follows: mere conservation of natural habitats (40% below threshold); medium landscape diversity (50% below); medium compliance with legal forest reserves (50% below); low mitigation of abandoned areas (70% below); and very low productive diversity (100% below). Other results related to water, soil and air compartments are more favourable (on the average, all are above the threshold) and differ according to the individual organisations.

Concerning indicators used by specific organisations, the results are as follows. For landscape ecology dimensions, indicators related to landscape and productive diversity show that H&A and CV have the most negative impact (85% of the contribution is from affiliated producers), due to the small number of vegetables (four to five crops) produced by farmers selling to these organisations. Conversely, crop diversity is higher with APPROV, direct sales, and APPOI, in increasing order. As a result, alternative markets, planning processes, and land use patterns would make greater crop diversity possible.

Concerning water and soil compartments where chemical analyses were used, H&A exhibits the lowest results (68% [water] and 75% [soil] of the producers monitored, respectively, are below the thresholds mentioned above), followed by APPOI (2/3 of the producers with low results). These results indicate a higher incidence of pests where landscape and crop diversity is lower, and when soil preparation and conservation (cover crops) conditions allow leaching and water contamination.

Discussion and conclusions

Our results indicate a relationship between forms of organisation and environmental assessment. Two of the organisations (H&A and CV) showed lower environmental performances. In such situations, OF would be considered as an input substitution and market opportunity (favouring visual quality of products) rather than a change in paradigm (identified as agro-ecology in Brazil) and the design of a new system interrelated with an ecosystem (Feiden *et al*., 2002). Certification processes also differ among organisations (Souza, 2003; Bellon and Abreu, 2005). H&A obtained group certification from the IBD, farmers selling to CV are certified by the IBD and the AAO, and CV is certified by the OIA (International Agricultural Organisation, whose headquarters are in Argentina), whereas the other organisations are certified by ECOCERT and their individual farmers by the AAO. One can then question whether certification (Seppänen and Helenius, 2004) and marketing as a group do not tend to standardise practices among farmers. Conversely, liberal or federal organisations allow more crop diversity and product variability (APPOI and APPROV), which is consistent with their marketing channels. This entails a better environmental assessment, on the basis of agri-environmental indicators.

The methodology used provided an initial ranking of cropping systems. Impact indicators were also evaluated in the field and during interviews, and weighted according to their spatial scale and their effect on environmental compartments. The selected reference value (0.7 in this case) can also be adjusted according to locally delineated environmental and development objectives discussed with stakeholders, who in turn make it possible to establish a judgment standard. As in the case of other approaches (Cittadini *et al*., 2004), this methodology indicates some ways to assess the impact of OF on environmental compartments in relation to farmers' practices and organisations. However, differences among individual farm results can also be analysed *per se* and discussed in farmers' groups. Further work could include a systematic assessment at the watershed level, focussing on surface water flows and their relationship to areas of permanent protection, such as woodlands or legal reserves (Primack and Rodriguez, 2002), which also shelter springs and ponds. This challenge led to the implementation of a horizontal programme dedicated to the restoration of habitats and land care, where technical proposals are suggested for OF (CATI, 2001).

Conversion to OF in Ibiúna is recent and our interviews showed that the main reasons for conversion are not environmental preservation or restoration. The main OF benefits are considered to be the improvement of the farmer's quality of life and consumption level, the absence of agrochemical inputs, the reduction in production costs, and market opportunities. Such results are consistent with those obtained in the metropolitan region of Curitiba, Paraná, based on interviews and monitoring in a wider sample of 57 small organic horticultural farms (Darolt, 2001). That study showed that two main factors influenced the farmers when deciding to adopt organic production: family and personal health, and the economic issue. It also showed that the group with the most farms in relation to the ideal sustainability level were the organic family farmers with small farm units. This confirms the potential benefits of OF and, more generally, agro-ecology in Brazil, for small-scale family farming (Ormond *et al*, 2001; Assis, 2001).

More generally, diversity of and connections among forms of organisation contribute to strong OF dynamics. Small farmers relied upon their own needs and citizens' expectations to meet the needs of an internal market and possibly contribute to environmental preservation. They enlarged their relationships with other farmers, urban consumers, technical assistance and certifying agents. These initiatives put farmers in a better economic position by qualifying production and creating new values in Ibiúna and other communities.

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ORGANIC CASH CROP FARMS AS NET ENERGY PRODUCERS: ENERGY BALANCES AND ENVIRONMENTAL EFFECTS

Halberg, N.*, Dalgaard, R., Berntsen, J., Olesen, J.E. and Dalgaard, T.

Danish Institute of Agricultural Sciences, PO Box 50, DK 8830 Tjele, Denmark
*Corresponding author: E-mail: Niels.Halberg@agrsci.dk

Key Words: Biogas, Energy, life cycle assessment, greenhouse gas, rapeseed, crop rotation

Abstract

Organic farming (OF) principles include the idea of reducing dependence on fossil fuels, but little has been achieved on this objective so far in Danish OF. Energy use and greenhouse gas emissions from an average 39 ha cash crop farm were calculated and alternative crop rotations for bio-energy production were modelled. Growing rapeseed on 10% of the land could produce bio-diesel to replace 50-60% of the tractor diesel used on the farm. Increasing Grass-clover area to 20% of the land and using half of this yield for biogas production could change the cash crop farm to a net energy producer, reduce green house gas emissions and improve the nutrient management on the farm while reducing overall output of products only marginally.

Introduction

The total energy use and Green House Gas (GHG) emissions from food production, transport and consumption contributes significantly to the global warming. On the other hand, agriculture may contribute with renewable energy by replacing fossil energy used for electricity production with biomass from perennial crops such as grass (Ney & Schnoor, 2002), willow (Heller et al., 2003) or seasonal crops (e.g. rapeseed, maize; Hanegraf et al., 1998). Many of these crops are efficient in terms of reducing greenhouse forcing, but the studies also show that the total environmental effect of the bio-energy substitution depends on the system included in the analysis (e.g. whether the indirect energy costs of producing the biomass is included). Thus, the indirect energy consumption through the use of fertiliser is significant in the CO_2-emission balances.

Therefore, an environmental assessment of bio-energy should include both the farm and the energy system, including the replacement of electricity production and fuels (Heller et al., 2003; Ney & Schnoor, 2002).

The original principles of organic farming (OF) include goals of reducing dependence on fossil fuel and other limited resources and this is still an explicit part of the objectives of the Danish OF movement. Due to – among others - the non-use of fertilisers, the energy use is usually lower in OF compared with conventional (Refsgaard et al., 1998; Dalgaard et al., 2001). However, it is interesting to explore the possibilities for changing organic farms into net-energy producing units by combining food and energy production. A knowledge synthesis (Jørgensen & Dalgaard, 2003) with participants representing disciplines such as energy analysis, farming systems, biogas production, crop growth and environmental impact assessment analysed the overall question of energy use and production in organic farming. From this work emerged the specific question of how to combine improvements in the crop rotation on organic cash crop farms and bio-energy production. This paper will report these findings only and will therefore focus on the double role of grass-clover leys combined with rapeseed as replacement for tractor diesel.

Methodology

The study consists of three steps:

1. An average organic cash crop farm on sandy soils in Denmark was described on the basis of a farm typology established from representative farm accounts and modelled to give coherent input-output relations following a method described by Dalgaard et al. (2004b).

2. Modelling of the consequences of increased proportion of grass-clover in the crop rotation for cereal yields, soil fertility and nutrient cycling with the model FASSET (Berntsen, et al., 2003).

3. Modelling of the potential for biogas production and recycling of nutrients from extra 10% grass-clover in the rotation and the consequences for energy balances using Life Cycle Assessment methodology (Dalgaard et al., 2004; Nielsen et al., 2003)

Results and brief discussion

The average crop rotation on certified organic cash crop farms in Denmark included only 10% grass-clover (often used for small beef cattle herds, which were also supplemented with 7,6 tonnes of imported rapeseed cake) and 5% pulses (Table 1). The rest of the 39 ha average land size was grown with cereals, thus reserving only a small proportion of the land to Nitrogen fixating crops. The average farm imported 4,4 t Nitrogen in pig slurry from conventional farms. In order to test the potential improvement in energy use and nutrient recycling alternative crop rotations with rapeseed (for diesel replacement) and grass-clover (for biogas) were modelled (table 1).

Table 1. Area and yields of different crops on an organic cash crop farm and two modelled alternative crop rotations including more rapeseed or grass clover for energy

Crop	**Yields ha^{-1}**		**Basis**[1]		**Rapeseed**[3]		**Grass clover**	
Spring Barley	3100 kg		13,9		13,4		13,6	
Winter wheat	4610 kg		3,6		3,6		3,6	
Rye	2530 kg		2,4		2,4		2,4	
Oats	3040 kg		2,4		2,4		2,4	
Peas	2170 kg		1,9		1,9		1,9	
Winter Rape seed	1760 kg		0		3,9		0	
Barley for silage	4300 FE[2]		4,0		4,0		4,0	
Grass clover (rotation)	5600 FE		4,2		4,2		7,8	
Permanent grassland	2000 FE		3,3		3,3		3,3	
Set aside land			3,3		0		0	
Sum			39,0		39,0		39,0	

1) Average yields and areas from the representative, average organic cash crop farm on sandy soils in Denmark.
2) One Feed Unit (FE) corresponds to the energy value of 1 kg cereal for cattle (app. 1 kg DM grass clover and 1,2 kg DM whole crop barley silage).
3) "Basis", "Rapeseed" and "Grass Clover" denotes crop rotations with a land use as described in the table.

Organic crops use between 90-110 litres of diesel per ha for field operations (Dalgaard et al., 2001). Rapeseed oil can replace tractor diesel after a slight moderation of the engine and using a farm scale cold pressing system can give an oil fraction of around 30% of the yield. Because Rapeseed is a difficult crop to grow in organic rotations in Denmark due to high Nitrogen demand and risk of crop losses due to insects and soil borne diseases, the area with this crop should not exceed e.g. 10% of the farms' land. With an expected grain yield of 17-1800 kg per ha the home-produced rapeseed oil - containing 35 MJ energy per litre - may replace 50-60% of the diesel use on a cash crop farm. The co-product of home-produced rapeseed cake can replace 30% of the input of concentrate for the farm's livestock production. This double use of the crop without industrial processing may be the reason for our positive evaluation in contradiction to the assessment of conventional rapeseed for biofuels by Hanegraf et al. (1998). To replace the total diesel use on the average organic cash crop farm would need a yield of 2800 kg rapeseed per ha on the 10% of the land, which may in fact not be unrealistic in winter sown rapeseed in the future.

Increasing the area with grass-clover from 10 to 20% of the crop rotation gives a surplus of Dry Matter (DM), which may be used for bio-energy (because of the small livestock herd). Moreover, due to improved soil fertility the average DM-yield per ha cereal increased by 10% according to FASSET simulation. It has been demonstrated that 1 kg grass DM may produce almost ½ kg Methane in a biogas plant. When using the biogas for a combined generation of electricity and heat, the grass-clover from 10% of the land can yield more than 2.5 times the electricity used on the cash crop farm. This corresponds to around 26000 kWh from 3.9 ha grass or enough to cover the electricity in 5-6 Danish households. Table 2 shows the energy balance of the average farm before and after the modelled alternative crop rotations. The generated 111 GJ of heat (as a bi-product of electricity production from the biogas) may be used for producing feed-mixtures, evaporating water from the resulting de-gassed grass-effluent or for heating houses in a village through pipelines (a type of centralised heating system very often used in Denmark already). Assuming that all electricity and heat is utilised for purposes where it saves other energy sources, the farm will be a net energy producer (also after deduction of the energy use for transport of grass and de-gassed grass-effluent to and from the central biogas plant, Table 2). The conversion between kWh and GJ depends on how efficient the marginal electricity production is (i.e. the type of fossil power plants to be saved when electricity from the biogas plant supplies the net) and this assumption was tested with different values as shown in the two Grass-clover scenarios in Table 3. However, the same coefficients (9.5 vs. 5 MJ fossil fuel used per kWh) were applied to both the used and the produced electricity on the farm in the grass clover I and II scenarios respectively, which is why in both cases the farm is a net energy exporter.

Table 2. Energy use and production (GJ year^{-1}) on a 39ha organic cash crop farm and two modelled alternatives. All farms export 58 tonnes cereals, 6 tonnes pulses and 9 tonnes live weight beef.

Direct and indirect Energy use, GJ	Basis	Rapeseed[4]	Grass clover I	Grass clover II
Diesel	129	50	124	124
Electricity[1]	90	92	90	47
Rape seed cake	1	0,2	1	1
Transport of grass and effluent	0	0	15	15
Other[2]	0	2	1	1
Sum	220	145	231	188
Replaced energy production, GJ				
Heat produced in electricity production[3]	0	0	111	111
Electricity production[1]	0	0	247	130
Sum	0	0	358	241
Net energy consumption, GJ	220	145	-127	-53

1) The fossil energy cost for electricity used on the farms is assumed to be the same as for the replaced electricity production: 9.5 MJ kWh^{-1}. Electricity is often produced on a combined gas driven power plant, where the heat is used for houses. Therefore in the alternative calculation, "Grass clover II", a more efficient electricity production using only 5 MJ kWh^{-1} was assumed.
2) A small import of cereals was included in the models to compensate for the reduced barley area, so that all farms deliver the same amount of products.
3) Assuming that the heat generated from the electricity production is used efficiently, which is questionable - see text for discussion.
4) "Basis", "Rapeseed" and "Grass Clover" denotes crop rotations with a land use as described in table 1.

The effects of introducing more rapeseed and grass-clover respectively in the crop rotation on the farm's emission of greenhouse gasses were estimated using LCA methodology and converting emissions of Nitrous Oxides, Methane and Carbon Dioxide into CO2-equivalents (Table 3). The CO2 emission from the combustion respectively digestion of the biomass was considered to be – at least - equal to the CO2-sequestration during crop growth, which is standard methodology (Hanegraf et al., 1998; Ney & Schnoor, 2002). This probably underestimated the net CO2 balance of the bio-energy system compared with the fossil fuel system because the CO2-sequestration in the roots and stubble of the grass-clover crop will contribute to a net build up of soil-carbon, which is not emitted in the bio-energy production. The simulation included transport to and from the biogas plant and a systems expansion to account for the saved fossil energy from using biogas for combined electricity and heat production. The effects of biogas production was a reduction of total greenhouse gas emission from 115 to 92 t CO2-equivalents (app. 20%) if assuming unchanged emission of nitrous oxide emission and including the effect of replaced fossil energy use for electricity. Further studies are needed to determine the degree of uncertainty on the estimates. Harvesting grass-clover for biogas and returning nutrients in the "grass-effluent" to the cash crops improved Nitrogen cycling on the farm (nutrient surplus was reduced from 60 to 49 kg N ha-1, results not shown) and reduced the need for imported manure, which should in fact reduce the NO2 emission. The leaching was reduced only 5-10% per ha because the lower input of DM in grass effluent compared with imported slurry resulted in lower increase of soil-N in the biogas scenario (results not shown).

Table 3. Emissions of greenhouse gasses from a 39ha organic cash crop farm and two modelled alternatives and the replaced emissions from energy production.

Tons CO2-equivalents $farm^{-1}$ $year^{-1}$	Basis[3]	Rapeseed	Grass clover I
Nitrous oxide	82	82	82
Methane from farm and biogas plant	13	13	16
CO_2 from diesel	12	5	12
Import electricity and rapeseed cake	8	7	8
Transport of grass and effluent	0	0	1
Replaced electricity production[1]	0	0	-17
Replaced heat production[2]	0	0	-10
Sum	115	107	92

See note 1 in table 2. 2) See note 3 in table 2. 3) See note 4 in Table 2.

Conclusion

Changing average organic cash crop rotations in DK to include 20% grass-clover and 10% rapeseed could serve the double purpose of building soil fertility and deliver input for energy production. While this possibility has become more attractive on the individual farm level after the reform of the EU Common Agricultural Policy, there are a number of structural and organisational challenges to overcome, such as locating joint biogas plants in suitable distance from a concentration of organic farms and near a facility, which may use the surplus of heat produced.

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ENHANCING SUSTAINABILITY BY LANDSCAPE-DESIGN AND CONVERSION TO ORGANIC AGRICULTURE

Maximilian Kainz

Institute for Organic Agriculture, Technical University of Munich, Alte Akademie 16, D 85350 Freising, Germany, ++8161 713034, kainz@wzw.tum.de, www.wzw.tum.de/oekolandbau

Key Words: Organic Farming, landscape-design, soil erosion, soil compaction, wildlife, sustainability.

Abstract

A hilly site with variable soils and facing all the problems of modern agriculture was re-designed and converted to organic agriculture in 1992. After 10 years of measurements and observations it was determined that soil compaction, runoff, and erosion were reduced, quality of groundwater and ponds was gradually enhanced, diversity of wildlife was enriched, and the economic situation of the farmer was improved. Besides landscape design, conversion to organic agriculture is regarded as a key instrument towards sustainable land use in this region.

Introduction

Agricultural systems of the future must protect resources while being productive, economically sound and socially viable. This paper describes the multi-disciplinary, multi-aimed project including landscape-redesign and conversion to organic agriculture performed on a representative segment of an arable landscape in Bavaria, Germany, that faced problems of impaired abiotic and biotic resources. Over the 13 years of the research, changes in the ecosystems and the environment were recorded and assessed. For some key indicators it has been estimated whether those changes result in a higher level of sustainability on the farm level.

Material and methods

The 1.5 km^2 research site is typical of this region, which contains the most important arable land in southern Germany and constitutes about 30% of the arable land of Bavaria. It is located in a rural area 40 km north of Munich in the middle of a prospering area with more than four million inhabitants. This hilly region was confronted with all the problems of modern intensive agriculture, such as deterioration of soil and water quality and species diversity. During a two-year inventory phase (1990-1992), all arable fields (125 ha) were cultivated equally with small grains and according to the intensity of the former owner in a conventional manner. The grassland (25 ha) was used in the same way as previously. Soils, nutrients, water balance parameters, growth properties, flora and fauna were recorded in a 50-m grid at approximately 500 points. Additionally, 3 weather stations, 18 stations for runoff and erosion, 6 shafts for measuring the soil water regime, 14 groundwater shafts and 23 soil pits were established for long-term monitoring. Measurements were performed according to the methods of the different disciplines. Details are published by AUERSWALD ET AL. 2001. In summer 1992 an experiment at the landscape level was started: the landscape was re-designed and the area was divided along a border of a watershed to implement two farming systems: integrated and organic.

Landscape design:

In order to arrange site-specific land use in this landscape with its small-scale variations in soils and slopes, the size of fields was decreased from 4.0 to 2.3 ha on average, but their layout was improved for machinery: the new fields have two parallel sides with a length of 60 to 180 m, and are mainly rectangular. By extending the fields along the contour and decreasing their length along the slope the homogeneity of soils and water conditions within the fields increased (SINOWSKI AND AUERSWALD 1999). This concept is regarded as superior to the so-called precision farming on huge fields, because the timing of soil-dependent farming operations can be optimized. Narrow-angled field corners, areas that did not fit into the new field design (“space left over in planning”), steep slopes (> 0.3 m/m), wet areas, and strips between the fields and along the woodland were set aside or converted to grassland. These areas may give space for species that cannot survive on intensively managed arable fields. Buffer strips along the creeks may reduce direct agricultural influence on water bodies. Pilings of deadwood may provide shelter and nesting places for many animals and will develop into living hedges. The area of unused land was increased to 13.5%. The farm roads are connected to the nearby village and a well-known abbey in order to increase accessibility for people who want to enjoy themselves by walking and visiting a farm.

Farming system:

An area of 96 ha has been converted to organic agriculture according to the EU legislation. The central issues when implementing organic farming were: (1) integration of animal husbandry to use non-arable land as grassland and the ley crops on the arable land, to enrich the diets for humans and to enhance attractiveness for visitors, (2) preventing loss of matter on the farm level by reducing leaching and erosion from fields and by processing of harvests while keeping wastes on farm, (3) high yields of a broad range of marketable products, (4) growing crops that were regarded as difficult to grow organically, and (5) growing crops that are attractive to visitors and wildlife. Besides this farm, an area of 54 ha was made into another farm following the principles of integrated farming. About 38% of the area of the organic farm is grassland, which is used for beef production using Simmental suckling cows with an Angus or Piedmonts bull. 60% of the grassland is used as pasture, where cows and calves graze day and night in the summertime, and 40% is used as meadow that is cut three times a year for hay or silage. The grassland received no fertilizers over 14 years except for the dung pats and the urine left by the animals when grazing and waste potatoes that were partly spread on the pastures in the wintertime.On the plots of arable land a 7-phase rotation was implemented: ley - potatoes - winter wheat with a legume cover crop - sunflowers + ley - ley - winter wheat - winter rye + ley. The grass-red clover-alfalfa mixture (ley) establishes itself under the preceding rye or sunflowers, providing an untilled and perfectly covered soil for 28 or 17 months, respectively.

The soil is ploughed twice in the 7-year rotation with a two-layer on-land mouldboard plough, each time after the purely ley crops in order to control voluntary grasses and alfalfa. In three years out of seven, soil is chiselled and in the two years when ley is established it is not tilled at all. For cultivation of small grains in order to reduce weeds and to aerate the topsoil, tiny springs are used. Potatoes are cultivated two to four times using a spring hoe and a rotating wheel ridger. All work is performed with light-weight tractors. Manure from the cowshed is spread before planting potatoes or rye, and slurry from a sealed pit is applied to growing winter wheat in the spring using tight hoses. Crop varieties were selected from on-farm plot trials. Main items were found to be the most vigorous and competitive varieties with very good quality and acceptable yields. The straw is collected, baled, and used for bedding. Mineral P and K fertilizers are not used because of the large supply from the soils. In order to increase the income of the farm, potatoes and small grains are sold for seed. Wastes are fed to the beef cattle. Oil from sunflowers is extruded and sold, wiith the residues used as feed for fattening bulls. Some new methods are being applied to achieve best management practices: ultra-wide tyres on all farming machinery and use of the lightest tractor for a given task; mouldboard-ploughing with an on-land plough, which allows running both tyres on the unploughed land; and sowing mustard into potato fields when chaffing the potato foliage in order to cover soil, produce biomass, and create an attractive landscape for insects and humans.

Measuring methods:

The Munich Research Alliance on Agro-Ecosystems (FAM) performed research over 13 years to measure pools and to study (1) matter fluxes by farming and natural processes, (2) energy fluxes, (3) information fluxes such as spreading of knowledge and genomes, and (4) money fluxes. Land-use change and conversion to organic agriculture gives the chance to study those fluxes, which are hard to detect under equilibrium conditions. In order to get representative results the cross-sections of a 50 x 50-m grid were used as measuring points for crop yields, soil and nutrient properties, water regime, and variables characterising wildlife. Meteorological conditions, groundwater, and runoff were measured at permanent stations (AUERSWALD et al. 2000, 2001).

Results and discussion

Soil compaction:

All the different measures – setting aside wetlands, reducing headlands, using wide tyres and light-weight machinery, reducing tillage, and long phases of ley with no-tillage - helped to avoid over-compaction and to increase the pore volume and infiltration capacity (Rogasik et al. 1995). The main contribution was from using ultra-wide tyres on combine harvesters. AUERSWALD et al. (1996) found that more than 90% of the arable land deviates by less than 0.2 g cm-3 from the optimum fixed soil density.

Runoff and soil erosion:

Runoff decreased from 43 l m^{-2} yr^{-1} to about 8 l m^{-2} yr^{-1}, resulting in 35 l m^{-2} yr^{-1} more water available for plant growth or seepage. Along with sediment and runoff reduction, P-transport to water bodies was diminished to one twentieth but remained high enough for eutrophication of water bodies. The P-concentration in runoff correlates well with P-concentration in soil water. Because the amount of P exported from the farm by harvests is only 3 kg ha^{-1} yr^{-1} it will take years before the concentration of P in the soil is reduced to an amount compatible with the demands of water conservation. The rate of water erosion was diminished from 9.1 t ha^{-1} yr^{-1} before 1992 to less than 0.05 t ha^{-1} yr^{-1}. The options of landscape design such setting aside steep land, creating field borders and dams to stop runoff, creating grassed waterways and border strips along water bodies contributed 58% to the total reduction of soil loss, whereas farming practices using almost continuous soil cover contributed about 42% (PFADENHAUER et al. 1997). Due to the reduced depth and frequency of tillage and the setting aside of the steepest slopes, tillage erosion dropped as well, which until 1992 had exceeded water erosion in some areas.

Organic matter and nitrogen:

Organic matter content in the soil has increased by 180 kg ha^{-1} yr^{-1} on average over the 10-year measuring period; therefore, soil gain by accumulation of organic matter after conversion to organic farming is higher than the soil loss by erosion. 56.5 kg ha^{-1} yr^{-1} of N is stored in the topsoil, thereby increasing the richness of the soil. Using mustard as a cover crop in potatoes helped to save about 50 kg ha^{-1} N that otherwise would have been leached. The amount of N fixed by legume-grass-mixtures was 240 kg ha^{-1} yr^{-1} (HEUWINKEL et al. 2003) leading to acceptable yields of 4.8 t ha^{-1} of wheat and 28 t ha^{-1} of potatoes, which are about 30% less than on conventional farms but much above comparable organic farms of the region. The N-concentration in the leachate at a 1.8 m depth decreased to less than 20 mg l^{-1} NO_3 at each measuring point, showing no hazard of nitrogen leaching even after ploughing of the ley crop. A reduction of nitrate in the regional groundwater ten years after conversion also can be detected (HEILMEIER et al. 2002), proving the positive effect of organic farming on groundwater quality.

Biodiversity:

The diversity of plant species on the farm scale remained nearly unchanged, whereas the number of species at the 129 measuring points on the arable fields increased from 17 to 32; on pastures from 26 to 32; on meadows from 28 to 40; and on former arable land that was set-aside from 19 to 40 (AUERSWALD et al. 2000). Endangered plant species increased at 49 and decreased at 18 of the measuring points. This increase is caused by a less efficient and more selective weed control since the land was farmed organically, compared to the former herbicide use. Six years after conversion the number of plant species in arable fields decreased (ALBRECHT 2003) because the crops grew more vigorously and had a higher leaf area index, resulting in a greater competition to weeds. Not all of the rare species respond with an increase in their habitat size due to their inefficient dispersal strategies. The diversity of all investigated animal groups increased from 1991 to 1995. The number of nesting birds and bird species increased rapidly from 1991 to 1993 (AGRICOLA et al. 1996), but remained almost constant afterwards (OSINSKI et al. 2005). Five rare bird species were attracted and are now constantly found on the farm.

Energy:

The energy input from gasoline, oil, machinery, seed and fertilizers of 453 kg ha^{-1} yr^{-1} CO_2-equivalents shows that the farm is run very intensively (KÜSTERMANN AND HÜLSBERGEN, 2005). The input for wheat is 1820 MJ t^{-1} and for potatoes 990 MJ t^{-1}, which results in a global warming potential of 210 and 100 kg CO_2 t^{-1}, respectively (WECHSELBERGER 2000). A typical output/input relation for the whole farm is 16.7. This can be regarded as high and sustainable.

Economic situation:

Economic calculations based on high-resolution yield mapping (AUERNHAMMER et al. 1994) showed that there are areas that caused a negative income in the inventory phase 1990-1992 (AUERSWALD et al. 2000), especially on steep slopes, which caused high inputs and nutrient losses, on wet soils, and on soils with a high sand content. Environmental quality and economic benefits could both be improved by taking these areas out of arable or even completely out of agricultural use (AUERSWALD et al. 2000). The new arrangement of the fields along with smaller field sizes increased the labour demand when using machinery by only 1.2 %, but for the triangles of land that can be weeded only by hand, the labour demand was reduced drastically. Economically most important for the farm are the prices for beef and potatoes and the marketable yields of potatoes. Compared to the former situation, the organic farm is economically prospering now, but is dependent on higher prices for organically grown products and on payments from the government. In former times the entire farm, with about 150 ha, was run by two individuals who were employed by the owner. Now the organic farm employs 1.5 individuals and works together with about three farmers from the surrounding area partly using their machinery. In particular, the growing, sorting, and packing of potatoes results in a lot of work and gives a chance also to employ people in the wintertime, when work in agriculture is scarce. The new design of the landscape was rated more attractive by comparing pictures from 1991 and those from 1999 taken from the same site (WECHSELBERGER 2000), and the number of visitors has increased. The public finds the animal husbandry with cows and calves, the diverse cropping situation with nice flowering crops like potatoes and sunflowers, and the wildlife areas to be the most attractive features.

Conclusions

Re-designing the landscape and implementing an improved concept of organic agriculture drastically improved the environmental and economic situation of the farm site studied. The improvements included: reduction of soil compaction and soil erosion, improvement of drinking water quality, and diminished risks for water bodies. Under organic management, the content of soil organic matter has increased as well as the CO_2 sequestration in the soil. Rare and sensitive species are being conserved, but dispersal to new habitats is sparse. Diversity of animal species has increased. The economic situation has stabilized due to comparably high yields and price premiums for potatoes and through payments from the government. Under current conditions the implemented land-use system can be regarded as sustainable. However, despite such positive results from the conversion to organic farming, the adoption of such management practices by farmers, remains limited in this region.

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MODELLING CARBON CYCLES AS BASIS OF AN EMISSION INVENTORY IN FARMS – THE EXAMPLE OF AN ORGANIC FARMING SYSTEM

Björn Küstermann & Kurt-Jürgen Hülsbergen

Chair of Organic Farming, Technical University Munich, Alte Akademie 16, 85350 Freising, Germany, phone: 08161/713032, kuestermann@wzw.tum.de, www.wzw.tum.de/oekolandbau

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Abstract

In organic farms, the internal carbon fluxes are of great importance. They are connected with soil fertility (humus contents, biological activity, soil structure) and the yield potential; some C pools (C fixation in humus) and C fluxes (CO_2 and CH_4 emissions) may affect the environment. The approach used in the described model software allows to quantify management related and site dependant C fluxes and also the resulting emissions as starting point for an inventory of emissions from farms. The software was validated on the basis of intensive investigations made in the Experimental Farm Scheyern over many years. The results corresponded well to the measured values and characterize Scheyern as a farming system of intensive ecological shaping.

Introduction

While fully developed systems for the analysis and management of nitrogen cycles are available, no methods are at our disposal for describing carbon cycles on farm level.

In the research sector, activities focus mainly on the analysis of single C fluxes and C pools, generalizing statements for higher system levels (farmscapes, ecosystems) or even global ratings of geochemical C cycles are made (Janzen, 2004). This is surprising because C fluxes are of great importance for farms indeed: An optimal consideration of mass fluxes and recycling processes in farms is a basic principle of organic farming. Above this, some C fluxes and C pools may affect the environment. Analyzing mass and energy fluxes allows to describe farm management systems, assess environmental impacts, disclose bottlenecks in farms and test optimisation strategies. If it were possible to quantify management related and site dependant C emissions with sufficient accuracy and to interrelate them to the N emissions, a step towards an inventory of total farm emissions would be accomplished.

The paper describes an approach to the combined analysis of N and C fluxes on farm level. For this purpose, the underlying environmental management system REPRO (Hülsbergen & Küstermann, 2005) has been supplemented by a module for the description of C fluxes. It includes:

the considered C fluxes and C pools, methods for their assessment and the coupling of these parameters in a farm balancing model,

the factors influencing C fluxes and pools,

the order of magnitude of single C fluxes and pools demonstrated using the example of a farm.

Methodology

REPRO **(Repro**duction of Soil Fertility, Hülsbergen 2003) is a model software for the analysis, evaluation and optimization of farming systems. Mass and energy fluxes are described using the following methods:

- energy balancing (Hülsbergen et al. 2002),
- humus balancing and C/N simulation (Hülsbergen 2003)
- nitrogen balancing and turnover (Abraham 2001).

Balancing inner-farm C fluxes in the system soil – plant – animal required the adaptation of existing modules and supplementation of their parameters and algorithms (for example the C levels in the biomass of plants and animals, organic fertilizer, …). As a new element, a methodical approach to a crop and site specific quantification of C input by root and crop residues has been included. It is based on studies on the root development of relevant crops. The root turnover can be calculated using the ratio between net root development and gross root development (i.e. total root production) in the growth period (Swinnen et al.

1995, Steingrobe et al. 2001). Total root production and C content allow to determine the C input into the soil. Soil conditions, management systems, yield level and/or shoot development are considered by use of correction factors.

C emissions in livestock keeping are handled separately due to the different specific greenhouse potentials of CO_2 and CH_4. CH_4 emissions from enteric fermentation which are estimated on the basis of feeding with consideration of energy uptake and performance (Hoffmann et al. 1972). CH_4 emissions from manure are quantified with regard to the share of volatile solids and manure management (IPCC 1996, Tier 2-Approach). The direct and indirect CO_2 emissions from production are estimated along with the balancing of the energy input by operating resources and machines. For this purpose, C emission factors are applied. The C source and sink potential of the soil is assessed on the basis of humus balance sheets.

The described model software has been first used in the Experimental Farm Scheyern in the Tertiary Hills of Southern Germany (description of site characteristics and farming system by Auerswald et al. 2000). The farm is one of the most intensely sampled organic farms in Germany. For more than 15 years, a complex measuring programme has been run on its production area. At more than 500 grid points, continuous samplings were made of soil conditions, water regime and yield parameters. The measurements of relevant C and N fluxes and pools (Flessa et al. 2002) provided an important stock of data and thus the basis for validating the model program.

Results and brief discussion

The given farm structure, a legume-based crop rotation, high N inputs into the farming system, intensive management and a high yield level have led to an intensive N cycle in view of the organic management (Hülsbergen & Küstermann 2005).

This intensive N turnover is also mirrored by the carbon cycle. The characteristics of the management system became evident in 2000 (see Fig. 1), when especially high yields pointed to a fixation of atmospheric carbon in the range of nearly 5500 kg ha^{-1}. The C input into the soil reached 4070 kg C ha^{-1}, 49 % thereof in form of crop and root residues as well as rhizodeposition, 16 % as straw and green manure and 34 % as farm yard manure (FYM) from livestock keeping. Altogether, 10 times more carbon was supplied to the soil than was withdrawn from the farming system in form of plant and animal products. Considering the humus demand (crop rotation, soil tillage and cultivation intensity) and the supply of organic matter, the C balance sheet shows a mean accumulation of 200 kg C ha^{-1} a^{-} (= recovery of 734 kg CO_2 ha^{-1} a^{-1}). The increase of the humus level in this order of magnitude after the shift to organic management has been confirmed by measurements (Gutser & Reents 2001). Compared to the C input, only a small quantity has been stored in the soil for a longer time (< 5 % of the C supply). Suggesting a C_{org} steady state, the sum of C supplies would be equal to the total C removal. The organic substances delivered to the soil differ in quality of matter composition and degradability; this was taken into account in the humus balance. Detailed information on the C/N turnover in the soil was furnished by simulation models; several models reflecting soil processes were tested in Scheyern using the farm balancing software REPRO with the target to find a suitable program approach for the given location.

In livestock keeping, 33 % of carbon which is fixed in the plant biomass is used as feedstuff or bedding material. More than 2000 kg C ha^{-1} are fixed in purchased feedstuffs, thus this quantity exceeds on farm production. About 42 % of the carbon supplied in feed and straw is emitted via the metabolism of animals. This corresponds to 6000 kg CO_2 ha^{-1} and 95 kg CH_4 ha^{-1}. These results correspond well to studies by Flessa et al. (2002) undertaken at the same farm.

Beside biological C emissions, mainly technogenic sources in form of direct and indirect C inputs by fossil energy carriers exert influence on the climate. Energy balances in plant production revealed an input of fossil energy in the range of 7.5 GJ ha^{-1} a^{-1}. By use of specific CO_2 emission factors this equals to an emission of 453 kg CO_2 ha^{-1} a^{-1}. A description of all emissions from agricultural production to the environment requires detailed recordings of all technologies and involved methods also in livestock keeping. Currently, the REPRO software is adapted and updated. First runs give numbers for the CO_2 emission of animal husbandry in a range of 250 kg CO_2 ha^{-1} a^{-1}.

Table 1 summarizes the magnitude of the integrated evaluation of farm-specific greenhouse gas emissions. It provides insights into the main sources of greenhouse gas emissions and shows their contribution to the total atmospheric impact, expressed as aggregate CO_2 equivalents. Regarding the numbers, the N_2O and CH_4

emissions are negligible but from the point of view of greenhouse potential they have to be considered because of their high specific greenhouse potential of 21 for methane and 310 for nitrous oxide in relation to CO_2. Those are contributing to the greenhouse effect more than is balanced by the CO_2-sequestration caused by 25 % of lay-crop in the rotation and by manuring.

All emission estimates for the biotic and abiotic processes have considerable uncertainties. This is especially true for N_2O emissions from soils since these emissions may vary by orders of magnitude, both spatially and temporally (Flessa et al. 2002). Measurements are done on certain spots, in general. Results for whole farms are, therefore, derived by emission-factors. For those one might find a broad range of numbers in the literature (Bouwmann 1996). In the present study, both the well-accepted emission-factors of the IPCC (1996) and of Flessa at al. (2002) which were derived from measurements in Scheyern are used. They result in a broad range of CO_2 equivalents. Implementing the soil-process-model DNDC (Li et al. 2000) within the REPRO is hoped to result in a more precise quantification of soil-borne N_2O emissions at sites where no measurements are performed.

Tab. 1: Total emissions of N_2O. CH_4, CO_2 and CO_2 equivalents in the year 2000

	N_2O kg ha^{-1} a^{-1}	CH_4 kg ha^{-1} a^{-1}	CO_2 kg ha^{-1} a^{-1}	CO_2 equivalents kg ha^{-1} a^{-1}
Plant Production				
Use of fossil energy	n.d.[a]	n.d.	453	453
Soil (potential of source or sink)				
arable land	4,6[b] ; 9,4[c]	n.d.	-734	692[b] ; 2180[c]
pasture land	3,1[b] ; 6,2[c]	n.d.	0	961[b] ; 1922[c]
Animal Production				
Use of fossil energy	n.d.	n.d.	250	250
Enteric Fermentation	n.d.	80	n.d.	1680
Waste management	n.d.	13	n.d.	273

[a]n.d. = not determined, [b]calculated by the emission-factor from IPCC, 1996 (1,25 % of the amount of N applied), [c]calculated by the emission-factor from Flessa et al 2002 (2,53 % of the amount of N applied)

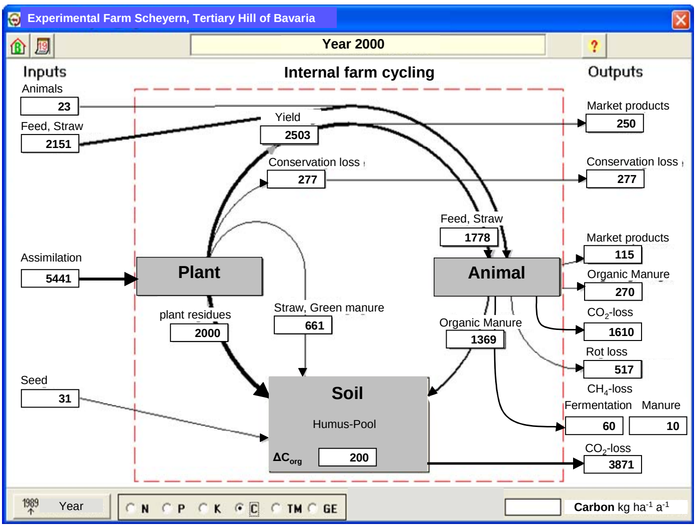

Fig. 1: On-farm carbon cycle 2000

Conclusions

C balances are essential elements in analyses of farm management systems and cannot be neglected when inventories of farm emissions are to be made. The communicated values of C fluxes characterize the management system properly. Significant deviations occurred in single years, due to structural changes, varying yield levels etc. The described C fluxes and C pools correspond well to the order of magnitude of the measured values; the latter, however, show a high variability both at selected places and in defined periods. When using balancing techniques and emission factors, absolute precision is not really claimed. Much more important is the correct display of the magnitude of emissions and the reflection of changes in management.

The described model approach shows analogies to the methodology proposed by Köpke and Haas (1995) for estimating the relationship between climate and organic farming. These authors, however, formulated generalizing statements about organic farming. Our studies focus on real farms. The coupling of C balances with other spheres of the environment (energy, nitrogen, soil fertility…) allows a multiple-purpose optimization of farm management.

New studies concentrate on improving the model approach and to extend the basis of data for validating the software (inclusion of more test sites).

The REPRO model program offers an actual chance for arriving at spatial statements vis-à-vis emission measurements of selected sources and thus for producing overall ratings of farm management systems.

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ECONOMIC, SOCIAL AND ENVIRONMENTAL BENEFITS ASSOCIATED WITH U.S. ORGANIC AGRICULTURE

Luanne Lohr

Department of Agricultural and Applied Economics, University of Georgia, Athens, GA 30602-7509, U.S.A., e-mail: llohr@agecon.uga.edu, tel: +1-706-542-0847

Key Words: conventional-organic comparison, economic indicators, environmental indicators

Abstract

This case study reviews the economic, social, and environmental benefits associated with organic agriculture in the United States. Measurable impacts are quantified by comparing indicators of benefits in counties with organic farms and counties without. Statistical differences across counties with and without organic farms provide preliminary evidence that organic farms may generate a variety of direct and indirect benefits. Of 36 indicators tested across a range of economic, social, and environmental benefits, 26 favor organic systems, three favor conventional systems, and seven are neutral. Even though organic farmers are not a large percentage of the total number of U.S. farmers, they may be influencing mainstream agriculture to shift toward greater sustainability.

Introduction/Problem

Consumers believe that organic foods are safer, healthier, and better for the environment and that they are safer for farmers to produce (HealthFocus, 1999). Farmers cite both personal and business reasons for organic farming, including a belief that organic is better for the land, a concern that conventional farming may cause negative environmental and health impacts, a sense of satisfaction in solving the challenges of organic systems in innovative ways, and an ability to make positive net returns on small scale, intensively managed farms (Duram, 1999). Most of the farm benefits usually cited – improved soil quality, greater diversity of soil organisms, insects, wildlife, and plants, greater net return, reduced income risk, better drought resistance, higher cumulative energy efficiency, and safer on-farm environment - are outcomes of the methods required for organic farming (Mahoney *et al*., 2004; Rigby *et al*., 2001; Stolze *et al*., 2000). Beyond the farm, benefits claimed from organic farming include enhanced biodiversity and habitat, cleaner groundwater and surface water, and reduced greenhouse gas emissions. Greater certainty about expected benefits of organic foods encourages consumers to pay the price premiums that internalize these benefits and encourages producers to incur the costs of converting farms to organic production. Government policy to support the organic industry is likely only if evidence of comprehensive beneficial effects is presented. Most studies of organic benefits in the United States have been localized in nature. To evaluate benefits for the entire country, indirect statistical measures must be used.

Methodology

Statistical comparison of organic farms with conventional farms would ideally be conducted at the farm level, with data collected on each individual operation relating farm practices to observable benefits. In the absence of such data sets, county level data, the next highest geographic level of analysis, were used. Counties are geopolitical units that may encompass several towns or cities, and thus multiple zip codes, but are subordinate to state governments. Data on the number of organic farmers per county were collected for 1997 from the Organic Farming Research Foundation and from certifiers throughout the U.S. Only one major certifier, accounting for about 200 farmers, refused to participate in the data collection, so the sample is nearly the entire population of organic farmers at that time.

Using the unique five-digit state-and-county identifiers, called FIPS (Federal Information Processing Standards) codes used by the U.S. Census Bureau, all counties in the U.S. were classified as either “with” or “without” organic farms, “with” being defined as having at least one organic farm located interior to the county boundary. Of 3,078 counties in the United States, 39.2% had at least one organic farm at the time of the analysis, with a weighted average of 3.3 organic farms in these 1,208 counties. The mean values of selected indicators from the U.S. Agricultural Census (USDA, 1997) were calculated for counties “with” and “without” organic farms. The counties were compared using a t-test for equality of the means under the assumption that as the sample size increases, the t distribution approaches the standard normal distribution

(Kmenta, 1986). For statistically different means, either the organic or conventional system was declared “best performance.” Higher means were preferred for positively valued attributes, such as hired worker payroll, and lower means for negatively valued attributes, such as pesticide use.

A similar process was conducted to evaluate watershed indicators. FIPS for the counties with and without organic farms were matched to eight-digit watershed identifiers known as HUCS (Hydrologic Unit Code System) used by the U.S. Geological Survey. It is common for several counties to overlap a watershed yet not be contained within it, since a watershed is a physical unit delineating surface water flows rather than a political boundary. The condition was set that all counties making up the watershed had to have at least one organic farm. Means for watersheds “with” and “without” organic farms were constructed from U.S. Environmental Protection Agency data on watershed indicators.

There are advantages in aggregating the data into two groups – counties with and counties without organic farms. First, the method is consistent with the theory that organic farmers influence other farmers’ behavior and county economies by their presence and contributions to the management information set within the county. Even a single organic farmer can stimulate change by requests to county extension agents, applications for government programs, participation in field demonstrations, and other activities that raise the awareness of both farmers and information providers. Second, this approach prevents the results from being skewed by states having many counties with large numbers of organic farmers, such as California. For example, confounding factors such as stricter pesticide laws in California do not influence the findings of benefits because California is not disproportionately represented in the sample, as it would be if the aggregation unit was the number of organic farmers.

The method used relies on correlations to document organic farm influence. Causality is not established, as might be possible with regression analysis, so it cannot be definitively stated that the presence of organic farms is the cause of the benefits indicated. Theoretically, there may be other commonalities in counties with organic farms that account for observed differences, although the geographic distribution and physical diversity of the farms are such that obvious factors such as proximity to cities or crop selection by region may be ruled out. Aggregation to counties allows statistical tests for the influence of organic farms, even if the relationship cannot be precisely quantified. Observing statistically significant results across multiple indicators suggests that the presence of organic farmers is strongly associated with the benefits.

Results and Brief Discussion

Table 1 shows the 36 indicators compared for counties with and without organic farms. Best performance is assessed for the system with the higher mean if the indicator has a (+), and the lower mean if the indicator has a (-). If the category heading has one of these signs, means for all the indicators in the category should be higher (+) or lower (-) to be best, with exceptions marked. If the difference of the means is not statistically significant at $\forall$=0.05, then neither system exhibits the best performance. This test is not a definitive indicator of the superiority of organic or conventional systems; rather, it indicates that counties with organic farms perform statistically differently than counties without.

The results suggest the dominance of counties and watersheds with organic farmers over those without. From Table 1, several direct conclusions may be made. First, counties with organic farms have stronger farm economies and contribute more to local economies through total sales, net revenue, farm value, taxes paid, payroll, and purchases of fertilizer, seed, and repair and maintenance services. Second, counties with organic farms have more committed farmers and better support rural development with higher percentages of resident full-time farmers, greater direct-to-consumer sales, more workers hired, and higher worker pay. Third, counties with organic farms provide more bird and wildlife habitat and have lower insecticide and nematicide use. Fourth, watersheds with organic farms have less agricultural impact and lower runoff risk from nitrogen and sediment.

Table 1. Indicators Tested for Counties With and Without Organic Farms

Indicator	Units	Mean With Organic	Mean Without Organic	Best Performance With Organic	Neither	With Conventional
Farm Economy (+)						
Total farm sales	dollars per farm	111,696	99,075	X		
Total farm expenses (-)	dollars per farm	85,358	76,748			X
Net return to agricultural sales	dollars per farm	25,813	22,226	X		
Market value of land and buildings	dollars per farm valued	511,250	474,740	X		
Local Economy (+)						
Property taxes paid	dollars per farm paying	95,000	84,479	X		
Hired worker payroll	dollars per farm hiring	24,145	16,685	X		
Fertilizer purchased	dollars per farm buying	8,681	7,770	X		
Agricultural chemicals purchased	dollars per farm buying	7,306	7,340		X	
Livestock and poultry purchased	dollars per farm buying	38,232	40,733		X	
Commercially mixed feed purchased	dollars per farm buying	26,763	36,201			X
Seed, bulbs, and trees purchased	dollars per farm buying	6,976	5,215	X		
Custom work, machinery rented	dollars per farm renting	5,110	4,758		X	
Repair and maintenance purchased	dollars per farm buying	6,268	5,365	X		
Farm Ownership (+)						
Sole proprietorship	percent of all farms	84.2	85.2			X
Family held corporation	percent of all farms	5.2	4.4	X		
Female farmer	percent of all farms	9.3	8.9	X		
Renting some or all land (-)	percent of all farms	41.5	48.1		X	
Operator Characteristics (+)						
Operator lives on farm	percent of all farms	72.1	68.0	X		
Farming principal occupation	percent of all farms	53.4	48.7	X		
Full-time farming	percent of all farms	65.4	62.7	X		
Years operating present farm	average years	20.5	20.1	X		
Rural Development (+)						
Direct-to-consumer sales	dollars per farm	5,247	3,489	X		
Worker pay	dollars per worker	4,122	3,675	X		
Workers hired	workers per farm	5.1	4.0	X		
Farms with net losses (-)	percent of all farms	47.8	50.2	X		
Bird and Wildlife Habitat (+)						
Idle or in permanent cover crops	acres of cropland	14,476	9,790	X		
Idle, cover cropped, or woodland	acres of farmland	27,487	24,019	X		
Land under CRP/WRP	acres	13,297	9,230	X		
Chemical Use (-)						
Fertilizer use	acres per farm using	204.94	200.70		X	
Insecticide use	acres per farm using	153.67	183.15	X		
Herbicide use	acres per farm using	240.09	240.27		X	
Nematicide use	acres per farm using	20.22	37.48	X		
Runoff Risk (-)						
Agricultural impact index	weighted index	0.85	1.03	X		
Nitrogen runoff index	weighted index	0.79	1.03	X		
Pesticide runoff index	weighted index	0.94	1.01		X	
Sediment runoff index	weighted index	0.86	1.02	X		

The measurable benefits of organic agriculture suggest other indirect gains to society. Higher average net farm revenues and higher values of land and buildings are important measures of financial stability for farmers, since the value of the farm represents both collateral for loans and retirement capital. Local rural economies benefit as well. In many states, property taxes pay for public schools, hospitals, and other infrastructure. Higher tax payments can translate to significant benefits to non-farmers. Adding payroll to the local economy is important not only for the multiplier effect in the retail and service sectors, but because it provides another avenue for recruitment of farmers young people are hired and trained in farming. If sales of more expensive organic inputs are generated, agribusinesses may survive on fewer sales, which could keep more firms in business.

Concern over the industrialization of agriculture has led to scrutiny of farm transition among families. Counties with organic farms have higher percentages of family held corporations and female farmers, as well as farms where the operator lives on farm, farming is the operator's principal occupation, and the operator is a full-time farmer. These factors contribute to a desirable rural sociology by stabilizing the agricultural sector and maintaining local information and social networks. Direct to consumer sales are an important means of linking farmers and consumers. Farmers in counties with organic farms obtain nearly 50% more revenue from direct sales than in counties without. Farm workers need to earn a living wage to contribute to the rural economy and maintain a reasonable standard of living. More workers are hired per farm in counties with organic farmers and pay per worker is higher.

Agricultural habitat for birds and wildlife was defined in several ways that relate to contiguity of habitat, measured by total acres. Habitat is statistically higher in all three categories for counties with organic farms. Less use of insecticide and nematicide and lower indexes of agricultural impact, nitrogen runoff, and sediment runoff result in fewer incidents of chemical exposures affecting worker productivity, less water quality degradation, and fewer fish consumption advisories.

Conclusions

This case study documents the statistical difference between U.S. counties with organic farms and those without. Counties with organic farms perform better on 26 of 36 economic, social, and environmental indicators. The findings suggest that even in small numbers, organic farmers are influencing mainstream agriculture to shift toward greater sustainability.

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ENVIRONMENT, BIODIVERSITY AND LANDSCAPE

A PILOT STUDY OF PRODUCING ORGANIC SHRIMP IN SUBTROPICAL REGIONS: A CASE STUDY IN TAIWAN

Yung-Song Chen (1), I Chiu Liao (2)

(1) Department of Animal Science, National I-Lan University, 260, I-Lan, Taiwan, yschen@niu.edu.tw
(2) Department of Aquaculture, National Taiwan Ocean University, 202, Keelung, Taiwan, icliao@mail.ntou.edu.tw

Key Words: Organic aquaculture, organic shrimp, tropical aquaculture, Litopenaeus vannamei, Marsupenaeus japonicus, integrated aquaculture

Abstract

The study was conducted to evaluate the applicability of producing organic shrimp without using any chemicals in Ilan, Taiwan. The trials respectively employed intensive monoculture of two penaeoid species, white shrimp (*Litopenaeus vannamei*) and kuruma prawn (*Marsupenaeus japonicus*) and extensive polyculture of kuruma prawn (0.56 m^{-2} stocking density) and grey mullets (500 pcs). Experimental units consisted of three earthen ponds, 900 m^2 , 1100 m^2 and 4600 m^2, respectively with a minimal water exchange. No significant effects in shrimp growth were found with the probiotics used in the trials. Although the survival rates for both species in the first two trials were low and obviously affected by the disease outbreaks, the third trial on extensive polyculture with grey mullet achieved a high survival and growth rate (3.8 g to 37.3 g) during the 12 weeks culture period. Dissolved oxygen concentration in three ponds fluctuates on a 24-hour basis, increases during daylight hours and decreases at nighttime even dropping to a critical level of 2.03 mg/L. The results obtained from those trials indicate that the culture conditions must be carefully maintained. Although our trials did not achieve good results, they can provide some implications for future research. Also, maintaining an organic ecosystem may simply be too difficult for some aquaculture systems. Thus, it would be unrealistic to say that all aquaculture systems, at least for those we currently know, would be suitable for organic certification. However, seeking a balance between aquaculture production and environmental protection will be our ultimate goal.

Introduction/Problem

Aquaculture plays an increasingly important role in food production as the catches of wild fish stocks continue to decline on a global scale due to overfishing. However, the rapid development of intensive aquaculture which requires high inputs of energy, food and capital, can result in adverse effects on the environment. These farms, due to mismanagement, have resulted in severe pollution and habitat destruction problems. The true damage from these ventures is recognized and is being addressed in many references (e.g. Nunes *et al.*, 1997). Hence, facing these problems, the pressure on aquaculture is to create a viable, environmentally stable industry. Some strategies have been recommended to attain such sustainable culture systems including polyculture. However, most of the current shrimp farming ventures use monoculture practices for its convenience of operation as well for its economy and higher production. Hence, the shrimp culture industry in particular is always a target of critics from environmentalists against aquaculture as a whole.

During the last three decades, Taiwan’s aquaculture industry has gained a reputation for its advanced technologies. At present, the industry is facing many problems and challenges including: availability of suitable land; high labour costs; regulatory constraints; the increasing trend toward globalization; and disease problems (Liao *et al*., 2004). The industry needs restructuring and will have to respond to an increased concern for sustainability. To make a successful transition, one strategy will be to shift the industry’s emphasis towards organic or sustainable system (Lockwood, 2000.).

The principles of organic aquaculture, which encourage low energy inputs and environmental protection, also support domestic consumption wherever possible (IFOAM, 2004). With the current scenario, is it time for tropical fish farmers’ to adapt organic systems? Before this can be answered, hands-on experiences from the practical operations of organic aquaculture are needed. Probiotics which are allowed for use in organic aquaculture may provide an alternative way to reduce the use of antibiotics in aquaculture (Rengpipat *et al*., 1998, Meunpol *et al*., 2003, Gullian *et al*., 2004). Hence, this pilot study is aimed at the innovation of producing organic seafood without usage of chemicals but with probiotics to investigate its effectiveness and potential use in organic aquaculture.

Methodology

Three trials were conducted in the present study. The first two trials respectively employed intensive monocultures of two penaeoid species, white shrimp (*Litopenaeus vannamei*) and kuruma prawn (*Marsupenaeus japonicus*), while the third trial used extensive polyculture of kuruma prawn and grey mullet. Experimental units consisted of three earthen ponds, 900 m^2(pond 1), 1100 m^2(pond 2) and 4600 m^2(pond 3), respectively with a low water exchange. The first trial was carried out for 12 weeks between May and August 2003, while the second and the third trials respectively for 18~30 weeks between October 2003 and Jan 2004 and then through May 2004. Commercial feed (Table 1) was given twice a day at 5-7% of the shrimp biomass in both the control and treatment ponds while the probiotics Aqua-Photo (manufactured by Woogene B&G Co. Ltd., Korea, see Table 2) were together fed at a rate 0.5 % of the feed weight only in the treatment pond. During the experimental period, 10~30 shrimps were weighed every week. Water samples from each pond were collected weekly from the inlet and the outlet for measurement of water temperature, pH, DO, salinity using Hydrolab water auto-analyzer. To better understand the fluctuation of water quality particularly with dissolved oxygen (DO) level, the water parameters in three ponds were recorded during a three continuously diurnal rhythm.

Results and brief discussion

No significant effect in shrimp growth was observed with the probiotics used in the trials (Figs. 1 and 2). The survival rates for both species in the first two trials were very low and obviously affected by the disease outbreaks of while spot virus (WSV). In the third trial, prawn (initial mean BW 3.8 g) in the second trial were stocked for further 12 weeks together culturing with the mullets grew to 37.3 g at the end of the experiment with specific growth rate (SGR) of 2.72 % d^{-1}. Dissolved oxygen concentration in three ponds fluctuates on a 24-hour basis, increases during daytime and decreases at night. Dissolved oxygen in a shrimp pond even drops to a critical level 2.03 mg/L (Fig. 3). The results obtained from those trials indicate that the culture conditions must be carefully maintained and the stocking density should be carefully monitored when the principles of organic aquaculture are employed. However, organic aquaculture itself is still in its infancy. Currently, organic standards are mainly oriented to meet the needs and conditions of temperate species, where interest and demand are greatest. It is not appropriate to apply these standards directly to tropical aquaculture as the nature of operations and species involved are different (Chen *et al*., 2002; Chen, 2004).

Conclusions

Successful development of organic aquaculture will depend on improving management at all levels, and every aspect – from low-pollution feeds, stocking densities and vaccines administration, to integrated aquaculture – needs to be considered. Although our trials were not achieving good success, they can provide some implications for future research. Also, maintaining an organic ecosystem may simply be too difficult for some aquaculture systems. Thus, it would be unrealistic to say that all aquaculture systems, at least for those we currently know, would be suitable for organic certification. In addition, basic standards adapted to local environmental requirements will have to be established, as well as a quality assurance programme with viable controlling systems.

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Table 1: Composition of the shrimp diets used for both white shrimp and kuruma prawn

Crude protein	> 50 %
Crude lipid	> 3.0 %
Ash	< 17 %
Crude fiber	< 3 %
Moisture	< 11 %
Undissolved materials	< 2 %

Table 2: Composition of probiotics (Aqua-Photo, Woogene B&G Co. Ltd., Korea)

Rhodopseudomonas capsulata
Lactobacillus spp
Acidophillus
Bacillus spp

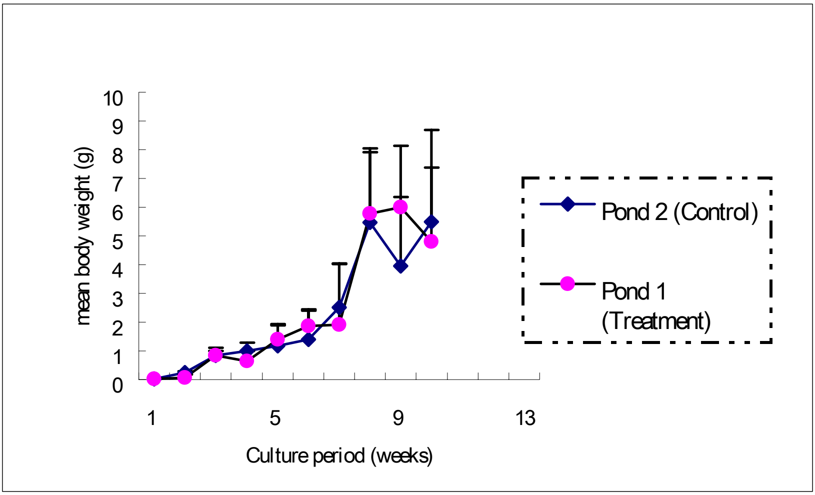

Figure 1: Changes in mean body weight of white shrimps in two ponds with organic aquaculture trials

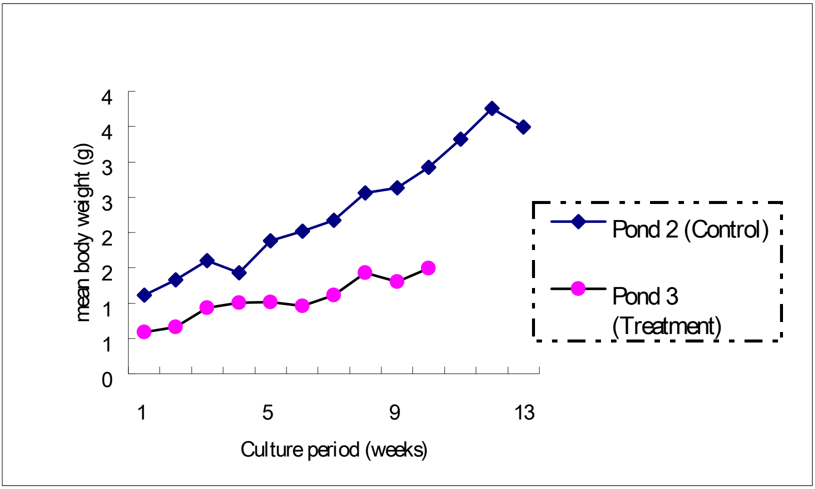

Figure 2: Changes in mean body weight of kuruma prawn in two ponds with organic aquaculture trials

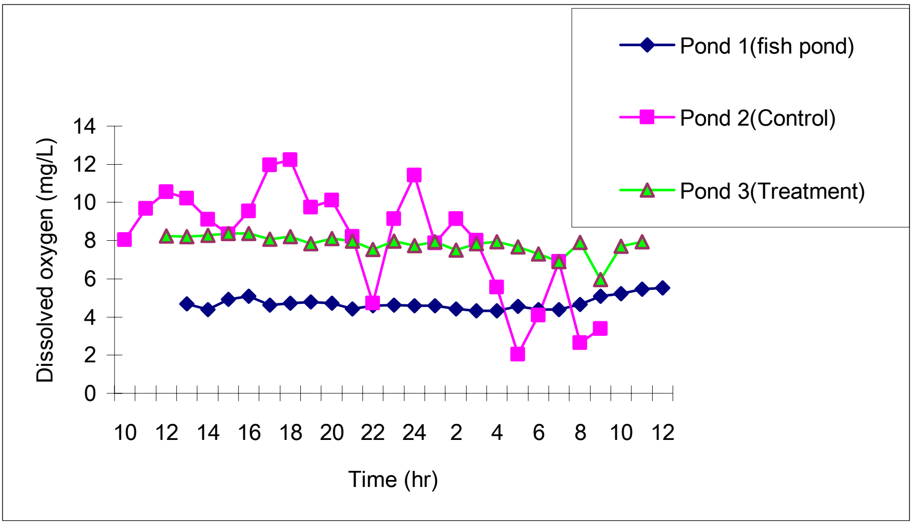

Figure 3: Fluctuation in dissolved oxygen (DO) level recorded in three ponds during the three continuously diurnal rhythm in the second trial

POTENTIAL OF WEEDS ATTRACTIVE TO BENEFICIAL INSECTS IN ORGANIC FIELDS – THEIR CONSIDERATION IN RESEARCH PROGRAMS

Bettina Frieben

Georg-Gröning-Strasse 70A, D-28209 Bremen, Germany, Tel. 0494213478021, E-mail bfrieben@gmx.de; affiliated with Institute of Organic Agriculture, University of Bonn, Katzenburgweg 3, 53115 Bonn, Germany, E-mail iol@uni-bonn.de, www.iol.uni-bonn.de)

Key Words: `beneficial` weed species, flower abundance, beneficial insects, problematic weeds, precautionary crop protection, weed monitoring

Abstract

Weed vegetation of organic arable fields was analysed in different regions of Germany. Weed species shown to be attractive to beneficial insects were prevalent and abundant in organic fields both in crop field margins and in the mid-field. Flower abundance of `beneficial` weed species amounted to about 2,800,000 flowers per hectare. In comparable fields with conventional management, `beneficial` weed species appeared rarely. Abundant problematic weed species appeared more frequently in organic cereal fields compared to organic row crop fields. To preserve beneficial impacts of weeds for preventive crop protection in organic farms, it is proposed that research programmes about farming practices include simple weed monitoring. In this way unintentional side effects on beneficial weed species could be detected.

Introduction/Problem

Western European farmed landscapes often show the characteristics of intensive farming, with little biodiversity and few flowers. In the management of farms one has to cope with the negative effects on populations of beneficial arthropods. For this reason, augmentation of these animals is a necessary element of preventive crop protection. It has been shown that beneficial arthropods are enhanced by characteristics of organic farming, such as loose soil, crop diversity, and certain weed or clover covers within the fields (Pfiffner 2000; Mäder et al. 2002, Hole et al. 2005). An important ecological function of weeds in organic arable fields is to attract beneficial insects. Pollen and nectar of weeds augment the fertility of ladybirds (Schmid 1992), hoverflies (Schneider 1948), chrysopids (New 1975, Frei & Manhart 1992) and parasitoid hymenopterans (Hassan 1967; Nentwig 1994, Gurr et al. 2004). Hoverfly (*syrphidae*) records within cereal fields on three organic farms showed that at least 75% of the recorded species have aphidophageous larvae. In fields with a high abundance of flowering weeds, up to 59% of the recorded hoverflies were observed visiting flowers like mayweed (Frieben 1998). The structure and colour of flowers of 27 weed species that occurred in at least 30% of 120 organic fields (Frieben 1998) have been shown to attract hoverflies and chrysopids (Hess 1990, Kugler 1970). Assuming that such weed species are an important factor for augmentation of beneficial insects, the following study analyses the quality of weed vegetation in organic fields. The results will be compared to conventional fields where a lack of preventive crop protection is normally compensated by insecticide application.

Methodology

Weed vegetation relevés were made in Germany in cereal (n=92) and row crop fields (n=29) on eight organic farms at different sites of North Rhine-Westphalia (1994-1996). Relevés were also made in comparable organic and conventional cereal fields (each in crop field margins and within the field; each 100 m²) in North Rhine-Westphalia (n=16/18; 1995), Hamburg (n=9/9; 1996) (recording date flowering state of cereals, 1996), in comparable organic and conventional row crop fields in North Rhine-Westphalia (n=7/9; recording date flowering state of maize, wilting state of potatoes, ripening of sugar beet 1995) and in comparable experimental cereal fields (1996, each 45 m²) managed by organic (n=6), integrated (n=12) and conventional (n=12) farming methods (1996). The relevés were analysed both for weeds that are attractive to beneficial insects and for problem weeds. Quoted numbers are based on median calculations (mdn).

Flower abundance was determined in 18 cereal fields on eight organic farms in 1995. Flowers of weed species known to be attractive to hoverflies and chrysopids were counted in 17 small squares (50x50cm) randomly distributed in the fields. The amount of flowers of each species was counted and projected to 1 hectare.

Results and brief discussion

Based on the count of flowers that opened on one day during the flowering state of cereals it is possible to estimate flower abundance. In a 1-ha organic cereal field there were 2,780,000 flowers of weed species attractive to beneficial insects. Most of these flowers belong to prevalent weed species (Table 1).

Table 1. Counted numbers of flowers in organic cereal fields.

weed species	flowers / ha	common name	attractive to
Matricaria chamomilla	420,000	mayweed	**hoverflies** (Frieben 1998, Hess 1990, Kugler 1970)
Myosotis arvensis	500,000	forget-me-not	**chrysopids** (Nentwig 1993), **hoverflies** (Ruppert & Klingauf 1988)
Stellaria media	360,000	chickweed	**hoverflies** (Weiss & Nentwig 1992, Hess 1990, Kugler 1970)
Capsella bursa-pastoris	250,000	Shepherd’s purse	
Polygonum aviculare	110,000	pigweed	**hoverflies** (Hess 1990, Kugler 1970)
Chenopodium album	60,000		
different weed species	1,080,000		**hoverflies**, **chrysopids**
❹	**2,780,000**		

8 farms were examined and 20% to 35% of weed species found in the organic cereal fields were attractively flowering weed species with considerable abundance. There were between 2 and 20 such abundant \`beneficial\` weed species per cereal field (mdn 10) and between 2 and 15 per row crop field (mdn 9) (Fig . 1). In the latter, weed regulation was more intensive.

The median of the number of abundant \`beneficial\` weed species was 3 to 6 in crop margin relevés of organic cereal and row crop fields (100 m²), and still 3 to 4 in relevés within the same fields. Comparable conventional fields rarely showed \`beneficial\` weed species. In experimental fields (45 m²) with organic, integrated and conventional management, abundant \`beneficial\` weed species only regularly occurred in organic plots (mdn 2) (Fig . 1).

The significance of abundant flowering weed species and their attractiveness to beneficial insects was proved by many studies (see introduction and Table 1). The beneficial effect is even more significant in large fields because of a lack of marginal vegetation with flowers. The presented numbers of abundant \`beneficial\` weed species within organic fields are particularly encouraging.

Cirsium arvense, Elymus repens, Galium aparine, *Vicia hirsuta, Rumex obtusifolius* and *R. crispus* are the most problematic weed species for organic farming in Germany (Eisele 1998). Their occurrence is dependent on soil, tillage and crop rotation. In 91 organic cereal fields on eight farms and 29 row crop fields on six farms there were 0 to 6 problematic weed species per field (mdn cereal fields 2, row crop fields 1; Fig. 1). In these cases there were little differences with comparable conventional fields (Fig. 1), although the conventional fields were poorer in problematic weeds in the mid-field. In experimental fields, problematic weed species were only abundant in conventionally managed plots and not in plots with integrated or organic management.

Conclusions

Normally weed cover is denser in organic fields than in conventional fields (Frieben 1998, Hole et al. 2005). Weed vegetation must be considered as a competitor for nutrients, and some species cause serious problems. The results show that these problematic weed species are frequent in organic fields. Other prevalent weed species have to be considered as beneficial for organic farming systems. Besides, the weed flora of organic fields is a source of biodiversity (Frieben & Köpke 1995, Hole et al. 2005). In eight organic farms in North Rhine-Westfalia, 21 endangered weed species were found in nearly half of the examined fields (Frieben 1998).

Intensification of organic farming is promoted by on-farm and experimental research programmes about tillage, crop varieties, weed regulation and catch crop management. Weed species diversity, flower abundance and their beneficial impacts may decrease in future. Therefore it is proposed that field experiments carried out by research institutions, extension services and farmers should include simple weed monitoring (see Table 2).

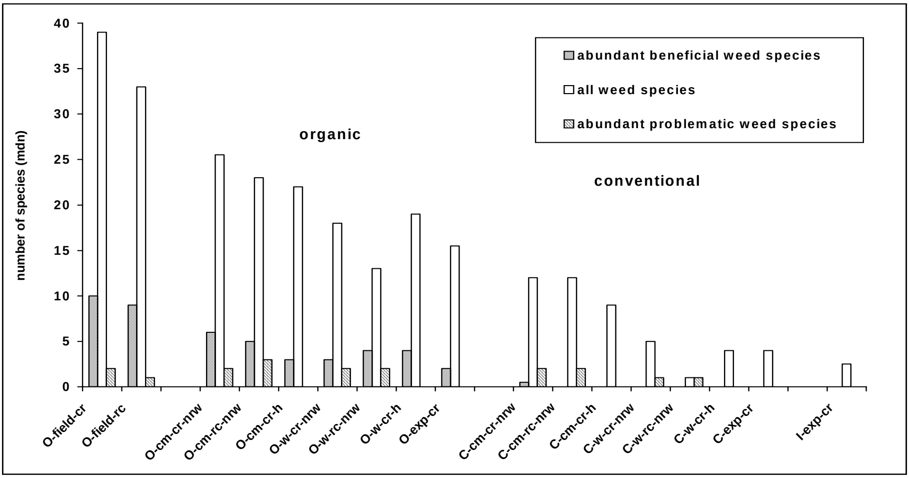

Figure 1. Number of weed species in crop margins and within organic and conventional fields and in variously managed experimental fields (O= organic, C=conventional, I=integrated; cm= crop margin, w= within, exp= experimental field; cr= cereal, rc= row crop; nrw= North Rhine-Westphalia, h= Hamburg)

Table 2. Weed monitoring for on-farm and experimental research projects for organic farming about tillage, crop varieties, weed regulation, and catch crop management

registration		**evaluation concerning decrease / increase of**
weed species	estimation of abundance	problematic weed species endangered weed species flowers attractive to beneficial insects
flower abundance	estimation of abundance	potential for flower visiting insects
vegetation structure	weed or catch crop cover / density	potential for beneficial arthropods bound to vegetation structure
conclusions		
effects tolerable / undesirable / positive for preventive crop protection and biodiversity		

The collected data would allow detection of unintended side-effects of modern organic farming methods on the agro-ecological functions of weed vegetation, permitting evaluation of whether such side-effects are tolerable or undesirable, and if they need compensatory actions. The promotion of beneficial weed species is an element of ecological engineering in organic farms enhancing effects of wildflower strip management .

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DEVELOPMENT OF AN ENVIRONMENTAL MANAGEMENT SYSTEM FOR ORGANIC FARMS AND ITS INTRODUCTION INTO PRACTICE

Kurt-Jürgen Hülsbergen & Björn Küstermann

Chair of Organic Farming, Munich Technical University, Alte Akademie 16, 85350 Freising, Germany, Tel. +49 8161 713032, huelsbergen@wzw.tum.de, www.wzw.tum.de/oekolandbau

Key Words: environmental impact assessment, organic farming, indicator, nutrient balance, humus, energy

Abstract

Increasing demands for documentation of farm activities as well as environment and quality assurance call for environment adapted management systems, also in organic farming.
The model software REPRO is a tool for farm management and consultation. It is distinguished by a systemic depiction of farming systems and can be used in agricultural practice.
The access to farm related data and site information is the basis for statements about matter cycles (C, N, P, K), humus budget, energy efficiency, erosion, soil structure and harmful soil compaction. Its application in rather differently structured farms under organic management discloses distinctly the relationships between the design of farming systems and their environmental effects. The possibility of scenario calculations allows the validation of optimisation strategies.

Introduction

Agricultural enterprises in the Federal Republic of Germany and the EU are confronted with increasing demands for documentation of environmental and quality assurance. This involves also farms under organic management. Researchers are challenged to develop suitable tools in cooperation with farmers and consulting services. The available methods and model software are preferably targeted at conventional farming and take only insufficient account of the conditions in organic farming. Therefore, their applicability is limited, and in single cases misinterpretations may occur. This paper attempts

- to describe a system for environmental management which is suitable for organic farming (model structure and elements, scientific fundamentals) and to elucidate its special features vis-à-vis other programs,
- to identify relationships between the design of farming systems and environmental effects on the example of program results,
- to show fields for using the management system in practice,
- to outline the further development of the tool.

Methodology

Efforts towards the definition of environmental indicators and their integration into software tools are being made all over the world (e.g. Bockstaller et al. 1997, Lewis & Bardon 1998, Sands & Podmore 2000). Recent approaches differ in considered system level (cropping, livestock keeping, farm level, landscape), fields of application (administration, marketing, optimization), the degree of complexity, choice of indicators, analytical methods, definition of limits and the aggregation of indicators.

The model software REPRO **(Repro**duction of Soil Fertility, Hülsbergen 2003) considers the farm enterprise as a system. Indicators are not considered as isolated criteria but in their mutual relationship. The program approach allows for scenario calculations. On the basis of mass and energy fluxes, interactions between subsystems are examined (crop and animal production, arable land and grassland...). The software respects the complex character of farming systems. Great importance has been attributed to the consideration of actual farms in their complexity rather than on an exact covering of all details. This objective requires to survey natural site conditions, farm structure and design of production processes with just adequate accuracy – thus a „virtual farm" is generated.

The REPRO program has a modular design and includes:

- databases for handling site and management information,
- balancing methods for disclosing mass and energy fluxes on farm level,

- links to simulation models (simulation of soil processes),
- interfaces to geographic information systems,
- evaluation tools (indicators, normalization and spin diagram techniques).

By use of DELPHI Professional, a PC version for WINDOWS 95/98/2000/NT/XP has been generated. The modular structure of REPRO allows its adaptation and extension to different target areas. Among others, the following agro-environmental sectors can now be analyzed: mass cycles (C, N, P, K) in the system soil – plant – animal – soil (Hülsbergen 2003), energy efficiency (Hülsbergen et al. 2001, 2002), humus budget (Leithold et al. 1997), erosion, soil structure/hazardous soil compaction. The basic data for the model were collected in long-term field experiments (Hülsbergen & Biermann 1997). The model has been validated both in field experiments and experimental farms (Hülsbergen & Diepenbrock 2001).

On the example of the Experimental Farm Scheyern located in the Tertiary Hills of Southern Germany (490 m a.s.l., mean annual temperature: 7.5 °C, mean annual precipitation: 833 mm; see Auerswald et al. 2000) it is demonstrated what results the model program can provide for N cycle and N management in farms. The N fluxes are closely related to the C fluxes, as has been described in the paper by Küstermann & Hülsbergen (2005). In order to bring the results of the investigations in Scheyern into the right context, a farm comparison is made on the basis of agro-environmental indicators.

Results and brief discussion

The structure of the farm in Scheyern (legume-based crop rotation: grass-clover mix – potatoes – winter wheat – sunflower – grass-clover mix – winter wheat – winter rye; catch crops on > 40 % of the arable land; stocking density: 1.4 LU ha^{-1}) and the high intensity and production level (dry matter yield: 7 to 8 t ha^{-1} a^{-1}) are reflected in an intensive N cycle (Fig. 1). Remarkable is the high N input with feedstuffs. They were produced on neighbouring fields under organic management. There is no purchase of conventional feed. With regard to the measured omissions (16 kg N ha^{-1} a^{-1}) and the recorded changes in soil-borne N owing to humus accumulation, the N surplus (= total of all N inputs into the soil and N removal by plants) amounts to 31 kg ha^{-1} a^{-1}.

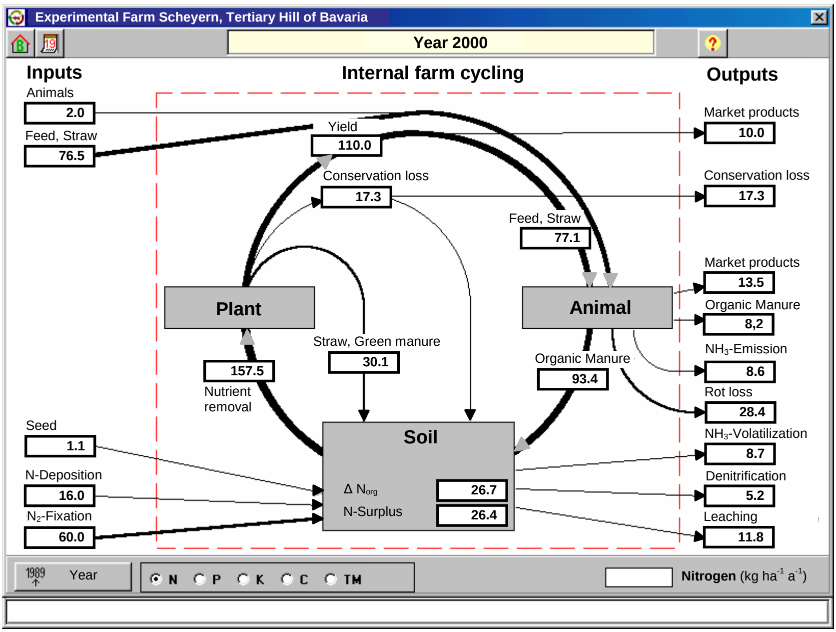

Fig. 1: REPRO screen shot: N cycle in the Experimental Farm Scheyern

This soil related N surplus characterizes the overall loss potential of reactive N compounds. The model allows to show the different loss paths. Nitrogen leaching reach 4 to 20 kg N ha-1 a-1, which corresponds to potential nitrate concentrations of 6 to 40 mg NO3- l-1 below the root zone in case of annual percolation of up to 470 mm a-1. The N losses entered into the model calculations dependent of local conditions corresponded well with the measured values (Matthes et al. 2001). The N accumulation in humus estimated by use of the model program has been confirmed in long-term samplings on a large number of grid points (Gutser & Reents 2001). The program approach allows to disclose, beside the described farm specific N cycles, also the spatial variability, for example subfield related N loss potentials. REPRO allows various partial aspects of the N budget to be integrated into an overall assessment. Scenario calculations make it possible to quantify the effect of modified farm structures and cropping technologies and to optimize farming systems.

In the Federal Republic of Germany, the model software has been used under differentiated site conditions in more than 200 agricultural enterprises of different structure, management intensity and design of production processes. Thus, a data pool has been generated that can be used also for inter-farm comparisons (Fig. 2).

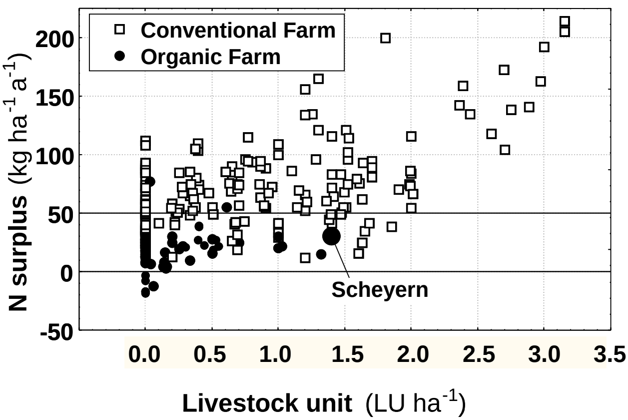

Fig. 2: Relationship between livestock unit and N surplus, n = 233 farms

In general, it can be estimated that in organic farming N losses are lower than in conventional systems. Farm-specific differences, however, may be considerable (see Fig. 2). The results obtained in the Experimental Farm Scheyern demonstrate that in organic farming the N surplus can be clearly limited to < 50 kg N ha^{-1} a^{-1}, even under intensive management and high livestock density (1.4 LSU ha^{-1} = admitted maximum acc. to the guidelines for growers associations). This requires optimal N management in a multicrop rotation with comprehensive catch crop growing.

Conclusion

REPRO represents a practice-oriented software program for analyzing, rating and optimizing farming systems and their environmental impact. The optimization of farming systems places high demands on software designers due to numerous interrelationships between technological and biological processes.

Since it is nearly impossible to assess the environmental effects of <u>all</u> agricultural activities, the approach used by REPRO emanates from the simplistic assumption that all environmental effects and ecological sustainability are dominated by the mass and energy regime as well as by the factors working on it (mainly site conditions, farm structure, input of operating resources and process design). Farm internal matter cycles play a key role in the functioning of agro-ecosystems (Edwards et al. 1993).

The model software has not only been used in scientific research but increasingly also in practical farming and consulting, so far preferably in ecologically sensitive areas (drinking water catchment zones, biosphere reserves). It is intended to closer adapt the program to the needs of practical farmers and to reduce the time for the software handling without impairing the results. Evaluations in graphic form as integrated into the software (for example the N cycle, Fig. 1) support the applicability of the software in farm consulting.

Currently it is checked whether the farm-related environmental management system REPRO can be coupled with product-related systems of quality management, because most agricultural processes are both environment and quality-related and require nearly identical management and process information. In the development stage are the modules “Nature Protection/Biodiversity” and “Emission Inventory” (see Küstermann & Hülsbergen 2005).

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ENERGY EFFICIENCY OF SELECTED ORGANIC FARMS AND THEIR INFLUENCE ON GREENHOUSE GASES EMISSION

Jarosław Stalenga, Jan Kuś, Andrzej Madej

Institute of Soil Science and Plant Cultivation (IUNG), Osada Pałacowa, 24-100, Puławy, Poland, tel.+48 81 8863421 ext.291, E-mail: stalenga@iung.pulawy.pl

Key Words: energy efficiency, greenhouse gases, methane, nitrous oxide

Abstract

Energy efficiency and greenhouse gas (methane and nitrous oxide) emissions were investigated in 2003 on 20 organic farms in the central part of Poland (Kujawsko-pomorskie voivodeship) using a questionnaire developed in the Institute of Soil Science and Plant Cultivation in Pulawy (Poland). Statistical data from the Central Statistical Office concerning the agriculture in the Kujawsko-pomorskie voivodeship was also used. A simple index (Ee) defined as a ratio of the total energy value of agricultural production (Pe) to the material and energy inputs (Ne) (in MJ) was used to evaluate the energy efficiency. The average value of this index was 2.05; however, it ranged from 0.04 to 16.59. In the organic farms, direct energy carriers (liquid and solid fuels and electric energy) contributed most (about 45%) to total energy inputs. Plant products had the biggest share in total energy value of the yields (81.7%), of which cereals were the most important component (56.4%). Animal products had only an 18.3% share, dominated by meat. Average methane emission per ha of agricultural land (AL) was 36 kg per year, 8 kg more than the average value for the whole voivodeship. This was mainly due to the higher cattle density on organic farms. Emission of N_2O from the organic farms was about half the average of others in the voivodeship. In the group of 20 organic farms, total methane and nitrous oxide emission expressed in units of Global Warming Potentials (GWP) was 985 and was 45 units less than the average for the Kujawsko-pomorskie voivodeship.

Introduction

Sustainability is a major objective of organic production, and energy efficiency and greenhouse gas emissions are important aspects of sustainable production. However, these aspects of sustainability are rarely reported for organic farms. This paper reports an evaluation of greenhouse gases emission (CH_2, N_2O) and energy efficiency of 20 organic farms located in the Kujawsko-pomorskie voivodeship (central part of Poland) and compared with average values for this voivodeship.

Methodology

The research was conducted in 2003 on 20 organic farms located close together in the central part of Poland (Kujawsko-pomorskie voivodeship). A questionnaire developed by the Department of Systems and Economics of Crop Production of the IUNG (Pulawy, Poland) was used for this purpose. Statistical data from the Central Statistical Office concerning the agriculture in the Kujawsko-pomorskie voivodeship was also used (Wybrane elementy et al. 2004).

A simple index was used to evaluate energy efficiency of agricultural production in the organic farms (Anuszewski 1987). This index (Ee) is defined as a ratio of the total energy value of agricultural production (Pe) to the material and energy inputs (Ne) (expressed in Mega Jules):

$$Ee = \frac{Pe \text{ - energy value of agricultural production}}{Ne \text{ - material and energy inputs}}$$

Four different streams of energy inputs were distinguished:

En - direct energy carriers (liquid, solid fuels and electric energy);

Em - raw materials (fertilizers, chemical crop protection products, fodder and livestock material);

Eu - depreciation of machines and buildings (tractors, agricultural buildings, etc.);

Ez - live labour (energy value of human work and horses).

The value (in MJ) of all purchased and fodder were taken into account in the calculations, whereas fodder produced on-farm, and other farm by-products (e.g. straw), were not included. Depreciation of tractors and self-acting machines only was determined (no data regarding annual depreciation of other machines and area occupied by animals in the agricultural buildings). In the case of labour inputs, only permanent and temporary work was taken into account. Both sold products (market production) and products used for self-supply were used to calculate the energy value of the products, using tables of chemical composition and nutritional value of different kinds of fodder (Ziołecka *et al.* (1985).

Emission of two greenhouse gases (methane and nitrous oxide) was evaluated in the research. Both processes of enteric fermentation from farm animals and manure management were taken into account in assessment of methane emission. The following values of methane emission from enteric fermentation for particular farm animals (kg/unit/year) were assumed: horses, 18; cows, 81; other cattle, 56; and pigs, 1.5 (Revised IPCC Guidelines 1996). Manure production was the main source of data to calculate methane emission from manure management. The following sources of N_2O emission were taken into account: manure management, N-fixing crops and synthetic fertilisers (for conventional farms). It was assumed that 1.15% of N_2O losses in relation to total N content in manure occurred during manure management, and that 1% of symbiotically-fixed N is denitrified to N_2O (Nalborczyk *et al.* 1997). Emissions of methane and N_2O were expressed in CO_2 equivalents using appropriate values of Global Warming Potentials (GWP), for methane: 21 and for nitrous oxide: 310 (Revised IPCC Guidelines 1996).

Results and discussion

Energy efficiency of agricultural production

In the organic farms, the average value of the index of energy efficiency was 2.05; however, it ranged from 0.04 (producing only for their own needs, where agricultural activity was not the main source of income) to 16.59 (market farms which sold their own fodder) (Table 1). Total energy inputs per ha of AL in a farm averaged 8,560 MJ, whereas value of own agricultural production was 18,640 MJ per ha of AL.

When the structure of energy streams is considered, it should be emphasized that 45% of total energy inputs were covered by direct energy carriers (liquid and solid fuels and electric energy). Agricultural production means used in the farms were the next important stream, covering 23.7% of all energy inputs. Within this category, seed material (cereals, potato and vegetable) and purchased animals were the most important elements. Because all of the farms analysed were organic, synthetic fertilizers, chemical plant protection products and veterinary medicines were not utilized. The next two streams, Eu (depreciation of machines and buildings) and Ez (energy value of human work and horses), covered 14.7 and 16.7%, respectively. Within the streams, Em and Ez were the most variable (82 and 74%, respectively). This shows that the farms studied were differentiated in relation to the level of consumption of agricultural production means and labour force coming from a non-agricultural sector.

In traditional (conventional) agriculture, the Em stream (synthetic fertilizers, chemical crop protection products, fodder and livestock material) usually dominates. Within this stream, synthetic fertilizers accounts for more than 50% of total energy inputs (Keller *et al.* 1997).

It should be noted that plant products had the biggest share in total energy value of the yields (81.7%), of which cereals were the most important component (56.4%), whereas animal products had only an 18.3% share, of which meat had a dominant position.

Greenhouse gases emission

Agriculture, like other human activities, is a source of emission of greenhouse gases; mainly CO_2, CH_4, N_2O. The rate of emission increases year by year as a result of increase of total crop and animal production all over the world. Nalborczyk et al. (1996, 1997) showed that the level of emission of particular greenhouse gases significantly depends on the type of a farm and system of farming.

Table 1. The most important parameters describing energy efficiency of agricultural production (per ha of AL) in 20 organic farms in 2003

Specification	**Average for the group**	**Variability coefficient (%)**
Index of energy efficiency	2.05	168
Energy inputs in MJ per of AL	8 560	86
Energy value of products in MJ per of AL	18 640	73
Share of streams (in %):		
- stream I (En)	45.1	36
- stream II (Em)	23.7	82
- stream III (Eu)	14.5	35
- stream IV (Ez)	16.7	74
Share of value of own products (in %):		
Value (in MJ) of animal products:	18.3	
- milk	6.4	
- meat	11.5	
- eggs and other products	0.3	
- manure	0.1	
Value (in MJ) of crop products:	81.7	
- cereals	56.4	
- potato	5.2	
- vegetable	9.4	
- other products	10.7	

Methane emission

Agriculture has about 25% share in total methane emission. Emission from process of enteric fermentation of farm animals is the most important element within this category (92 %). Emission from manure management is an additional source of this gas.

In the group of 20 organic farms investigated, average methane emission was about 36 kg/ha of AL per year, which was 8 kg more than the average value in the Kujawsko-pomorskie voivodeship (Table 2). The higher emission appeared to be due mainly to the higher cattle density on organic farms, although animal density expressed in Large Units did not differ from values for the whole voivodeship.

Table 2. Methane emission: pure and as a equivalent of CO_2, in kg/ha in 20 organic farms and average in the Kujawsko-pomorskie voivodeship in 2003

Specification	Average for 20 organic farms		Average in the Kujawsko-pomorskie voivodeship	
	Expressed in CH_4	Expressed in CO_2 eq.	Expressed in CH_4	Expressed in CO_2 eq.
Enteric fermentation	36	756	28	588
Manure management	1.5	31	1	21
Total	37.5	787	29	609

Emission of nitrous oxide

Emission of N_2O from the 20 organic farms investigated was about half the average for the voivodeship, and amounted to 0.64 kg/ha of AL per year (Table 3). This was because organic farms do not apply any nitrogen synthetic fertilizers, and such substances bear the highest degree of responsibility for emission of this greenhouse gas. It should also be mentioned that, due to a significant share of leguminous crops, organic farms were characterized by 8 times higher level of N_2O emission within this category than average in the voivodeship.

In the group of 20 organic farms investigated, total methane and N_2O emissions expressed in units of Global Warming Potentials (GWP) amounted to 985, and was 45 units less than the average for the Kujawsko-pomorskie voivodeship.

Table 3. Emission of nitrogen monoxide: pure and as a equivalent of CO_2, in kg/ha of AL in the investigated organic farms and average in the Kujawsko-pomorskie voivodeship in 2003

Specification	Average for 20 organic farms		Average in the kujawsko-pomorskie voivodeship	
	Expressed in N2O	Expressed in CO2 eq.	Expressed in N2O	Expressed in CO2 eq.
Synthetic fertilisers	0	0	0.98	304
Manure management	0.39	121	0.35	108
N-fixing crops	0.25	77	0.03	9
Total	0.64	198	1.36	421

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NEW WAYS OF INCREASING BIODIVERSITY ON ORGANIC FARMS AND THEIR EFFECTS ON PROFITABILITY: THE NATURE CONSERVATION FARM BRODOWIN

Karin Stein-Bachinger (1), Peter Zander (2), Heike Schobert (2), Helmut Frielinghaus (3)

(1) Nature Conservation Farm Brodowin, c/o ZALF e.V., Eberswalder Str. 84, 15374 Müncheberg, Germany, 0049-33432-82346, kstein@zalf.de, www.naturschutzhof.de
(2) ZALF e.V., Eberswalder Str. 84, 15374 Müncheberg, Germany, pzander@zalf.de
(3) Ökodorf Brodowin, Dorfstr. 15, 16230 Brodowin, Germany, feldbau@brodowin.de

Key Words: Organic farming, nature conservation, landscape, target species, crop production, economic analysis

Abstract

Although organic farming systems have many positive biotic aspects, the protection of target species characteristic of open landscape is not guaranteed. Specific knowledge and financial incentives are necessary in order to integrate nature conservation goals successfully into agricultural practice. The main objectives of the interdisciplinary 'Nature Conservation Farm Brodowin' project are: the investigation of the interactions between large-scale organic farming and nature conservation; the identification of points of conflict; and the working out of solutions that pay sufficient attention to economic aspects. Legume-grass forage is important for typical species of farmland wildlife. Alternative methods of fodder production which better meet nature conservation demands are evaluated economically. Initial calculations of the compensation payments required to offset the losses of a higher first cut range between 120 and 180 Euro/ha. A delayed second cut would cost on average twice as much. The losses and additional operational expenses incurred by retaining 10 % unmown strips are approximately 90 to 140 Euro/ha. The use of special silage harvesting techniques can also help to improve the living conditions of farmland birds without resulting in disadvantages for the farmer.

Introduction/Problem

Over the past 30 years there has been a significant decline in the population of species typical of the once rich fauna and flora of open habitats such as arable fields (SRU 2003, NABU 2004). As organic farming systems take a more ecological approach, reflecting the multifunctional nature of agriculture, they contribute significantly to environmental protection (SRU 2003, Hole *et al.* 2005). The extension of organic agriculture is therefore recommended by policy makers. However, nearly all of the documented advantages of organic agriculture are based on comparisons between conventional and organic farming systems. There is still comparatively little research dealing directly with the possibilities and potential for improving nature conservation within the organic farming system itself.

Generally speaking, changing economic conditions are increasing the pressure on organic farming. This is leading to an intensification of production procedures wherein the protection of nature and natural species is taking a back seat. From the farmer´s perspective, the most important limiting factors for the integration of nature conservation into the farm organisation are time, money, and manpower. Furthermore there is a lack of specialist knowledge on the implementation of nature conservation measures in plant production procedures (Heyland 1996) and their economic consequences.

The 'Nature Conservation Farm Brodowin' project (Grimm et al. 2004), financed by the German Federal Agency for Nature Conservation (BfN), focuses on these issues. The purpose of the first 'Nature Conservation Farm' model is to address deficits in organic farming and landscape conservation whilst reducing points of conflict between ecological and agricultural goals. The focus is on improving the living and reproductive conditions of typical farmland species (farmland and hedgerow birds, amphibians, insects, mammals and segetal flora) in large-scale organic agriculture. The impact of modified farming procedures on target species and simultaneously on plant production (yield and quality) and economic parameters (cost benefit analysis) is examined. Conflicts between the long term conservation of species and short term constraints on economic production have to be ascertained. Compromises between the demands of nature conservation and the fundamental principles of organic farming have to be worked out within the context of the whole farm organisation. Future European Union agricultural environmental programmes envisage real ecological improvements being used to claim compensation payments.

Methodology

The main project partner is the Demeter farm 'Ökodorf Brodowin GmbH and Co. KG' with 1240 ha of farmland, about 270 dairy cows and 250 young cattle. It is located in the Schorfheide-Chorin biosphere reserve in Brandenburg, 60 km northeast of Berlin. The soils are of diluvial origin with a very high small-scale heterogeneity. The predominant soil texture of the arable fields ranges from sandy to loamy. Soil rating indexes[1] range from 18 to 58 (average value 33). Mean annual precipitation amounts to 540 mm. The farm makes large parts of its agricultural land available for project investigations. Consequently, the results are obtained under real working and market conditions. The responsible body is the Ökodorf Brodowin e.V. (registered association).

The effects of nature conservation oriented field operations, such as the reduction of tillage measures, changes in mowing systems during the main reproductive season, and the implementation of structural measures are investigated at the level of the entire field, depending on the habitat requirements of the target species (e.g. breeding time of farmland birds). The effects of modified field operations on yield and product quality, subject to soil quality, are examined in large-scale on-farm experiments (Stein-Bachinger et al. 2000). Plots were placed in pairs comparable in terms of soil parameters, topography and coverage. Yield measurements performed by the farmer were taken into account. The economic analysis will be performed using a farming system approach based on linear programming techniques (Zander 2003). Restrictions with respect to nature conservation objectives, as well as restrictions at the farm and field levels (i.e. fodder production, weed control) are included. Based on a partial analysis of the ecological and economic evaluation, a comparison is made of standard and conservation oriented agricultural methods concerning yield and product quality, gross margins and e.g. reproductive success. Here, we present the results on modified farming procedures in legume-grass forage production, including a full consideration of the agricultural and economic parameters.

Results and discussion

The investigations confirm a clear preference by farmland birds and hares for forage fields (Stein-Bachinger & Fuchs 2004). Legume-grass forage, which holds a share of up to 30 % of the rotation, plays a crucial role, especially for the dairy farm. The necessity of mowing to produce high quality fodder means that these fields can become an 'ecological trap'. On the one hand, numerous species (farmland birds, hares and amphibians) are attracted and high density levels of individuals are reached, on the other hand, the successful reproduction of these animals is inhibited by routine farming operations. Beneficial effects on reproductive success can be obtained by increasing the cutting height, delaying cutting, using special harvesting techniques, and including structural features, such as unmown strips.

The increase in height of the first cut has two positive effects on nature conservation: (i) less damage is inflicted on bird broods, and (ii) the greater height of the vegetation could lead to a quicker reestablishment of broods. Hence, delaying the second cut would not be necessary. Table 1 shows the opportunity costs required to compensate for the yield losses of a higher first cut. The basis of these calculations is the measured energy-yield loss (related to the annual yield) between normal (about 7 cm) and higher (about 14 cm) first cuts conducted in two field experiments in 2002, with soil rating indexes between 35 and 40. Two different types of fodder production are chosen. In model 1 we assume that the yield losses will be compensated by additional fodder from external sources. The relative purchase rates range between 145 and 181 Euro/ha. In model 2 we postulate that the yield losses will be compensated by internal fodder production. This is achieved by reducing the production of cash crops. The calculation of the gross margin is based on a six-field crop rotation corresponding to the farmers´ current practice. The opportunity costs in model 2, which is more typical in organic agriculture, vary from 117 to 156 Euro/ha.

Table 1: Costs of a higher first cut (incl. subsidies), SRI = Soil Rating Index1), three cuts per year: 2) silage/silage/hay, 3) silage/hay/hay, 4)NEL = Netto-energy-lactation

	Field 1 (SRI[1)] 40)		Field 2 (SRI 35)		
	SSH [2)]	SHH [3)]	SSH	SHH	
Model 1: Relative purchase rate					
Energy-yield losses	4,10	4,41	3,50	3,49	GJ NEL [4)]/ha
Purchase rate	40,00	40,00	40,00	40,00	Euro/GJ NEL
Purchase for compensation of yield losses	164,00	176,36	139,83	139,71	Euro/ha
Difference in production costs	-8,34	-5,34	-5,29	-4,29	Euro/ha
Management costs (coarsely assessed)	10,00	10,00	10,00	10,00	Euro/ha
Relative purchase rate	165,66	181,02	144,54	145,42	Euro/ha
Model 2: Internal production					
Energy-yield losses	4,10	4,41	3,50	3,49	GJ NEL/ha
Difference in production costs	-8,34	-5,34	-5,29	-4,29	Euro/ha
Internal transfer price	14,11	17,98	15,14	19,79	Euro/GJ NEL
Farm costs of internal production	57,84	79,28	52,94	69,11	Euro/ha
Management costs (coarsely assessed)	10,00	10,00	10,00	10,00	Euro/ha
Required area to compensate yield losses	0,09	0,11	0,09	0,10	ha
Gross margin II of a standard crop rotation	657,00	657,00	657,00	657,00	Euro/ha crop rotation
Loss of use for not producing the standard crop rotation	61,77	72,22	59,43	65,69	Euro/ha internal production
Opportunity costs	121,27	156,16	117,08	140,51	Euro/ha

One scientifically proven method which guarantees a sufficient reproductive success of ground-breeding birds is a minimum interval of seven weeks between the first and second cuts. The huge decline in fodder quality associated with this delay, especially its energy content (Stein-Bachinger & Fuchs 2004) results in a great reduction in the amount of fodder suitable for dairy cows. As with the higher first cut, either the farmer compensates the losses with internal fodder production on other fields or with additional fodder from outside. A new amendment to the standards of organic farming, only permits organically grown fodder. Large reductions in fodder production for nature conservation reasons consequently result in high compensation payments (on average twice as high as losses incurred by a higher first cut).Another option for improving the living conditions of farmland bird species is the retention of unmown strips (about 10% of the whole field). These strips provide potential nesting and foraging habitats, song and rest sites, as well as a refuge from agricultural operations and predators during and after the cut. At the first cut, strips with a width of e.g. 9m every 100m (depending on the available machinery) are not harvested. 10% of the field unmown means a total loss of this fodder as well as the necessity for extra mulching in autumn or spring. These losses, plus the additional operational expenses based on site conditions similar to fields 1 and 2 in table 1, amount to about 90-140 Euro/ha. Considering the possibilities of meeting the nature conservation requirements of the target species described above, a delayed second cut does assist the successful reproduction of ground-breeding birds, but it causes a severe reduction in fodder for the farm. As an alternative, the increase of the cutting level at the first cut would minimise the economic losses and better allow the fodder requirements of a dairy farm to be met. The results also show that the fodder quality of a higher cut is slightly better due to a lower proportion of stems. Further positive effects, especially on hatching success, can be achieved by using silage harvesting methods rather than making hay (Stein-Bachinger & Fuchs 2004). But it should be remembered that the farmer is required by Demeter standards to produce a sufficient amount of hay as a fodder basis for the cows.

[1] The soil rating index (SRI) indicates the soil quality through the so-called ‘Ackerzahl’, a dimensionless parameter that ranges between 7 and 100, mainly based on different soil types and soil texture. The SRI was assigned to every acre in Germany during an assessment campaign, the ‘Bodenschätzung’, which began in the 1930s, aimed at assessing the yield capacity for fiscal and leasehold issues. The SRI is the only nationwide soil data available at field level.

The method of leaving unmown strips may be modified so that the strips from the first cut are harvested with the second cut and new strips simultaneously left uncut. A further positive effect for nature conservation is e.g. that the availability of flowering plants for insects is better maintained throughout the whole year. Different ways of integrating unmown strips into farming operations are: either mixing the produce from the strips with the following cut, where it would lead to a deterioration in fodder quality, or harvesting it separately in autumn for seeds, which can be profitable for the farmer. Further analysis will start with a balanced view of the whole farm organisation, site conditions and the habitat demands of the target species. It will investigate which and how many fields should be managed using nature conservation oriented production procedures. Work continues to determine which combinations or modifications of cutting regimes will ensure the productivity and health of the dairy cows and at the same time suit the farmers' economic situation. By testing various scenarios and trade-offs between production and conservation, compromises can be worked out. Within the framework of the optimisation of the whole farm, cost-efficient solutions will be elaborated which fulfil nature conservation objectives and economic requirements simultaneously.

Conclusions

Legume-grass forage offers a high potential for the protection of typical farmland wildlife species where modified production methods are used. However, the examples show that it is hardly possible to implement measures which assist individual species or fulfil the specific requirements of nature conservation without certain financial losses to the farmer. The acceptance of the integration of nature conservation goals into agricultural practice will increase if the farmer can be provided with the means to assess the consequences of each measure. In addition, a co-operation between farmers, consultants, consumers, scientists, and policy makers is necessary in order to promote understanding and emphasise the value of conservation of biological diversity. In addition to financial incentives, close dialogue is necessary to avoid and eliminate misunderstandings and to inform all those concerned of each others needs and wishes. The 'Nature Conservation Farm' serves as a good model of how to meet these challenges.

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PRACTICAL APPROACHES ON ORGANIC FARMS IN GERMANY TO INTEGRATE AIMS AND OBJECTIVES OF NATURE CONSERVATION AND LANDSCAPE DEVELOPMENT

Thomas van Elsen

Research Institute of Organic Agriculture (FiBL), Standort Witzenhausen, Nordbahnhofstr. 1a, D-37213 Witzenhausen, Germany , +49 5542 981655, Thomas.vanElsen@fibl.org, www.fibl.org

Key Words: Organic Farming, Nature Conservation, Landscape Development, Advisory service

Abstract

The conversion to organic farming already means a contribution to nature conservation and landscape development. In a case study 16 organic farms in Germany were investigated whose farmers try to integrate such goals actively by certain measures into their farming system. The contribution of these farms to diverse landscapes is obvious. The motives of the farmers are strongly based upon intrinsic values. However, organic farming also shows a tendency towards intensification. Support is needed, not only with financial tools. The approach of a special advisory service at farm level can help to optimize the impact of organic farms upon the environment.

Introduction/Problem

The appearance of "cultural" (rural) landscapes in Middle Europe is influenced in a strong way by the farming of the land – ca. 50% of Germany's land is farmed and including forestry more than 80%. Less than 3% of people work on the farms but they create the landscape for all others. Landscape is a production area for farmers. But landscape is also a place for living, working, home, experience, recreation, moving through and making connections.

In former times cultural landscapes were a by-product of agriculture with lots of handwork, whereas today a diverse and aesthetic landscape is preserved and developed only by active decisions and means. Also on organic farms cultural landscapes do not appear automatically as by-products of organic farming methods.

The conversion to organic farming already means a contribution to nature conservation (Weiger & Willer 1997; van Mansvelt et al. 1998; Soil Association 2000). However, organic farming also shows a tendency towards intensification and specialisation which reduces the positive effects of organic farming on nature. Within a project "Optimising nature conservation on organic farms" (supported by the German Federal Agency for Nature Conservation with funds of the Federal Environmental Ministry) 16 farms which implement approaches to nature conservation into their practice were investigated (van Elsen et al. 2003). In addition to a survey and evaluation of different measures that had been established on the farms, the motives of these farmers to deal with questions of nature conservation and landscape development, and – furthermore – to create and develop their landscape actively, were investigated. Which circumstances allow such initiatives? What are the motives behind them? The following hypotheses were the starting point of the investigation:

- There are organic farms that are exceptional among organic farms concerning their engagement in nature conservation and landscape development.
- The motives that lead to actions are different.
- There are different ways of acting and different systems of knowledge applied in order to find ideas and realise means of landscape development.

Methodology

The biotopes and hedgerows on the farms were mapped, phytosociological investigations on arable fields and grasslands were carried out and the historical development of structure elements in the areas were investigated using common methods of landscape ecology. To explore the farmers' motives, due to the lack of previous investigations, an explorative approach was chosen. In different regions of Germany 13 interviews were carried out on organic farms belonging to different certifying organisations. A wide spectrum of farms with respect to size, geographical site, structure, social structure and assumed intentions of the farmers were chosen. The interviews were elaborated using methods of qualitative social analysis (Mayring 1988, Strauß & Corbin 1996).

Furthermore approaches of advisory services especially for organic farms that want to improve their impact on nature and landscape were investigated by evaluating a two years period of the work carried out by the advisory service of the "competence centre for organic farming" in Lower Saxony.

Farmers optimising nature conservation on organic farms – results

All the farms that were investigated try to integrate the conservation and development of the rural landscape and biodiversity into their way of farming. The reconstruction of the history of the landscape structure shows the tendency towards bigger production units also on the organic farms, but that the farmers try to divide their fields by using structure elements. The planting of hedges is the most frequent measure so far. The investigations of biotopes and plant communities of grasslands, arable fields and hedgerows prove the positive impact of the farming system on biodiversity.

The interviews with the farmers show that their motives are exceptionally intrinsic in nature. Especially the relation to nature is very important. Two types can be selected, one of an "intimacy" relation to nature which is characterized by a close connection to nature and landscape including feelings and the ability of "living within". The other type is characterized by a "more distant" relationship to nature. With respect to the reasons for acting again two types can be found: On the one hand the protection of endangered plant and animal species and biotopes, and on the other hand a phenomenological approach with a strong connection and reflection of individual experiences. Such farmers have more of the whole farm in their mind. The different measures implemented on the farms are more uniform than the approaches of the farms.

It becomes obvious that so far there is very little support for the farmers by agro-environmental schemes for advice in nature conservation topics. A need for a participatory landscape development concept is apparent, taking the knowledge of the farmers seriously into account. Despite many examples of farmers contributing to landscape and nature conservation, due to the growing support for conversion more and more farmers decide to convert mostly for economical than rather idealistic reasons. Will it be possible to combine the quantitative growth of organic farming with the aim to preserve and even increase biodiversity by organic farming?

Modern landscape development on organic farms needs:

- a participatory approach (bottom up instead of top down planning),

- a qualified advisory service for farmers who are willing to improve their impact on biodiversity,

- support for farmers by better agri-environmental schemes which help farmers to realise locally adapted concepts,

- better education at agricultural schools and universities.

There is a growing demand to improve the guidelines of organic farming and to integrate the task of nature development and the "production of biodiversity" into the regulations. But a better landscape is not produced by better regulations but by farmers who are willing to improve their land, who are convinced of this task and who change their attitude towards nature. This needs advice and education; it needs a participatory approach and cooperation between landscape planners, farmers and experts from the nature conservation movement.

Advice for farmers to improve landscape development by organic farming

In order to help and to support farmers at the "Competence Centre for Organic Farming" in Lower Saxony an advisory service for organic farms was implemented in November 2001 after a test-period of four months. The intention of this offer is to support farmers with an on-farm-advice service to put more means of nature protection into practice (Keufer & van Elsen 2002). The advice for single farms takes place on the farms. The advisory service is an "all-round service" including the following that are often more than only advisory talks (figure1):

- Development of ideas and practical actions that can be implemented on the farm.
- Practical realisation of these.
- Advice for financial support activities.
- Communication-support if there are problems with nature-conservationists.
- Organizing actions together with nature-conservationists and other groups.

Farmers' request by telephone call

▼ ▼

Discussing the request and looking for an appointment for a farm visit

The questions can be answered on the telephone or with written tools – possibly by using the advisory service for brochure material and information

▼ ▼

Getting specific information to prepare the farm visit
i.e. contacting official institutions and local stakeholders in the region where the farm is situated.

▼

Meeting and advisory talk on the farm

- Visiting the relevant places and biotopes on the farmland
- Specific advice
- Advice concerning financial support
- Participatory creating ideas
- etc.

▼ ▼

Result:
The organic farmer wants to implement certain measures and to improve nature conservation

Result:
Advisory talk without resulting in concrete measures

▼ ▼

List of open questions and tasks for the advisory service

No further dates

▼ ▼

Organisation of further meetings on the farm to clarify open questions, with participation of authorities, hunters, nature conservationists, local stakeholders etc.

Clarifying open questions resp. fulfilling the tasks and give feedback to the farmer
i.e. – elaboration of a landscape plan for the farm
– elaboration of plant lists

▼ ▼

Organising the realisation of a concrete idea, i.e.

- contacting groups that help to realise measures
- Writing applications, apply for support money

▼ ▼

Realisation of nature conservation measures
In greater projects the advisory service participates in the implementation of measures on the farms

Informing the newspapers and other media
During of after a concrete action

- Writing articles for newspapers
- Organisation of meetings with journalists

i.e. supporting meetings with journalists on the farm

Figure 1: Scheme of a nature conservation advice

The advisory service is based upon the needs and the interests of the farmers. They are supported in realizing their own ideas and to optimise approaches under the aspect of nature conservation. Many farmers have taken advice and a lot of measures by taking the ideas of the farmers as a starting point.have been implemented successfully. The first visit of the advisor is free for the farmer; for the next steps individual contracts are made. The interest shows the good will of farmers to integrate aims of nature conservation. On the other hand qualified support is needed to find the right means for each farm and for the special landscape concerned. It helps a lot that the advisory service in Lower Saxony is linked to an agricultural advisory institution. The service is a model being unique in Germany that supports the development of organic farming towards a farming system that also develops nature. Besides implementing such advisory services all over the country it is needed to improve its concept, especially by developing model farms by using participatory concepts to develop nature and landscapes on farm level as good examples. To support these aims and to build up a network for nature conservation advisory services at farm level, a new project has started in Germany at the FiBL.

To conclude: Organic farms have a high potential to integrate goals of nature conservation and to develop the rural landscapes by active measures. To increase the intrinsic will of the farmers not only financial support but also more advice at farm level is needed. In Lower Saxony such an advisory system has worked quite successfully for three years now. Supporting the growing demand of such advisory services could also support organic farming systems in their quality of being estimated as nature friendly and as a contribution to active development of cultural landscapes. The integration of nature preservation is not only a question of natural or environmental sciences, but a social question, how people with different professions and backgrounds can work together: the farmers with their unique experience managing the land, the environmentalists and biologists who know the species, and customers and friends of the farm who give practical help to support the farmer to improve the landscape. Landscape development can become an added value of multifunctional farming, being the starting point of a new culture of the European landscape.

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RESEARCH STUCTURES AND METHODS

TRENDS IN ORGANIC FARMING RESEARCH IN THE NETHERLANDS

Blom-Zandstra, M.

Innovation Centre Organic Agriculture (IBL), Wageningen University & Research Centre, P.O. Box 9101, 6700 HB Wageningen, the Netherlands, E-mail: greet.blom@wur.nl

Introduction

The cultivated area of organic farming in the Netherlands is still low (i.e. 2,2%) compared to the European average. Therefore, the Ministry of Agriculture, Nature and Food Quality promotes the development of market oriented organic production aiming at the ambition that 10 % of the total area cultivated will be organic by 2010. Research on organic production is considered to be one instruments to achieve these objectives. In the next decades urbanization in the Netherlands will probably increase resulting in the development of both small-scale, region-oriented farming on one hand and large scale, global market oriented farming on the other hand. This perspective requires a strategic vision on the transition to a production system that is more integrated in social life, well equipped to follow global trade and is sustainable in the sense of *People*, *Planet* and *Profit*. At the same time this production system has to face increasing global warming and concomitantly upcoming water stress and drought. New research programs are focussing on these challenges for the near future.

Optimization of knowledge production and flow

The current research system in the Netherlands has to focus more on the demands of society and consumers and needs more commitment from stakeholders. Moreover, communication flow within the production – consumption chain needs to be optimized and evident differences in interests and perception of needs for innovations within the field of organic farming need to be overcome. Therefore a new approach has been developed in which the interactions between researchers, entrepreneurs, chain-players, non governmental organisations and policy makers are optimized in order to achieve the approval and mandate of the different stakeholders in OA (Figure 1).

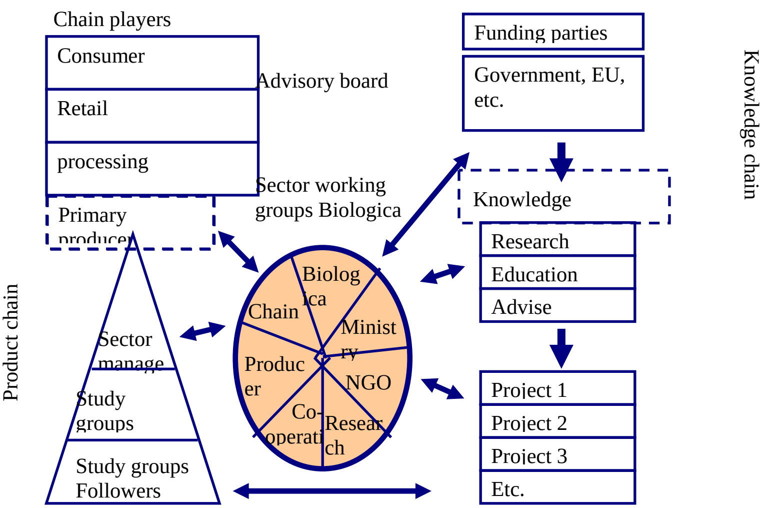

Figure 1. Research optimally tuned to the societal demand

The platform of parties involved in the chain production, processing and marketing of organic products (organised in the sector working groups 'Biologica') is the central pivot responsible for monitoring and control. The advisory board pursues an optimal synergy between product chain and knowledge chain. This warrants an optimal articulation of the demand for knowledge as well as maximal knowledge dissemination and use.

Research strategies

The required transition to a sustainable production system comprises three strategic development pathways with different time horizons (Figure 2):

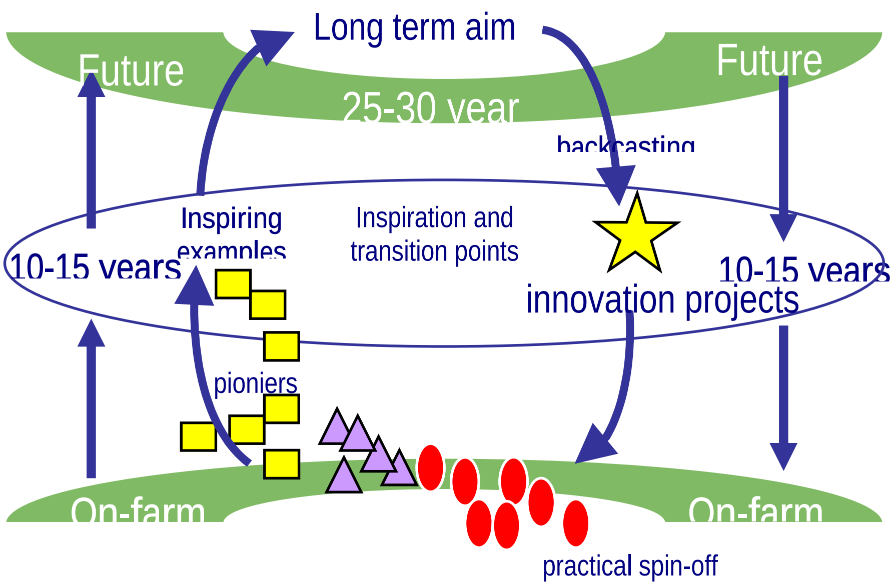

Figure 2. Strategy to develop long term, mid term and short term innovation targets

<u>Long-term transition targets (2030 – 2050)</u>

Farming systems coping with the development of regional production or global marketing were designed. As a cpnsequence, new and robust future oriented production systems come up, in which agriculture and urbanization are interrelated on the one hand, and functions, like social life, labour and recreation are combined on the other hand. As a result designs are made, like for example urban agriculture, recreation spots in agricultural centres, combination of nature preservation and agriculture, energy cycling (clusters of) greenhouses or agriculture combined with healthcare for people.

<u>Desired innovations within 10 – 15 years</u>

Based on the designs developed in the long term perspectives, necessary transition points are characterized by the technique of backcasting. This procedure will deliver new research topics to be elaborated for midlong term. A few examples are: the development of new warming and cooling devices or buffering systems for close system greenhouses; multifunctional growing systems in which nutrient cycles are optimally closed (Figure 3); combining agriculture and social life; development of GPS-driven equipment for weed control; combination of dairy farming and water management.

Knowledge networks (0 – 5 years)

This comprises production of knowledge in networks of researchers which focus on actual demands of farmers. The intensity of the participation in these scientific networks differs between farmers. Approval of farming systems occurs by mutual interaction between farmers in study groups. Real innovations of farming systems only occur when farmers are pioneers, the so called inspiring examples or ‘pearls’. Inspiring examples of remunerative organic farming systems appear to have a clear impact on traditional farming methods, and thus make farming in general more sustainable. This is the result of a good balance between future oriented innovative power of the pioneers and an effective interaction with spin-offs to study groups of the more traditional farmers and other parties involved in the production - consumption chain. This procedure is expected to result in an increase of the organic farming production capacity and will contribute to the governmental ambition that 10 % of the total cultivated area will be under organic farming by 2010.

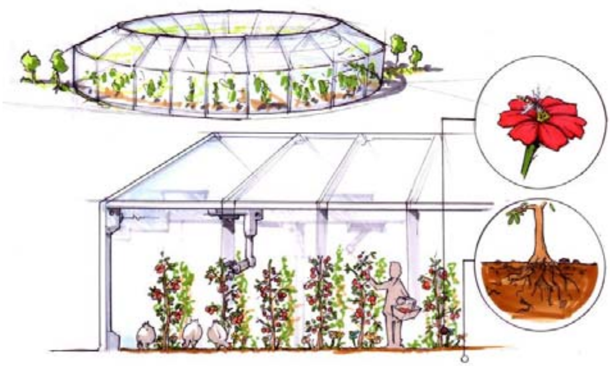

Figure 3. Multifunctional organic growing system in which animal husbandry and crop growth are combined in a closed nutrient cycle

On-farm research methodology

In the past, knowledge on technical solutions for farmer use was mainly produced at research centres. Advisers and farmers were instructed on technical improvements on their farms by a top-down approach. It turned out, however, that this research and knowledge transfer system was insufficiently tuning to the demand for knowledge from individual farmers. Since a few years, research activities have been moved towards the farms and experiments are executed in a participatory way together with the farmers. Both farmers and researchers are organized in socio-technic knowledge networks for knowledge dissemination and mutual support. By this way, research aims are maximally tuned to farmers’ individual and collective demands and generate solutions for local problems. Knowledge will be transferred from researchers to farmers and *vice versa*, resulting in an intensive knowledge exchange. Up scaling and developing generic solutions are the new scientific challenges.

Research themes

Until recently, research mainly focussed on primary production, as most problems were related to technical imperfections. The themes comprised for instance nutrient management, weed control, crop protection, animal husbandry and breeding. This approach resulted in a significant increase in production of organic products, while consumer behaviour and sale of organic products did not increase concomitantly. The government policy to aim at a market oriented organic production is however expected to cause a shift towards the requirement of knowledge on consumer awareness, food safety and quality and economic production. Adapting organic farming systems to the rural environment or even to urban life (Figure 4) also requires a paradigm shift focussing on a multifunctional approach.
This requires a shift from a pure beta-approach towards a beta-gamma one. Researchers will need to work in teams with different expertises, varying from technical experience to social-economic skills. United research groups originate from different research centres and universities, warranting a systemic, holistic approach.

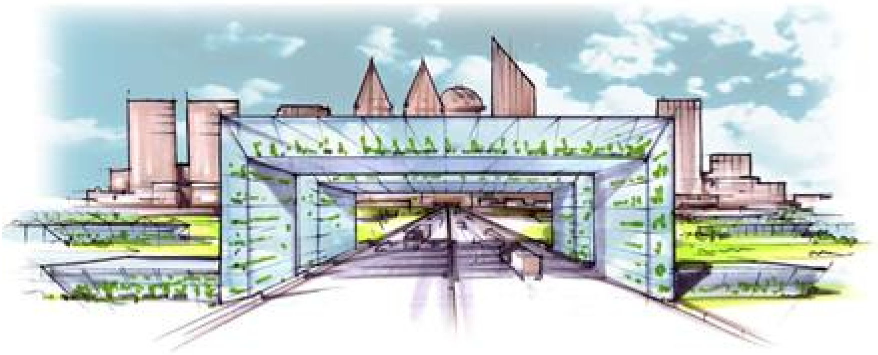

Figure 4. Organic farming integrated in urban life

ORGANIC AGRICULTURE AS ROLE MODEL FOR SUSTAINABILITY

One of the important political ambitions is to use the innovative strength of the organic production sector to enlarge sustainability of the whole agrisector. Organic farming may serve as precursor of the development of the conventional agriculture. Many results from organic farming are examples of the innovative power to improve sustainability and can be used as a basis for implementation in conventional farming. Functional biodiversity is one example that serves many goals. Flower rich borders are a basic element for the abundance of natural enemies of agricultural pests.

The introduction of flower rich borders and subsequently attraction of predators are very effective with respect to biological (i.e. non-chemical) pest control. It turns out that this has a substantial impact on:

- reducing chemical protection
- reducing environmental pollution
- preservation of biodiversity
- strengthening nature and landscape
- increasing farm income
- developing new market concepts
- improving labour conditions

Many examples are already identified as the so-called ‘pearls’ for the development of agriculture as a whole and will be used to innovate the sector to fulfil the aim that 10 % of the total area cultivated will be organic by 2010.

THE SWEDISH CHALLENGE – INTERDISCIPLINARITY, COLLABORATION AND INTEGRATION FOR RESEARCH AND DEVELOPMENT IN ORGANIC FARMING

Ulrika Geber (1), Kjell Ivarsson (2), Inger Källander (3), Lennart Salomonsson (1)
(1) Centre for Sustainable Agriculture CUL, P.O. Box 7047, S-750 07 Uppsala, E-mail ulrika.geber@cul.slu.se
(2) Federation of Swedish Farmers LRF, S-105 33 Stockholm, E-mail kjell.ivarsson@lrf.se
(3) Swedish Ecological Farmers Association, Sågargatan 10 A, S-75318 Uppsala, E-mail inger.kallander@ekolantbruk.se
(1) Centre for Sustainable Agriculture CUL, E-mail lennart.salomonsson@cul.slu.de

Key Words: Sweden, Research Structures, Research Policy & Development

Introduction: Strategic issues in the sustainable development of organic and conventional farming

Organic farming is an example of the integration of non-monetary valued goals (as for example environmental concerns and animal welfare) in a market driven production. The main tool is the use of certification of the production. In this perspective organic farming becomes an interesting model for the entire food system. Current fast structural changes in Swedish agricultural primary production with decreasing numbers of farmers and an increasing size of farms on the one hand and increasing market competition and decreasing food prices on the other hand are well known realities. Reports on the decreasing capacity of the global ecosystems to generate non-monetary valued life supporting *ecosystem services* also emphasize the role of agriculture to fulfil these functions (Millennium Assessment, 2005). Multifunctional agriculture, making use of ecosystem services for biomass production, collective utilities and new workplaces, is highlighted. In order to play an important role on these issues, the sustainable development of organic farming requires research covering a wide scope of aspects, from environmental issues in the farm and food production system to questions about ethics, precaution and feedback at different levels. Knowledge from different disciplines, areas and perspectives need to be integrated. Scarce resources for research and development, along with the historical development of organic farming (to a substantial part based on experiential learning and knowledge) highlight the importance of relevance and validity in organic research.

Theoretical framework

With agroecology as a basis for the development of organic farming, research on organic farming also deals with the long term sustainability issues of agriculture. With theories of resilience (e.g. Berkes *et al.*, 2003) and systems ecology (Odum, 2001), ecological concepts and ecological principles are used to describe and in practice design farm and food systems. Tight feedback loops as a design principle for a farm or a food distribution system is a strategy to promote capacity for self organisation and efficient learning. In research it implies a close communication with different actors and a common effort in the identification of relevant research questions and areas, choice of research methods and evaluation of results. Science- and experience-based knowledge from different disciplines should be integrated in order to handle complex problems where uncertainty and goal conflicts are inherent. This integration is in line with research results concerning effective learning and the sustainable human use of the common natural resource base (Holling *et. al*., 2001). The maintenance of diversity, genetic as well as agricultural and organizational is important at farm level for the buffering net capacity to unexpected changes and for the development of contextual management solutions (i.e. supporting development of system modularity) (Levin, 1999). Diversity of institutional support in research across scales is promoted through different networks of e.g. practitioners and researchers at local level and research networks at national and international level. The Swedish national research program in organic farming together with the Swedish participation in the European research network for financing of transnational research in organic farming (CORE organic) is an example of such a commonly targeted diversity.

Results and brief discussion

Dialogue and collaboration with different actors in the organic farm and food system

In Sweden CUL (Centre for Sustainable Agriculture) is the platform for researchers and other actors with an interest in organic farming. It is part of the national University (SLU, Swedish Life Science University), and has the responsibility to facilitate communication between different actors in the farm and food system in order to ensure relevant and good quality research. It also has the responsibility to coordinate research and to initiate interdisciplinary research and education. A board/reference group is connected to CUL. It consists of representatives from organic and conventional farmers' associations, consumer organisations, retailers, and other authorities who deal with agricultural, environmental and consumer and food security issues. Researchers from different research areas are also represented.

CUL is financing the Swedish participation in the Nordic network AGROASIS (Nordic School of Agroecology/Ecological Agriculture), which develops a common MSc in agroecology. The aim of such an educational program is to create a learning environment for candidates with relevant knowledge, skills and attitudes to act ("action knowledge") in the development of sustainable food systems (Francis *et al.,* 2004; Lieblein *et al.,* 2004). The educational program is based on agroecology with a clear interdisciplinary approach. The curriculum has been organised around the principles of experiential or action education, where learning is seen as experience, reflection, action and reflection (Kolb, 1984). The Kolb's learning cycle is used in the design of course content, as well as in the design of the order of courses (Sriskandarajah *et al.,* 2005, Salomonsson et al. 2004).

In the preparation of a frame programme for priorities of research in organic farming, every third year, a broad group of actors is invited. Farmers' associations, advisers, researchers, financing bodies and representatives of the organic food system are taking part in the process. Problem descriptions and priorities of important questions, as well as the balance between solving short-term bottlenecks in the production chain on the one hand and long-term sustainability issues on the other hand, are negotiated. One challenge is to develop different arenas for this negotiation in order to engage a larger number of people in the process, be it on the web or in in-group discussions.

Coordination and strategic discussions

A consulting group coordinated by CUL, consisting of financing bodies, authorities and representatives of the organic production chain, has the responsibility to maintain an overview of the research financing in different areas. To some extent funding bodies are coordinating their activities, exchanging information about funding of ongoing research. Prioritised Priority areas without research funding are identified and actions are commonly taken. This includes discussions with specific financing bodies, the support of the formation of new research groups or the formation of focus groups consisting of researchers as well as practitioners in order to cover all areas. The further development of research questions is sometimes on the agenda. Discussions on participatory research methodology, on methods that promote the handling of local conditions and interdisciplinary research are taking place in order to enhance the financing of relevant research projects of good quality.

In the preparatory work for setting the political goals for organic farming in Sweden, the Swedish Board of Agriculture has used an inclusive approach, inviting representatives from organic and conventional farmer associations, environmental and consumer organisations, authorities and representatives from the organic food chain. During a process over several months, evaluation of the fulfilment of earlier goals and of policy instruments are discussed and inputs to the formulation of new goals are made.

In an Action plan for the fulfilment of the political goals of organic farming in Sweden, the Swedish Board of Agriculture appointed the Royal Swedish Academy of Agriculture and Forestry as responsible body for the formation of an *Ecological Forum,* organising seminars and workshops, connecting politicians, researchers and practitioners in the food chain. To the *Ecological Forum* a reference group is connected with representatives from organic and conventional farmer associations, consumer associations together as well as processing and market representatives. In the *Forum* discussions, constraints are identified and hot research topics are formulated and discussed.

Integration of organic and conventional farmers for the development of organic farming and long term sustainability of farming in Sweden

The development of organic farming in Sweden has promoted the sustainable development of the Swedish conventional agriculture. The pioneering efforts made by organic farmers and researchers in organic farming have given raise to fruitful reflections and discussions in conventional farming. This is true, e.g. for the area of animal welfare and for the national goal, decided by the parliament, to minimise the pesticide use in conventional agriculture. The development of an environment and quality certification body for conventional farming “Svenskt Sigill” (Swedish Seal of Quality) was also trigged by the formation and development of the Swedish organic certification system KRAV. This “pulling effect” of organic farming on conventional farming has now been more formally developed by co-operation between the organic farmers’ and the conventional farmers’ associations. Common goal documents have been prepared, and the joint efforts to develop the Swedish agriculture were presented at the IFOAM conference in 2000. This cooperation is partly due to the fact that a substantial part of the organically farmed area in Sweden exists on farms with both conventional and organic production, and more than ten percent of members of the conventional farmer association have organic production. This large number is probably due to the fact that the Swedish subsidies for organic farming until today are disconnected from certified production although the all organic farmers – certified or not – have to comply to the same rules.

The Swedish parliament has decided upon 15 environmental quality goals. They cover all parts of society and are to be reached within one generation. Among them is a reduced use of pesticides, but there is also a focus on eutrophication and nutrient losses from agriculture. A campaign called “Nutrient in focus” has been launched for agriculture in target areas. An increasing number of organic farmers and farms are taking part in the “Nutrient in Focus” campaign. Among other things this has resulted in a slowly growing database with information on nutrient management on organic farms, absent until today. Organic production is now a natural part of the extension service offered at county level.

The integrative and collaboratory approach taken by Sweden has the effect that a large number of farmers, researchers and other actors are participating in the development of, and research in, organic farming. It results in a development process with a large number of perspectives and – sometimes – conflicting goals. The creation of many different fora for discussion and reflection on the development of the organic farm and food system is on the other hand an insurance of the stability and sustainability of the development process.

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RESEARCH PROGRAM FOR ORGANIC FOOD AND FARMING IN FINLAND

Arja Nykänen

MTT Agrifood Research, Ecological Production, Huttulantie 1, 51900 Juva, Finland, tel. +358 15 321 230, e-mail: arja.nykanen@mtt.fi Internet: www.mtt.fi/english/research/environment/ecological.html

Key Words: Trifolium pratense, grazing, suckler cows, dairy cows, pathogens, Phytophthora infestans, recycling, soil fertility, local food, environmental efficiency, consumers, food chain, cooperation

Abstract

The Finnish Ministry of Agriculture and Forestry started a three-year Research Programme on Organic Food and Farming in 2003. The programme consists of 15 projects on different themes covering the whole food chain and has an annual budget of about 2.2 MEUR. All ongoing projects on organic food and farming in Finland can be found at the web site http://www.agronet.fi/luotu/eng/index.htm

Introduction

In Finland, 7.6 % of the total arable area and 6.9 % of the farms were fully organic or in conversion in 2004, with 12.8 % of the organic farms having animal production. The Finnish Ministry of Agriculture and Forestry (MAF) has set a target to increase the area under organic farming to 15 % of the total area of arable land by 2010.

The volume of research in organic agriculture has been at the level of 2.5 MEUR annually in recent years. The main financial efforts in organic farming research has been supported by the Finnish Ministry of Agriculture and Forestry (MAF) either through the budgets of its research institutes (mainly MTT Agrifood Research Finland) or by financing research projects from its non-preallocated research budget. The Academy of Finland and Tekes - the National Technology Agency - have also supported research in organic farming, but only in a small number of projects.

Main research centres carrying out research on Organic Food and Farming in Finland are MTT Agrifood Research Finland (www.mtt.fi/english/), Helsinki University (www.helsinki.fi/university/), National Consumer Research Centre (www.kuluttajatutkimuskeskus.fi/english/index.html) andVTT Technical Research Centre of Finland (www.vtt.fi/vtt/inbrief/).

In 2003, MAF started a three-year Research Programme on Organic Food and Farming with 15 projects on the topics: Quality and risks of organic food, Consumer oriented product development, Maintenance of soil fertility, Safe recycling of organic waste, Improved production of organic milk and meat, Animal welfare and organic farming, Local food systems, and Role of organic farming in multifunctional and pluriactive agriculture. The annual budget for this programme is about 1.1 MEUR from MAF with a further estimated 1.1 MEUR coming from the budgets of the institutes involved in these projects.

Plant production and soil quality

Under this theme, there are six projects: ‘Control of potato late blight by caraway oil in organic farming’, ‘Disease management in organic seed potato production’, ‘Red clover efficiently into organically produced milk’, ‘Development of meat-bone meal as organic fertilizer’, ‘Waste composts in organic crop production – future risks and possibilities’ and ‘On-farm soil quality assessment’.

Potato late blight, caused by the oomycete *Phytophthora infestans* (P.i), is the main factor determining the length of the growing season for organic potato, by killing the canopy. In Finland there are currently no compounds available for direct blight control in organic production. Caraway (*Carum carvi*) seeds contain biologically active essential oils, which have shown potential as a biocontrol against potato late blight. The project includes experiments on the extraction of caraway oil, formulation and efficiency. In field conditions, caraway oil has delayed the onset of late blight for about 10-14 days. Changing towards more diverse crop rotations and better control of nitrogen release can delay the onset of blight epidemics considerably. Increasing row spacing and mechanical defoliation have very limited value in blight control.

Red clover (*Trifolium pratense*) is the most common fodder legume in Finnish organic grasslands. The persistence of clover is often poor after the second production year. The focus in the project is to provide tools for farmers to choose the best red clover varieties for their fields, based on yield production, resistance to pathogens and over-wintering. Plant physiological, molecular biological and statistical methods are used. The spatial variation of soil characteristics, nitrogen fixation of red clover and yield of clover-grass leys are studied also. The over-wintering of a red clover variety seems to be essential for persistence of a red clover sward. A variety which might not be the most productive at the beginning of growth but accumulates nitrogen and carbon in its roots, seems to be the most persistent and most productive in the long run. Fourteen Fusarium strains were collected from swards and only one could infect red clover, being able to penetrate the clover cells. The variation within a field of the yield and clover content of a red clover-grass sward can be surprisingly high. Very preliminary results show a slight correlation between sward yield and some soil characteristics, such as pH, potassium, manganese, cobalt, copper, molybdenum and iron.

Recirculation of nutrients from municipalities back to the fields is one aim of organic farming. Organic wastes such as composted waste from municipalities and meat/bone meal are often considered unwanted material because of possible contamination by heavy metals and microbiological risks. In Finland it is not permitted to use them in organic production at the moment, but their fertilizer value and risks of use are being studied in two projects. Biowaste composts were tested in one field experiment as a fertilizer for potato and cereals. The microbiological quality (Salmonella, Coliforms, Colifages, Clostridia) of the composts was analysed as well as the nutrients and heavy metals. Meat/bone meal was studied as a fertilizer for cereals on farms. According to the microbiological and chemical analyses, all the tested composts were suitable for use as plant fertilizers. However, quite large amounts of compost are needed to satisfy the nutritional demands of plants. Farmers who used meat/bone meal as a fertilizer for cereals were quite satisfied with it, but spreading the greasy and fine material was problematic on many farms. Farmers would have liked a pelleted or pilled form of the meat/bone meal. The fertilization effect was clearly visible on their fields.

At present, testing of soil fertility is based on chemical analysis. Organic farming is dependent on biologically-mediated processes and the function of the whole soil system. Therefore soil quality should be seen as the soil's ability to function, depending on the intended usage. A practical soil quality test for on-farm use is being developed by modifying an existing soil quality test kit to make it suitable for Finnish conditions. See more: Nykänen et al. 2005a.

Animal husbandry and food safety

Under this theme, there are five projects: ‘Red clover efficiently into organically produced milk’, ‘Quality beef with efficient suckler cow production’, ‘Emerging food-borne pathogens (EHEC) in primary production’, ‘Risk assessment on food safety risks in organic pork production: pathogenic *Yersinia* and *Listeria* monocytogenes’ and ‘Organic egg production: management of animal welfare and food safety’.

Organic milk production is largely dependent on the supply of nutrients from forage. The most important forage legume in Finland is red clover (*Trifolium pratense*). More information is needed to improve the determination of the energy and protein values of red clover and to measure the nutrient supply and milk production responses of dairy cows on diets containing red clover. The energy and protein values of red clover were measured *in vivo* with sheep and using the omasal sampling technique with rumen-cannulated dairy cows. Red clovers’ content of indigestible neutral detergent fibre challenged the traditional rumen liquor or commercial cellulase-based laboratory methods successfully in estimating the digestibility of red clover silage. Contrary to pure grass silage, delayed harvest of pure red clover silage did not decrease the supply of nutrients to dairy cows. The main reason was the decreased intake of early-cut red clover silage. An Internet service which presents red clover and grass digestibility (using separate equations for each species) based on cumulative temperature and geographical location within Finland has been developed to assist in correct timing of forage harvest. The optimal harvesting time for a mixed ley with 50 % red clover was approximately one week later than that for a pure grass ley.

Suckler cow production suits organic meat production well and has not reached the demand volume of consumers in Finland. To improve the narrow profit margin of cattle and sheep enterprises, it is necessary to develop methods to increase the efficiency of forage use. In the project, feeding experiments with suckler cows and bulls were carried out to evaluate different feeding strategies and the effect of forage digestibility on meat production. The results suggest that suckler cows can be fed every third day without harmful effects on the performance, thus reducing the labour requirement and improving better profitability. The performance of growing bulls was greatly affected by the digestibility of the grass silage offered, while the protein content of the concentrate had no effect. An increase in fodder digestibility of 5 % points increased the meat production of beef bulls by about 190 g day^{-1}. Mixed grazing of suckler cows and sheep proved to be a promising way to intensify pasture utilization. Calves of suckler cows grew 10-15 kg per animal more if there were no sheep with them on pasture. The sheep produced 19 kg of meat each when they were on the same pasture with suckler cows and their calves. This can be considered as extra production from the pasture. Also, white clover grew better and weeds like Rumex were controlled better if sheep were together with suckler cows.

It has been suggested that due to different husbandry practices in organic and conventional farming, differences may exist between them in microbiological food safety. As food safety starts on the farm, a simple but comprehensive method for evaluation of farm level hygiene is needed. An ideal method would be objective, feasible and applicable to different production types and farm sizes, and should help to identify dubious husbandry practices on individual farms. The method being developed is based on an enquiry about hygienic practices at the farm level. The method of assessing farm hygiene proficiency will be connected to the detected prevalences of pathogens (Yersinia enterocolitica, Yersinia pseudotuberculosis and Listeria monocytogenes). Cattle are now widely accepted as a major reservoir of E. coli O157:H7 (EHEC). The prevalence of EHEC is not well known in Finland and the effects of different farming systems on the prevalence are not known. In the project, the prevalence of E. coli O157:H7 on conventional and organic cattle farms was investigated with test samples from farms. Faecal samples and barn surface samples were collected from 126 cattle farms, of which 54 were organic. E. coli O157 was found on seven farms, of which two were organic. See more: Nykänen et al. 2005b.

Economics, food and markets

Under themes, there are five projects: ‘Local food system: impacts and learning challenges’, ‘Consumers, decision makers and local or organic food. Possibilities of SMEs’, ‘Interaction between actors of organic demand-supply chain’, ‘Specialisation of organic farms through co-operation’, ‘Frontiers of organic and conventional farming technologies – environmental efficiency, productivity and learning’ and ‘Quality beef with efficient suckler cow production’.

Concurrent with globalisation is a growing interest in local food; this is also the case in Finland. It is assumed that increasing use of local food, either conventional or organic, has impacts on the environment, landscape and economics. This is studied by using and developing agri-environmental and regional economic models. For the investigation of learning challenges, selected food chains and their networks are qualitatively analyzed by interviews and an actor meeting. All data are centred around a rural municipality case and its region. The environmental impact of various dietary options relying on local food is assessed in terms of nutrient balance, greenhouse gas emissions and the landscape. In the area studied there is enough agricultural land to supply all the food needed for local consumption even if the food is produced organically. Preliminary results suggest that the socio-economic changes as well as the environmental and landscape impacts of increasing local food are rather small. On the national level, greenhouse gas emissions could be markedly reduced if, e.g., imported vegetables were replaced by domestic produce.

The attitudes of consumers and local decision makers to local and organic food are of interest and important when markets for organic food and the functioning of demand supply chain are developed. Local and organic food offers alternatives and opportunities for consumers, actors of food systems and local SMEs. The attitudes and views on local and organic food as well as the demand-supply chain of the organic food system were studied using qualitative and quantitative methods. Different types of interviews, questionnaires and focus group discussions with consumers, decision makers and actors at different levels of the food chain were applied. According to the preliminary results, both consumers and decision makers have a better understanding of organic food than of local food. Organic food production is defined by legislation. In general, attitudes are quite positive to both local and organic food. Organic food was associated with cleanness or purity, referring to the method of production, not so much to the product itself. Surveys of consumers and supply chain actors indicate that the changes in the conventional food system have had an impact on the organic chain too. Other obstacles to the optimisation of the organic food chain are the unbalanced power structures between actors of the chain who have divergent objectives, and poor communication between the end consumers and the actors of the chain.

In organic production, specialisation has been feasible only up to a certain point. Co-operation can bring even larger benefits in organic production than in conventional production. On animal and cereal farms it would allow farmers to specialise in their respective lines while safeguarding a sufficient nutrient rotation.

This would be highly sensible also in terms of environmental impact. The first stage of the study has studied existing co-operation models in five co-operating rings of farms and the second stage will create co-operation models between different lines of production. The models aim at optimising production environmentally, economically and functionally compared to farms operating alone. The benefits of the co-operation were experienced as lower production costs, specialisation of professional skills, more free time, better or wider crop rotation, more efficient use of green manure as fodder and better use of manure as fertilizer and better profitability.

The environmental efficiency of farms is one way to measure the environmental impact of agricultural production. The trade-offs between conventional production (in)efficiency and environmental (in)efficiency are identified to recognize potentially contradictory targets implemented in agricultural-environmental policy. Another way to asses the environmental impact of agricultural production is determination of shadow prices for environmentally detrimental outputs. The shadow values derived reflect the costs of the negative environmental effects of agriculture. The results of environmental efficiency show that public goods produced by organic farming have to be added to the efficiency of input-output calculations. The theoretical model also shows that if the payment of organic subsidy is to be explained by the public goods produced by organic farming, the subsidy must be based on the value of the public goods, not the market share of organic products. When comparing how efficiently livestock farms use their resources, our preliminary results indicate that the representative organic farm is found to be technically more efficient relative to its own technological frontier than is the representative conventional farm.

Suckler cow production is a branch of livestock farming which may increase strongly in Finland, because the Finnish EU quota for suckler cows is not fully utilised. This could especially increase organic beef production. The low interest in suckler cow production is mainly due to the low profitability of this line of production. The economic return on suckler cow production is studied with model calculations and on the basis of data from actual suckler cow farms. The profitability of investments is calculated using the real option method. There are opportunities to improve the economic performance of Finnish suckler cow farms by increasing the unit size, utilizing effectively the low-price fodder from pasture and decreasing the labour input with rational feeding and handling systems, for example. Besides, low capital costs can help to achieve an economic return that is competitive with other lines of production. See more: Nykänen et al. 2005c.

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COMBINING ON-FARM, PARTICIPATORY RESEARCH METHODOLOGIES WITH MODELLING IN ORDER TO CREATE A REGIONALLY BASED ORGANIC AGRICULTURE IN HOLLAND

Udo Prins, Jan de Wit, Wytze Nauta

Louis Bolk Institute, Hoofdstraat 24, 3972 LA Driebergen, NL., www.louisbolk.nl
E-mail: u.prins@louisbolk.nl, j.dewit@louisbolk.nl, w.nauta@louisbolk.nl

Key words: participatory research, modelling, nutrient cycles, regional production, partner farms, intersectoral cooperation

Introduction

Like conventional farming, organic agriculture in the Netherlands is highly specialized. Both livestock and arable farmers have optimised production independent of each other which has led to a high use of external inputs from conventional agriculture (manure and other fertilisers and straw) and feedstuffs (mainly concentrate feed) from abroad. This situation conflicts with important principles of organic agriculture such as a balance between livestock and arable farming, closing nutrient cycles and regionally based production. In an attempt to find solutions for this dilemma, the Louis Bolk Institute (LBI) started with a series of projects called “Partner Farms” in which the LBI cooperated closely with leading edge farmers (Wit et al, 2003). In these projects the cooperation between specialised livestock and arable farmers was stimulated, in some cases ultimately leading to “mixed farms at a distance”. Later the LBI became involved in a combined research programme together with various research institutes of the Wageningen University and Research aimed at studying “intersectoral cooperation” and nutrient cycles on a national level, using both modelling and participatory research (Enting et al. 2005). In both cases it became clear that the simultaneous use of both types of research methodology is necessary to get credible and practically viable results.

Methodology

In the “Partner Farms” projects as well as in the “Intersectoral Cooperation” programme both modelling and participatory research have been used simultaneously. In the participatory approach there is a cooperation with leading edge farmers (or pioneers) who are already experimenting or willing to experiment. By making changes to the farm layout and management these farmers helped to find solutions to closing cycles. The variety of strategies chosen by the different leading edge farmers was then used as input into the modelling phase. The modelling was used to explore the impact of developments that are beyond the farm level. The model used (“Organic Resource Flow Model”) calculates the amount of necessary inputs for the different sectors and the inputs coming from outside (international import or import from the conventional sector). The model is used to evaluate scenarios of possible developments in the Dutch organic sector with regard to their effect on nutrient balances and reliance on external inputs.

Results

For the first study on closing cycles in the organic sector the LBI started with a participatory approach to explore possible innovations in current practice. Livestock farmers were able to provide the manure for arable farmers in return for animal feed and bedding material. It soon became clear that due to the isolated development of the sectors for many years, the input demands of both sectors exceeded the supply potential of the other sector. A shortage of manure occurred due to the high fertilisation levels in the arable sector, caused by the ample availability of conventional manure. There also appeared to be a shortage in concentrate feed, as high quality arable soils in Holland are mainly used to produce human food due to the better financial returns compared to animal feed production. A third problem area was the bedding material. The deep litter houses for the milking cows need more straw than the arable farmers can deliver. This is also due to current Dutch cropping patterns with relatively few cereals and more vegetables compared to surrounding countries.

To explore the relevance of these problems for the Dutch organic sector as a whole, we developed an input flow model: Organic Resource Flow Model. The shortage in manure and concentrate feed was obvious (table 1 and 2). The shortage of bedding material however was less obvious. The demand for bedding material largely depends on the kind of housing used in the livestock sectors (especially in the biggest livestock sector: dairy cows). Deep litter stables need large amounts of bedding material, but most of the recently converted dairy farmers have cubicles, instead of deep litter houses that hardly need any bedding material. Thus the problem with bedding material is solved when the percentage of farmers with cubicles increase at the expense of farmers with deep litter houses.

Table 1. Supply and demand of manure in Dutch organic agriculture in 2003

Demand		Fertilisation rates	Demand	Supply	
		Kg N/ha	*ton N/year*		*ton N/year*
Arable farming	clay soils	150	1.291	Dairy cows	2.238
	sandy soils	105	859	Dairy goats	168
Horticulture	full field	170	94	Pigs	198
	glass house	130	13	Poultry	139
	fruits	130	33	Other	745
Livestock	ruminants	90	2.865		3.492
	monogastrics	130	142		
			5.297		

Table 2. Supply and demand of concentrate feed in Dutch organic agriculture in 2003

Demand			Supply	
	herdsize[1]	*ton/year*		*ton/year*
Dairy cows	17.359	20.258	Cereals	12.160
Dairy goats	13.279	4.249	Pulses	318
Pigs	20.000	22.445	Alfalfa	5.790
Poultry	367.000	18.437	Maize	0
Other	18.478	5.407	Molasses	630
		70.796	Waste products	2.155
				21.054

[1] number of producing animals

After analysing the current situation, solutions to closing nutrient cycles were explored. The type of possible solutions, however, hardly originated from the model used. The model is highly descriptive and contains a lot of variables that can be chosen freely, which can lead to unrealistic results. Making the model less descriptive does not solve this problem, as the factors determining possible outcomes are highly variable (financial, ecological, agronomical, social, political) and their interactions so complex that outcomes are not credible, while the data-demands of such complex models are often beyond present data availability.

Alternatively, the practice of leading edge farmers often gives a reasonable impression of the scope of possible solutions. Leading edge farmers often do things that can not yet be understood from the current available scientific knowledge and therefore could not have been predicted by using models. Moreover, farmers often come up with creative solutions that have not been thought of in research. By learning from these farmers and examining the precondition that need to be met to implement these farmer based solutions on other farms, one is assured that solutions found are embedded in the whole complexity of factors that determine practical viability.

For example: the model estimates that manure availability is about 50-60 kg N/ha when evenly spread over Dutch organic soils. This is in contrast with current fertilising levels of 140-150 kg N/ha under arable conditions. When searching for solutions we focused on arable farmers that are currently using considerably less manure. Analysing their crop rotations the following pattern emerged. About half the crops in the rotation consisted of soil improving crops (cereals, alfalfa, grassclover, peas), in at least on one third of the area legumes were grown (either as main crop or as green manure) and green manures were used as much as possible. Furthermore, most of these farmers had converted to organic farming some time ago (5-10 years) and had been able to build up soil fertility and soil life. Maintaining the biological, chemical and physical soil fertility by fertilising the soil and avoiding compaction had increasingly become a key concern for these farmers. Over time they found out that the nutrient efficiency of such a healthy and biologically active soil was good enough to reduce their use of manure whilst maintaining good yields. One farmer with such a rotation even manages to produce without any animal manure (see table 3) (Prins, 2004), only using compost and a little molasses as fertiliser in his rotation. Most surprisingly for some researchers, the yields on these farms are comparable with yields on other farms with higher fertilisation levels.

Table 3. Crop rotation, fertilisation and yields on a stockless arable farm in Holland

Crop	Green manure	Yield	Compost	Molasses
Carrots		60 t/ha	25 t/ha	
Green peas	Fodder radish	7 t/ha	25 t/ha	
Spring wheat	Red clover	5,5 t/ha	25 t/ha	
Potatoes	Fodder radish	35 t/ha	25 t/ha	2 t/ha
Alfalfa		12 t DM/ha		
Onions	Yellow mustard	50 t/ha		3 t/ha

Using these experiences as an inspiration, the effect of such cropping patterns and fertilisation strategies were calculated on a national level. One important result of these calculations was that although this could solve the manure shortage, a new problem emerged: negative mineral balances. As nutrient cycles become more and more closed, mineral balances either at livestock farms or at arable farms turn negative, due to the export of nutrients and fertility in the form of products being sold to consumers. There needs to be a return input to compensate for this “loss”. The question is what kind of product is acceptable for the organic sector as return input. Human waste in the form of kitchen scraps or sewer waste would form the ultimate product to close cycles but these products are highly contaminated with heavy metals, GMO material, etc. as a result of a highly contaminated society. This makes most of these products unsuitable in the short run. The material that seems to be the most acceptable and practical return input seems to be organic material coming from nature reserves.

To see how these materials can best be incorporated into the organic farming system the research focus returns again to farming practice to find innovative farmers that are already implementing such type of strategy, and cooperating with them in overcoming subsequent problematic implications. This way the process of simultaneous participatory on-farm research with the use of models to up-scale possible solutions enters a new cycle.

Combining research methodologies

In the agricultural research and development process there is a lot to be gained by combining different kinds of research methodologies. Modelling can be used to get an impression of the implications of proposed changes in the farming system on a scale that exceeds the farm level. It also allows an examination of the effects of changes that are, for any reason infeasible in current practice. The danger of this research methodology, however, is that its output consists of purely theoretical solutions, optimising one aspect, but which might have major negative effects on other levels or aspects. With participatory on-farm approaches, the research is well embedded in the diverse complexity of current organic agriculture. Technical feasibility as well as economical, ecological, organisational and social implications of proposed innovations are part and parcel of such type of research. A limitation, however, lies in the fact that most farmers respond to current social, legal and economical preconditions, which make it difficult to look far ahead in time.

The solution to the limitations of each type of research methodology seems to be in the combination of modelling and participatory research with leading edge farms. The experiences gained at these farms can be used as input for the models while the output of the models can be used as a trigger for the farmers to change farm strategies.

The importance of applying a wide range of research methods is also suggested by Davies and Gibbon (2004) who argue further that solving complex problems usually involves jumping back and forth between various stages within a research cycle, very similar to the practice within the described projects. Only in this way can agricultural research produce results and innovations that are both acceptable to and applicable in organic agriculture.

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ORGANIC FOOD AND FARMING RESEARCH IN ITALY: A REVIEW OF ITALIAN MINISTRY OF AGRICULTURE AND FORESTRY POLICIES (MIPAF)

Serenella Puliga[(1)], Annamaria S. Marzetti[(3)], Stefano Canali[(3)] , Francesco Zecca[(2)]

(1) Ministero delle Politiche agricole e forestali, c/o CRA-Istituto per lo studio e la difesa del suolo P-zza D'Azeglio 30 – 50121 Firenze – Italy, +39 055 2491248 s.puliga@politicheagricole.it
(2) Ministero delle politiche agricole e forestali - POSR IV - Via XX settembre 20, 00187 Roma Italy, +39 06 46655077, f.zecca@politicheagricole.it, http://www.politicheagricole.it
(3) National Council for Agriculture- Istituto per la nutrizione delle piante – Via della Navicella, 2/4 00185 Rome, Italy +39 06 7005413 s.canali@isnp.it, http://entecra.it; amarzetti@tiscalinet.it

Key Words: Organic farming, Italian research, funding

Abstract

In Italy, as in other countries, Organic Food and Farming (OFF) research suffers from a very high fragmentation as it is carried out by many public research institutes, universities and private centres. In recent years, due to the increasing relevance of OFF within national rural development programmes, strong efforts have been addressed towards an improvement of the efficiency of the distribution of funds, the research system and the reorganization of its activities, and a reduction of overlapping initiatives. This paper presents projects and institutions currently working on OFF research in Italy, focusing on the available public financial instruments and the main projects funded by the Ministry of Agriculture and Forestry MIPAF. Most of the Italian research projects investigate plant production subjects, some actions involve animal production, animal health and welfare and environmental aspects. In order to facilitate the dissemination of research, the "National Information System on organic farming" (www.sinab.it) was established. It is financed by MIPAF. Furthermore, recognizing the need to coordinate research efforts also at transnational level, MIPAF is one of the 11 partners of the CORE-Organic ERA-net project, which started in October 2004, co-financed by the European Commission. This network could represent a very powerful tool to strengthen future national and international research actions and cooperation.

Introduction

It was only in the last decade that in Italy interest in organic farming really took off, when production methods continued to develop, along with consumers' keen concern to be supplied with more wholesome, environment-friendly products.

There was a major increase in the number of producers, and new initiatives got under way for processing and marketing organic products, making Italy the European country with the largest cultivated surface. Currently 954.361 hectares, including 246.318 ha in conversion, are under organic management (MIPAF 2004). The total surface is mainly cultivated with forage crops and pastures (48%); the remaining area is dedicated to cereals (20%), to fruit trees, vineyards and olive-trees (18%), and to vegetables and industrial crops (4%). These data refer to the organic land cultivated land under EC Regulation 2092/91 and its modifications.

The gradual recognition of the potential of organic farming for the producing food, creating a specific market and socio-economic benefits to the farmers and for producing environmental benefits, public health, social and rural development and animal welfare, has driven the European Union and Italy to adopt specific legislation and promote research actions.

The EU was one of the first to set up a policy on organic farming by defining the requirements for agricultural products and foodstuffs (EC Regulation 2092/91).

More recently, EC Regulation 1257/1999 on support for rural development, the EU Commission's Strategy for Sustainable Development (2001), the Sixth Community Environment Action Programme in 2002 and, finally, the Mid-Term Review of the Common Agricultural Policy (2003) have all recognized organic farming as a strategic tool to realize a sustainable development of European society. Several Member States and regions have already adopted national or regional action plans for the development of organic farming, focusing on agri-environment programmes, market development, research and capacity building. These action plans have contributed to the fast growth of the sector in the Member States and the Commission has defined its own strategy on OFF to complement and interact with the national and regional plans.

European and National policies

European Action Plan for OFF. In June 2004 the European Commission published a Communication on a European Action Plan for Organic Food and Farming, strongly supported by Italy during its EU chairing semester (June-December 2003). This document aims "to assess the situation and to lay down the basis for policy development in the coming years, thereby providing an overall strategic vision for organic farming's contribution to the common agricultural policy (CAP)". The Commission recognizes the dual key role of OFF for market and land management and the importance of ensuring the necessary research into organic farming and processing methods (Action 7) "in order to facilitate the expansion of organic farming, but also to increase production capacity, new information and, above all, new technologies are required". Therefore an important part of any policy aimed at developing the organic sector has been addressed to strengthen research and training at different levels, adopting specific research programmes and farmers training to ensure the innovation transfer into agricultural practice with close cooperation between research, advisory services, farmers and food production chain.

Italian National Plan for OFF. Italy adopted its own National Plan on OF (January 2002), to optimize the use of the resources under a strategic framework program of actions. The general objective of the plan is to establish a national coordination of all research initiatives in progress, by adequate monitoring and evaluation of results, and to improve strategies of research result fruition by the organic farming sector, with the cooperation of Regional organisms. The plan promotes: research projects "from farm to fork" involving the different stakeholders; the strengthening of the research institutions devoted to OFF; coordinating all the research initiatives and the knowledge dissemination system. The research should be focused on: exploitation of germoplasm and biodiversity; genetic improvement and rescue of old species; improvement of crop techniques; set up of new processing and marketing technologies; identification of quality indicators; strengthening of control systems.

Financial resources. Since 2001 an Italian specific law supports research actions in organic farming through a fund devoted to the development of OF and "quality agriculture". It is financed through a compulsory contribution (now fixed at 2% of sales) from producers or importers of phytosanitary products.

Research actions

Italian OFF research suffers from a very high fragmentation. Apart from national projects many different public and private bodies support OFF research initiatives, due to the very high relevance that this sector represents for agricultural zones where organic farming products have an added value compared to conventional products. Table 1 lists MIPAF research projects 1998 up to now. Moreover, an inter-regional programme involving different Regions and funded by law n. 499/99 on Organic husbandry was launched at the end of 2004.

Many other projects specifically devoted to OFF research have been supported in the last years by Regions, Provinces and Universities. Between 2000 and 2002, 130 projects were financed by those public bodies and some private ones (CEDAS, 2002). Unfortunately, the available data do not give an idea of human and financial resources involved and are not easily accessible considering the high number of institutions financing very small initiatives, which do not always have a large impact on the sector. In particular, Italian Regions are active in organic farming research, using their own Agencies who give both technical support to farmers and promote and finance research on behalf of the Regional Government. Also some trans-national collaborative programmes involve Italian research institutions, mainly supported by the EU or international funding bodies (ORGIN, SIMOCA, WECOF, QLIF, OMIARD, CEEOPF, EISFOM, CONDOR, RUDOLPH).

Research Centres and Universities carrying out OFF research

In Italy no national single centre exclusively dedicated to OFF research exists.

MIPAF Research Centres: most of the agriculture research centres (30 different Institutions) refer to MIPAF and have recently been reorganized under a National Agriculture Research Council (CRA, http://www.entecra.it). CRA has institutional competence on different fields of agricultural research, and its structures are strongly involved in OFF projects.

Table 1 - Projects financed by MIPAF since 1998 up to now (MIPAF data)

Year	N	PROJECT	Participants				Budget €	Deadline
			Tot	Univ.	MIPAF	other		
1998	1	Developing organic fertilization systems	2	-	2		100.000,00	concluded
1998	2	Pest and disease management in organic farming	9	5	2	2	620.000,00	concluded
2000	3	Quality indicators in organic farming products	6	-	4	2	890.000,00	concluded
2002	4	Organic animal production in Italy: current situation and perspectives	4	-	3	1	194.000,00	concluded
2004	5	Plant essences as crop protectors in organic farming	2	2			99.000	2006
2003		CALL						
	6	Sustainable, traceable and safe organic olive oil production	7	5	2	-		2006
	7	New production system for industrial crop: sugar beet and tomato	8	2	2	4		2006
	8	High quality production for organic hazelnut	8	4	3	1		2006
	9	Economic, environmental and health sustainability in organic farming	5	3	1	1		2006
	10	High quality production in fruit and vegetables for fresh and processed product	12	4	3	5		2006
	11	Genetic and crop improvement for organic cereals – wheat, barley, oats	5	5	-	-		2006
	12	Bioactive substances in organic farming chain	1	1	-	-		2006
total		*Call projects*					4.000.000,00	
2005	13	Soil management, substrate production and plant nutrition for organic Mediterranean products	5	2	2	1		2008
	14	Analysis of sheep-milk production by organic method	4	1	1	2		2007
	15	Traceability markers for organic fruits	5	-	3	2		2008
	16	Defining strategies to improve competitiveness of organic farms	5	2		3		2007
	17	Strategies and alternative products to face the EU legal threshold values for copper in: vine-tree; fruit-tree; vegetable; tomato	4	1	1	2		2008
	18	Potato cultivars for organic farming	3	1	1	1		2008
	19	Evaluation of new crop techniques for organic nursery	7	2	5			2007
total		2005 projects					3.241.000,00	

Other research centres related to MIPAF and involved in OFF are: National Research Institute for food and human nutrition (http://www.inran.it); National Institute of agricultural economy, http://www.inea.it); Institute for agricultural market studies (http://www.ismea.it)

Universities:

In Italy there are 23 Faculties of Agriculture; the Agricultural Science Department of the Santana School of Advanced Studies in Pisa (http://www.sssup.it). In addition, some Departments belonging to different Faculties (Medicine, Biology, Economy, Veterinary Sciences etc.) and related to human health disciplines, economy and marketing, plant and animal biology, carry out joint projects in OFF.

Other National or Regional Centres

- IAMB (Institute for Mediterranean Agronomy of Bari): CIHEAM - (http://www.iamb.it)
- ENEA (National Body for New Technology, Energy and Environment) - (http://www.enea.it)
- Laimburg Research Centre for agriculture and forestry (Province of Bolzano; www.laimburg.it)
- Agriculture Institute of S. Michele all'Adige (Province of Trento; www.ismaa.it)
- Research Centre for Fruit and Vegetable production - CRPV (Region of Emilia-Romagna; www.crpv.it)
- Research Centre for Animal Production - CRPA (Region of Emilia-Romagna; www.crpa.it)

National and local initiatives with OFF dissemination activities

Since 2003 MIPAF has been funding a "National Information System on Organic Farming", which maintains an internet site covering all aspects of organic farming (www.sinab.it). At this internet site a specific section on research mapping, a library network, and a service bureau in order to strengthen inter- and intra-sectorial communication are available. IAMB-CIHEAM is in manages this internet site. CEDAS (Centre for sustainable agriculture information, Provinces of Forlì and Cesena), monitors Italian research actions in OFF. Every two year it publishes a yearbook (the latest in 2002) containing information on research projects, research themes, objectives and location of the activities, but without information on financial and human resources allocated.

EU Coordinated Action - CORE ORGANIC

MIPAF, recognizing the relevance of improving the efficiency of the OFF research system is participating with 11 partners in the CORE-Organic network (www.coreorganic.org). The coordinated Action started in October 2004, co-financed by the European Commission. The overall objective of CORE Organic is to enhance quality, relevance and utilisation of resources of European research in OFF and to establish a joint pool of funding for transnational research in OFF by the end of the project. By gathering a critical mass and establishing a coordinating centre the specific objectives are:

- Increased exchange of information through a common open web based archive on research programmes, projects, results, human resources, infrastructures and financial resources in the European Union on OFF research.
- Coordination of existing research and integration of knowledge identifying common priorities and research subjects. Increased cooperation between national and regional programmes should improve synergies "*add value*" to the OFF research system.
- Sharing and developing best practices for evaluating OFF research and strengthening its impact on the whole organic agriculture and food production chain.

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POSTERS
CROP SCIENCE

EFFECTS OF SOME ORGANIC FERTILIZERS ON YIELD AND QUALITY OF ROUND SEEDLESS (=ROUND SULTANA) GRAPE VARIETY

Ahmet Altindisli

Ege University, Faculty of Agric., Dept. of Horticulture, 35100 Bornova-Izmir, TURKEY
Tel:+90.232.3881865, E-mail: altindis@ziraat.ege.edu.tr

Key Words: Organic grape growing, farmyard manure, green manure, E-2001, yield, grape quality

Abstract

The study was conducted in two 0.5 ha-organic vineyards in Manisa Province in 2000 and 2001 to determine the effects of different manuring programs on yield and quality of fresh and dried grapes in the Round seedless (= Round sultana) variety. Different combinations of farmyard manure, green manure and E-2001 tested in the trial did not have any statistically significant effect on table grape yield, average bunch weight, 100 berry weight, total soluble solids, and titratable acidity in both vineyards. The highest increase in fresh grape yield compared to non-treated plots was measured as 12.8 % in GM+E-2001 application in the grafted vineyard, compared with as 25.4 % in GM+FM+E-2001 application of self-rooted vineyard. Different manuring treatments did not have statistically significant effects on investigated parameters of dried grape in both vineyards with the exception of 100 dried berries weight in 2001 and expertise score in 2000 of the non-grafted vineyard. However, taking into consideration the improvements obtained by the tested manure applications compared to non-treated controls in two years, higher performance with statistical significance can be expected on the long term.

Introduction

Turkey is the main producer of seedless raisins in the world with 250 000 tons of production and 230 000 ton-exportation that amounts to almost 46 % of the world market. In Turkey, organic seedless raisin production started in 1984 and reached to 3 365 tons raisin production and 9 505 tons fresh grape production recently (Altindisli 2003). In this study, the effects of different manuring program on yield and quality of fresh and dried grapes in Round seedless (= Round sultana) variety have been investigated. Natural capacity of the soil is also determined in control parcels, where neither fertilizer nor manure was applied. Results are also compared with the regional averages of the conventional vineyards that are generally carried out as low-input agriculture.

Methodology

The study was conducted in two 0.5 ha-organic vineyards (OV_1 and OV_2) in Manisa Province in 2000 and 2001. In the first vineyard (OV_1) Round seedless variety was grafted on a *Vitis berlandieri x Vitis rupestris* rootstock, R-99, and trained as "Big T" trellising system. The second vineyard (OV_2) has the same variety, grown on its own roots and trained as "Y" trellis. The distances between and on-row spacing were 3x2.25 m in both vineyards. Soil characteristics of OV_1 and OV_2 were loamy and sandy loam, respectively. The experiment was conducted as randomized blocks design with three replicates. Each plot has one row of 30 vines. One row between each application was not evaluated to eliminate the border effect. Both vineyards received minimal tillage and soil was cultivated without turning. Vineyards were irrigated by furrow. Soil tension was recorded and physiological growth of vines was observed for scheduling of irrigation. To determine the effects of tested variables on quality of table and dried grapes, the following parameters were measured.

Table grapes: Yield (kg/vine), average bunch weight (g), 100 berries weight (g) (Amerine & Cruse 1960), total soluble solids content (TSS) (%), titratable acidity (as tartaric acid) (g/l).

Raisins: Raisin yield (kg/vine), dried/fresh grape ratio (%), 100 berries weight (g), Expertise score (Anonymous 2002).

The trial was composed of four treatments as follows**:**

a) Green Manure+Farmyard Manure combination (GM+FM):A mixture of 80 kg vetch+20 kg barley was sown per hectare between the rows at the end of September 1999 and 2000 for green manuring. At the beginning of April 2000 and 2001, 30 ton/ha of farmyard manure was applied to the rows of green manure, and then incorporated into the soil.

b) Green Manure+Farmyard Manure+E-2001 EM Bacterial Soil Inoculant combination (GM+FM+E-2001):E-2001 (Agricultural Research Technologies International, Inc., Bonham-Texas/USA) at a rate of 5 % + 80 kg vetch+20 kg barley and 10 ton/ha farmyard manure were applied on rows. At the beginning of April, fermented liquid was applied to the root area of vines at the dosage of 2000 ml/ha.

c) Green Manure+E-2001 EM Bacterial Soil Inoculant combination (GM+E-2001): E-2001 was applied (2000 ml/ha) after sowing of 80 kg vetch+20 kg barley hectare.

d) Untreated control: No fertilizer or manure was applied.

Results and brief discussion

In 2000 and 2001, the effects of GM+ FM, GM+FM+E-2001 and GM+E-2001 on fresh grape yield, average bunch and 100 berry weight, and total soluble solids and titratable acid content of grapes harvested in OV_1 and OV_2 and the comparison with the untreated control are shown in Table 1.

Table 1. Yield, average bunch weight, 100 berry weight, and total soluble solids and titratable acidity contents of fresh grapes

	OV_1				OV_2			
Treatment	Year 2000	Year 2001	Average	% Increase	Year 2000	Year 2001	Average	% Increase
Fresh grape yield (kg/vine)								
GM+FM	15.67	14.81	15.24	6.2	19.24	15.42	17.33	15.7
GM+FM+E-2001	17.13	14.66	15.90	10.1	21.85	15.16	18.51	25.7
GM+E-2001	15.02	17.77	16.40	12.8	17.01	15.90	16.46	16.4
Control	14.53	14.05	14.29	-	15.64	11.87	13.76	-
LSD %5	*n.s.*	*n.s.*	*n.s.*		*n.s.*	*n.s.*	*n.s.*	
Average bunch weight (g)								
GM+FM	424	445	434.5	14.41	400	511	455.5	7.90
GM+FM+E-2001	380	463	421.5	11.63	382	551	466.5	10.08
GM+E-2001	465	474	469.5	20.73	411	559	485.0	13.51
Control	359	385	372	-	376	463	419.5	-
LSD %5	*n.s.*	*n.s.*	*n.s.*		*n.s.*	*n.s.*	*n.s.*	
Average 100 berry weight (g/100 berries)								
GM+FM	143.29	167.00	155.15	6.77	155.06	136.00	145.53	-10.11
GM+FM+E-2001	154.61	138.50	146.56	1.33	152.92	191.40	172.16	6.92
GM+E-2001	152.84	127.30	140.07	-3.26	151.77	145.70	148.74	-7.73
Control	156.27	133.00	144.64	-	136.78	183.40	160.09	-
LSD %5	*n.s.*	*n.s.*	*n.s.*		*n.s.*	*n.s.*	*n.s.*	
Total soluble solids (%)								
GM+FM	20.43	19.20	19.82	-2.62	19.80	19.80	19.80	1.26
GM+FM+E-2001	20.73	18.90	19.82	-2.62	20.30	19.50	19.90	1.76
GM+E-2001	20.23	18.40	19.32	-5.28	20.00	19.30	19.65	0.51
Control	20.97	19.70	20.34	-	20.40	18.70	19.55	-
LSD %5	*n.s.*	*n.s.*	*n.s.*		*n.s.*	*n.s.*	*n.s.*	
Titratable acidity (g/l)								
GM+FM	5.33	6.23	5.78	-1.90	5.42	7.53	6.48	4.48
GM+FM+E-2001	5.31	6.78	6.05	2.64	5.33	7.65	6.49	4.62
GM+E-2001	5.40	6.59	6.00	1.83	5.41	7.32	6.37	2.83
Control	5.36	6.42	5.89	-	5.32	7.05	6.19	-
LSD %5	*n.s.*	*n.s.*	*n.s.*		*n.s.*	*n.s.*	*n.s.*	

Different treatments tested in the trial did not have any statistically significant effect on table grape yield, average bunch weight, 100 berries weight, total soluble solids, and titratable acidity in both vineyards. Fresh grape yield varied between 16.6 t/ha and 30.6 ton/ha in the experimental vineyards. The highest increase in yield compared to non-treated plots was measured as 12.8 % in GM+E-2001 application in the grafted vineyard, whereas as 25.4 % in GM+FM+E-2001 application of self-rooted vineyard. The highest increase in bunch weight was found as 20.73% and 13.51% in GM+E-2001 treatment in grafted and self-rooted vineyards, respectively. The average 100 berries weight increase was ca 7 %, 6.77 % in GM+FM applied grafted vineyard and 6.92 % in GM+FM+E-2001 applied self-rooted vineyard. Although the TSS content of grapes harvested from organic manure applied vines was lower than the untreated control, it was within acceptable levels since sugar content of grapes vary between 18 and 23 % at harvest for commercial drying in the Aegean Region. High TSS values obtained from untreated control could result from lower yield obtained in this treatment. Increase in titratable acidity was 2.64 and 4.62 % in grafted and self-rooted vineyards treated with GM+FM+E-2001 when compared to untreated control. The values obtained for yield and quality parameters are in agreement with the results obtained from conventionally grown fresh grapes in the Region (Ilter 1980; Ilhan e*t al.* 1991; Ilhan *et al.* 1992; Erdem *et al.* 1995; Altindisli 1997b; Yilmaz *et al.* 1997; Altindisli & Kismali 1998; Ilgin & Kismali 1998; Yilmaz *et al.* 1998; Ilhan *et al.* 1998; Ilgin *et al.* 2002; Altindisli *et al.* 2000; Yagci *et al.* 2004)

The effects of different manuring treatments on raisin yield, dried/fresh ratio, 100 dried berry weight, expertise score in 2000 and 2001 for the two vineyards (OV_1 and OV_2) and their comparison with the untreated control are presented in Table 2.

Table 2. Raisin yield, dried/fresh ratio, 100 dried berry weight, expertise score

	OV_1				OV_2			
Treatment	Year 2000	Year 2001	Average	% Increase	Year 2000	Year 2001	Average	% Increase
Raisin yield (kg/vine)								
GM+FM	4.11	3.86	3.99	11.78	4.98	4.11	4.55	21.10
GM+FM+E-2001	4.42	3.39	3.91	9.97	5.53	3.97	4.75	24.42
GM+E-2001	3.80	3.70	3.75	6.13	4.36	4.18	4.27	15.93
Control	3.70	3.34	3.52	-	4.15	3.02	3.59	-
LSD %5	*n.s.*	*n.s.*	*n.s.*		*n.s.*	*n.s.*	*n.s.*	
Dried/fresh ratio (%)								
GM+FM	26.21	26.08	26.15	5.16	25.90	26.65	26.28	1.10
GM+FM+E-2001	25.32	23.13	24.23	-2.35	25.32	26.21	25.77	-0.99
GM+E-2001	25.49	20.81	23.15	-7.13	25.65	26.31	25.98	-0.04
Control	25.78	23.81	24.80	-	26.53	25.45	25.99	-
LSD %5	*n.s.*	*n.s.*	*n.s.*		*n.s.*	*n.s.*	*n.s.*	
100 dried berry weight (g/100 berries)								
GM+FM	26.21	29.80 a	28.01	-2.61	25.90	36.20 a	31.05	9.11
GM+FM+E-2001	25.32	27.60 b	26.46	-8.62	25.32	35.30 a	30.31	6.90
GM+E-2001	25.49	30.00 a	27.75	-3.57	25.65	35.10 a	30.38	7.11
Control	25.78	31.70 a	28.74	-	26.53	29.90 b	28.22	-
LSD %5	*n.s.*	*2.011*	*n.s.*		*n.s.*	*3.570*	*n.s.*	
Expertise score								
GM+FM	9.25	9.50	9.38	2.67	9.00 a	9.00	9.00	3.00
GM+FM+E-2001	9.50	9.20	9.35	2.35	9.25 a	9.20	9.23	5.42
GM+E-2001	9.00	9.30	9.15	0.22	8.75 ab	9.00	8.88	1.69
Control	8.75	9.50	9.13	-	8.25 b	9.20	8.73	-
LSD %5	*n.s.*	*n.s.*	*n.s.*		*0.629*	*n.s.*	*n.s.*	

Different manuring treatments did not have statistically significant effects on examined criteria in both vineyards with the exception of 100 dried berries weight in 2001 and expertise score in 2000 of the non-grafted vineyard. The organically grown raisins were not different from conventional raisins (Ilter 1980; Ilhan *et al.* 1991; Ilhan *et al.* 1992; Erdem *et al.* 1995; Yilmaz *et al.* 1997; Altindisli & Kismali 1998. Altindisli *et al*. 2000; Ilgin *et al*. 2002). The highest increase rates in raisin yield were obtained as 11.78 % from GM+FM application in grafted vineyard and as 24.42 % from GM+FM+E-2001 treatment in self-rooted vineyard. Dried/fresh grape ratio was around 25 % that is similar to the regional average. In the experiment, the highest dried/fresh ratio was obtained from GM+FM treatment in both grafted (5.16 %) and self-rooted (1.10 %) organic vineyards. The largest dried berries in grafted vineyard were obtained from untreated control, GM+E-2001 and GM+FM treatments (31,70; 30,00; 29,80; *a*). The smallest dried berries were produced in GM+FM+E-2001 treatment (27,60; *b*). In self-rooted vineyard, all manuring treatments (GM+FM: 36,20; GM+FM+ E-2001: 35,30; GM+E-2001: 35,10; *a*) produced significantly larger berries than those of untreated control. Untreated control had the smallest berries with 29.9 g, *b*. Raisin berry sizes obtained in this study are similar to the results of the previous studies carried on conventionally grown raisins in the region. The effect of different manuring treatments on expertise score was significant only in self-rooted vineyard in 2000. The highest scores (9.00; 9.25) were obtained from GM+FM and GM+FM+E-2001 treatments, followed by GM+E-2001 (8.75) and untreated control (8.25) in the decreasing order. Expertise scores from the tested treatments were not found to be statistically different in 2000 and 2001. The expertise score of the great majority of raisins grown in the region generally ranges between 9 and 9.5 points (Altindisli 1997a).

Conclusion

The results presented comprise the first two years of a long-term experiment. During these years, the treatments did not display statistically significant effects on yield or on analyzed quality parameters of fresh and dried grapes, however, taking into consideration the improvements obtained by the tested manuring applications compared to non-treated controls, higher performance with statistical significance can be expected on the long term.

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COMPETITIVE ABILITY OF MAIZE IN MIXTURE WITH CLIMBING BEAN IN ORGANIC FARMING

Franc Bavec[1], Urška Živec[1], Silva Grobelnik Mlakar[1], Martina Bavec1[1], László Radics[2]

[1]University of Maribor, Faculty of Agriculture, Vrbanska 30, 2000 Maribor, Slovenia, Tel. +386 2 250 58 30, franci.bavec@uni-mb.si, www.uni-mb.fk , [2]Corvinus University of Budapest

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Abstract

Intercropped crops represent an important production system in organic farming, especially maize/climbing bean mixture due to its high content of protein in bean seeds for human diet, and producing silage for ruminants. To test this hypothesis, the effects of maize (Zea mays L.) sown as a sole crop and maize/climbing bean (Phaseolus vulgaris L. cv. Cipro) mixtures on maize plant height, maize leaf area index, bean leaf area index and grain yield were investigated in field experiments on an organic farm following accepted rules of certification. The maize/climbing bean mixture increased maize plant height as well as maize and bean leaf area and reduced maize grain yield in comparison with maize sown as sole crop, but 477.5 kg ha-1seed yield of bean sown in mixture was obtained. Maize was a stronger competitor than bean. The overall conclusion is that maize/bean mixture has promise for producing valuable yield of maize and bean, but mixtures needs further investigation.

Introduction

In organic farming systems designed in accordance with EU regulation 2092/91, agricultural systems are often based on intercropped plants growing in plant mixtures, especially intercropped maize (Zea mays L.) and grain legumes. Most researches have been focused on bush bean has and maize planted simultaneously in alternate rows (Willey and Osiru, 1972; Francis et al., 1978; Santalla et al., 1995; Pilbeam, 1996; Santalla et al., 1999; Santalla et al., 2001;), but in Slovenia and other countries in addition to intercropped maize and climbing bean (Phaseolus vulgaris L.). Maize/bean intercropping may help converse a deficiency of bean production in European countries (Santalla et al., 1995), for example in organic farming where maize for grain produced for human consumption. Due to high crude protein value and increased nitrogen digestibility for ruminants compared to maize silage (Anil et al., 2000), maize/climbing bean silage may be an important source of proteins for ruminants. Important benefits in organic farming of intercropping cereals with legumes are as follows: efficient competition of cereals with weeds, improved soil structure, reduced loss of plant nutrients, less damage of plants to pathogens and insects (Herrmann, 1993), and more available nitrogen due to nitrogen fixation with legumes, with up to 84% of nitrogen may be derived from fixation by climbing bean (Kumarasinghe et al., 1992. For yield performance in plant mixtures, the Land Equivalent Ratio (LER: Mead and Willey, 1980) has been used to measure the agronomic advantage of the mixture, and the aggressivity (McGilchrist and Trenbath, 1971) used to identify dominant species or subordinate species in the mixture. Leaf area is measured (Tethio – Kagho and Gardner, 1988a,b; Bavec and Bavec, 2001, Bavec and Bavec, 2002) and has shown a strong correlation with yield. In spite of cited literature, the growth and yield performance of mentioned crop mixtures in organic farming have not been traced in literature. The aim of this report is to compare influences of intercropped system (maize/climbing bean and maize mixtures) with maize sown as sole crop on some morphological changes and grain yield production in organic farming. In accordance with results we wish to initiate research for new production needs.

Methodology

In Majšperk (organic farm Živec), Slovenia, in two years, maize (Zea mays L.) was grown as a sole crop, maize/climbing bean (Phaseolus vulgaris L.) mixture and system performance observed in the field experiment. Initial experiment was performed only in three treatments in a randomized block design with four replications. Plots were 4.0 x 5.6 m, with a constant 0.7 m inter-row spacing (common in maize production practise). The soil texture was loam. Characteristics of soil in 1997 and 1998 were: 5.4 and 5.7 pH (0.1 N KCl), 2.6 and 2.3% of organic carbon, 9.0 and 11.0 P2O5 mg 100 g-1 soil (ammonium lactate), 14.0 and 17.0 K2O mg 100 g-1 soil (ammonium lactate), 139 and 159 kg ha-1 of mineral nitrogen (nitrate, ammonium), as measured in the soil layer from 0 to 0.9 m before maize sowing, respectively. Conventional tillage and fertilisation with stable manure (30 t ha-1) and cover crop (Phacelia tanacetifolia Benth.) with 2 t dry matter ha-1 were applied. The land race maize ‘dent type’ genotype was sown on 27 and 29 April (first and second year, respectively), and on 16 and 17 May the indeterminate-type climbing bean cv. Cipro. On 4 and 6 June the plants were thinned to the final stand. Plant populations were 5.6 plants m-2 of maize and 12.0 plants m-2 of bean in intercropping and the same plant populations in sole cropping. Weed control was done manually, depending on weeds. Maize plant height to cob at the stage of flowering (Maier code 57; Schütte and Meier, 1981), and green leaf area index (LAI) of all species was measured at the maize waxy maturity stage (83), when the maize expressed the maximum value of LAI (Bavec, 2002). Ten maize plants and ten bean plants from inside the plots for each repetition were taken to evaluation. Individual green leaf areas were measured using scanner and personal computer, which enabled counting the number of black dots on the screen picture of leaves to determine the leaf area (Bavec and Bavec, 2002). On this basis LAI value (leaf area units per unit land area) were calculated. Yield harvest was on 2 and 3 October in first and second years. Ten plants per each plot were weighed after drying (two months field ear drying and then 1 day at 70o C) and calculated as yield for silage kg ha-1. The grain yield was determined by harvesting 10 m-2 area from middle rows in plot and inside plants in row (Davis et al., 1981) in each subplot and replication. After drying (70 ºC, two days) the maize grain yield was calculated to the content of 14% moisture, and bean seeds with 11% of moisture. The Land Equivalent Ratio for maize (LER: Mead and Willey, 1980) was used to measure the agronomic performance of the mixture, allowing comparison of grain yield of maize and climbing bean in mixture with maize sown as a sole crop. LER values >1.0 indicate an agronomic benefit of growing a mixture over sole crops, since the index denotes how much land would be required for growing sole crops to obtain the same yields of each component as was obtained in the mixture. The aggressiveness (McGilchrist and Trenbath, 1971) of maize with respect to climbing bean is given by difference between grain yield of maize (mixture/sole crop) and the grain yield of bean (mixture/sole crop). LER values and aggressiveness were calculated for mean grain yield of maize and maize/bean mixture. Analysis of variance (ANOVA) among years and treatments was conducted using SPSSX for factorial experiments and the significance of factor effects, determined at $P \leq 0.05$ (*). Significant differences in the mean values were determined using the Tukey test at significance level $P \leq 0.05$, where different letters indicate significantly different means. The correlation coefficients between grain yield and LAI were calculated.

Results and discussion

In the experimental site the total rainfall during the vegetative period (from May to September) was 565 mm in first year and 681 mm in second year (30 years average is 566 mm). During the vegetative period among monthly rainfall total there were no considerable deviations in comparison with the long term averages. In second year June, July and August were warmer (average were 19.9, 20.7, 20.8^{o} C, respectively) compared to first year (19.0, 19.9 and 19.8^{o} C, respectively), but May and September were warmer in first year (16.4 and 16.1^{o} C, respectively) than in second year (15.7 and 15.1^{o} C). With regard to climatic requirements of these crops, it appears that conditions were normal for growth and development. Interactions of year by treatments for the measured parameters were not significant. Plant heights of maize to cob were not significantly different between years and ranged from 1.38 to 1.40 m. Maize/climbing bean mixture had significantly influenced taller maize plants (1.41 m) in comparison with maize sown as sole crop (1.35 m). Maize plant height was not significantly affected by maize/bean mixture. LAI of maize varied between years from 3.6 to 4.1, but LAI of maize was not significantly different in all treatments. Total system LAI of maize-climbing bean mixture was significantly higher (5.0) than LAI of maize sown as sole crop (3.7). In average, LAI of maize in all treatments varied from 3.8 to 4.1, similar to LAIs in the same plant populations in conventional farming system (Tethio – Kagho and Gargdner, 1988a,b; Bavec and Bavec, 2001, Bavec and Bavec, 2002). Bean and maize grain yields were significant ($P = 0.05$) between years, but the trends of treatment effects on yield are similar in both years, thus years were combined and averages reported. Averaged over two years, maize grain yield was significantly lower in maize/climbing bean mixture (11.20 kg 10 m^{-2}) compared to maize sown as sole crop (12.07 kg 10 m^{-2}), (Fig.1), but mixture produced also additional 0.48 kg 10 m^{-2} grain yield of bean.

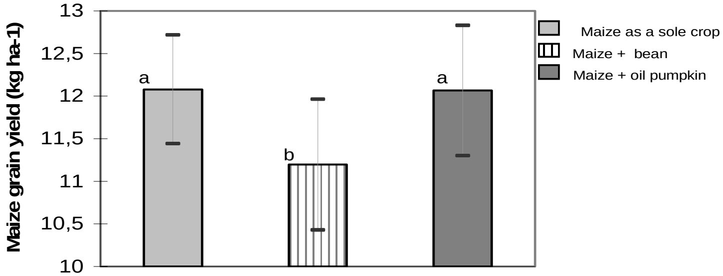

Fig. 1: Grain yield of maize as sole crop and intercropped (also with oil pumpkins)

At these experimental plants population before the ensiling process, similar trends were noted in plant dry matter production for total silage (maize sown as sole crop and maize/bean intercropping: 25.4 t and 24.5 t of silage ha^{-1}, respectively). Maize/bean mixture on the basis of our results produced high yield of mixed silage, the same as sole maize, but which could be an important source of protein from beans (grains of cv. Cipro content from 20.0 to 23.7% of crude proteins on dry weight basis) to improve ruminant nutrition (Anil et al., 2000). Mixture of maize with climbing bean is important in organic farming, similar to intercropped wheat and field beans (Bulson et al., 2000). Among LAI values in maize as sole crop and maize/bean mixture a positive correlation was calculated between LAI and grain yield (r = 0.98* and 0.95; r = 0.73 and 0.27, maize as sole crop and maize/bean mixture in 1997 and 1998, respectively). LER values for maize varied from 0.91 to 1.0 in 1997 and 1998 respectively, and averaged 0.98. LER $\leq$ 0.1 indicated a disadvantage due to intercropping. But LER varied between years in this trial (data not shown), and in other work similar maize LER values were found for maize and bush bean under long and short rains, and close to 1.0 in both seasons (Pilbeam et al., 1994). There could be an advantage to the intercropping due to higher silage value as economics of selling the two crops (data not shown). Aggressiveness index data for maize with respect to climbing bean were positive in both years (0.49 in 1997 and 0.44 in 1998, respectively) and averaged 0.45. This showed that maize was the stronger competitor. As previously found in bush bean (Francis et al., 1982; Pilbeam et al., 1994) maize was more competitive than climbing bean in experimental conditions.

Conclusions

On the basis of research results the following may be concluded: maize/climbing bean mixture increases plant height of maize, increases the sum of maize and bean leaf area index and reduces maize grain yield in comparison with maize sown as a sole crop. Maize/bean mixture can compensate for lower grain yield of maize with higher bean yield, especially if more than 20% of crude protein content in dry bean seeds should taken into account. We can conclude, that this initial investigation show that results of maize/climbing bean mixture are promising, and for those reasons further research should be done.

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PRODUCTION OF ORGANIC ORNAMENTALS IN GERMANY – A STATUS QUO ANALYSIS OF THE INDUSTRY

Bettina Billmann (1), Jutta Schaser (2), Dietmar Schlüter (3) and Wolfgang Schorn (4)

(1)Forschungsinstitut für biologischen Landbau (FiBL) Fachgruppe "Anbautechnik Einjährige Kulturen", Ackerstrasse, CH-5070 Frick, bettina.billmann@fibl.org

(2) Im Brühl 9, D 89257 Illertissen, jutta.schaser@web.de

(3) Arbeitsgemeinschaft Ökologische Baumschulen, Tarmstedter Str. 24, D 27404 Zeven, gaertnerhofbadenstedt@t-online.de

(4) HDLGN Wiesbaden, Mainzer Str. 17, D 65185 Wiesbaden, schorn@gartenbauberatung.de

Key Words: German Federal Organic Farming Scheme (BÖL), organic flowers, organic trees, organic ornamentals, production methods, status quo analysis

Abstract

In the German Federal Organic Farming Scheme (BÖL) project "Organic production of ornamental plants and nursery trees – structure of the industry, development, problems and required policy initiatives" a qualitative and quantitative survey of certified organic and conventional / integrated nurseries was carried out. The aim was to assess the current status of production and marketing of organic ornamentals in Germany and to provide an overview of the general framework of this industry.

The results show that organic production of ornamentals, trees and shrubs is technically feasible but still difficult. For further development this sector needs improvement of the basic conditions such as market structure, advisory services, subsidies and research activities.

Introduction

In the German Federal Organic Farming Scheme (BÖL) project "Organic production of ornamental plants and nursery trees – structure of the industry, development, problems and required policy initiatives" a qualitative and quantitative survey of certified organic and conventional / integrated nurseries was carried out. The aim was to assess the current status of production and marketing of organic ornamentals in Germany and to provide an overview of the general framework of this industry.

Methodology

To analyse problems and the action needed, first 36 gardeners working in conventionally and organically run nurseries were interviewed using specially designed interview guides. Results from these interviews were, following round table discussions, used to create questionnaires for all of the 190 listed operations growing organically and for 77 selected operations producing under conventional or integrated conditions.

The data on organic nurseries are based on statements made by ca. 30% of the producers of ornamentals and 45% of producers of trees and shrubs.

To provide an overview of the general framework, experts from market organisations, advisory services, inspection bodies, administration and research were interviewed.

Results

Structure of organic production of flower and tree nursery products

Currently approximately 1% of the nurseries producing ornamentals in Germany are organic. Considering the small scale of many of the organic units, the share of total sales of ornamental plants in Germany - which amounted to 2.4 billion Euros or 7.6% of agricultural production in 2001 - is likely to be lower.

Field and greenhouse production of organic annuals and perennials totals an estimated 56 ha and 12 ha, respectively. Organic field and container production of trees and shrubs totals an estimated 370 ha and 7 ha, respectively.

44% of the nurseries producing flowers, 55% of the nurseries producing perennials and 70% of the tree nurseries were newly founded in the nineties. This trend did not continue after the turn of the millennium.

90% of the organic nurseries surveyed would choose organic production again if faced with the question of conversion a second time.

Table 1. Structure of the "Organic Ornamentals" sector in Germany

	Flower nurseries	Tree nurseries
Total number		
Total number of flower and tree nurseries in Germany	11 200	3 800
Total number of organic nurseries	146 ≅ 1.3%	44 ≅ 1.16%
Total number of integrated flower nurseries (DGZ*)	85	
Number of analysable questionnaires		
- Organic	48	19
- Conventional (DGZ*)	47	-
Area under cultivation		
Total area under cultivation in Germany (outdoor and greenhouse)	7 056 ha	24 690 ha
Area under organic cultivation		
- Outdoor	56 ha	377 ha
- Greenhouse	12 ha	-
Turnover		
- Conventional ornamentals (2001)	€ 1 506 million	€ 910 million
- Organic ornamentals (estimated)	< 1%	< 1%

* DGZ - "Das Grüne Zertifikat": Integrated production label of ornamentals in Germany

Problems

Fewer problems than anticipated were encountered in production – even in pest and disease management. However, problems persisted in weed control and continuity of nutrient supply from the growing media. Other challenges were the sourcing of organically acceptable inputs (such as seedlings or growing media) in the production of annuals and perennials. In tree nurseries, especially the decline in plant vigour caused by the common practice of successive planting of rosaceae raised difficulties.

Marketing was reported to be the biggest problem for nurseries which engage in direct marketing. Wholesalers anticipated continuity and consistency of supply of quality product as their biggest problems.

The majority of organic operations surveyed encountered financial difficulties during the conversion period and afterwards.

More than 30% of integrated growers have already considered organic production, but have not pursued this idea further for economic reasons.

The operations surveyed noted that organic standards need expansion and revision to cover their industry; and that organic inspectors lack sufficient technical knowledge. State subsidies for organic ornamental nurseries were found to be inconsistent among the individual states of the Federal Republic of Germany.

A great need for an organic advisory service for these types of operations was reported, which has not been met sufficiently to date. Further, there is almost no research on the organic production of ornamentals.

Action needed

The survey showed a great need for co-ordination and streamlining of this industry. In particular the following policy initiatives were recommended by the authors:

- Installation and funding of a national system of advisory services focusing on the use of beneficial insects
- Improvement of products and methods of liquid fertilisation and non-chemical pest management
- Development of concepts for increased cost recovery
- Measures for improving the availability of organic propagation material
- Perfection and price reduction of weed control methods
- Support for research on decline in plant vigour caused by successive planting of rosaceae in tree nurseries

- Establishment of marketing organisations bringing about more successful sales of organic ornamental plants and nursery trees

- Funding of publicity campaigns and promotion material on organic ornamentals

- Establishment of efficient advisory bodies and drafting of advisory material

- Provision of adequate subsidies for growers of organic ornamentals and harmonisation at national level

- Adoption of directives that focus research on questions of organic horticulture – especially to provide guidance for growers – and provision of research funding.

Conclusions

The production of organic ornamentals, trees and shrubs is still in a pioneering stage. This status quo analysis proves: It is possible to implement organic production of ornamentals as a sustainable and safe form of production. The sector could become a leading example for the horticulture industry as a whole if support by public authorities, advisory services and research organisations was provided, as well as adequate subsidies.
Up to now almost no organisational structures have been established in the field of organic ornamentals. This presents a window of opportunity to develop an optimal system from the outset. A round table of experts consisting of producers, advisors, administrators and scientists is needed to foster the ongoing development of the organic ornamentals sector.

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Soil Quality Comparison between Organically and and Conventionally Managed Citrus Orchards in Eastern Sicily (Italy)

Stefano Canali [(1)], Emanuela Di Bartolomeo [(1)], Biagio Torrisi [(2)]

(1) ARC, Agricultural Research Council - Experimental Institute for Plant Nutrition, Via della Navicella, 2 - 00184 Roma, Italy – stefano.canali@entecra.it – www.entecra.it

(2) ARC, Agricultural Research Council - Experimental Institute for Citrus Production, Corso Savoia, 190 – 95025 Acireale (Catania), Italy

Key Words: organic farming, soil quality, soil fertility, citrus, organic matter mineralization

Abstract

The aim of this work was to compare soil fertility status of conventional and organic managed citrus orchards, using specific soil system descriptors. The research was carried out in a Mediterranean environment (Sicily region, Southern Italy), on Navelina and Tarocco orange orchards. Soil characteristics were analysed in 54 farms under both organic and conventional management. Farms were selected to obtain similar pairs (27) in the same environmental conditions. For each soil, total organic carbon, total nitrogen, mineral NO3-N and NH4-N were determined. In addition, in order to evaluate biological fertility status of soils, carbon mineralisation and nitrogen mineralisation in anaerobic conditions were studied. Soils humic fraction was at least characterised qualitatively by isoelectric focusing technique, to obtain information on soil organic matter stability. Results obtained attest that the organic citrus orchards soils are able to conserve energy and store nutrients more than the conventional ones.

Introduction

In order to verify if the organic farming cultivation method could determine an increase in the quality of environment, complying with the consumers expectation and political targets, we wanted to evaluate the effects of the organic farming management on soil quality and fertility status of Mediterranean citrus orchards, one of the most important organically managed crop in Italy. Liebig and Doran (1999) discussed the impact of organic production practices on soil quality. Accordingly, in a previous paper, Intrigliolo *et al*. (2000) demonstrated that organic management, in contrast to the conventional one, induced only slight differences on main soil physical and chemical characteristics in citrus orchards of Southern Italy. Since it is well known (Nannipieri, Grego, 1990) that biochemical parameters are suitable and sensible indicators able to detect changes in soil properties, the aim of our work was to verify if introduction of organic farming system could induce differences in the biochemical characteristics of soils, by using some specific soil system descriptors in a field survey approach.

Material and Methods

The research was carried out on citrus orchards (Navelina and Tarocco orange) located in the Eastern Sicily (Italy). Soil characteristics were analysed in 54 farms under both organic and conventional management. Farms were selected to obtain similar pairs (27) in the same environmental conditions. Moreover, orchard pairs were homogeneous in age, cultivar and rootstock to reduce effects not linked to soil management. At soil sampling, the requested three years conversion period foreseen by the low in force (EEC. Regulation 91/2092) was completed for all organic citrus orchards. Soils were sampled in January and February and analysed, according to official guidelines (Intrigliolo *et al*., 1999). In Table 1, main physical and chemical parameters of considered soils are reported.

Organic carbon amount and turnover: Total organic carbon (TOC, $mg \times kg^{-1}$) was determined by Walkley-Black's method.

Estimation of organic carbon mineralisation was performed by measuring $C\text{-}CO_2$ production [$mg(C\text{-}CO_2) \times kg^{-1}_{soil} \times d^{-1}$] by soil in closed environment (Isermeyer, 1952). The kinetic study of organic carbon dynamic was performed by fitting the cumulated data to experimental curves by first order exponential equations $C_t = C_0(1\text{-}e^{-kt})$. This elaboration allowed to calculate the potentially mineralisable carbon C_0 [$mg(C) \times kg^{-1}_{soil}$] and the kinetic constant k ($days^{-1}$) for each investigated soil. Mineralisation coefficients were determined to obtain information on mineralisation activity related to the different farming management. In order to evaluate the level of stability reached by the soil organic matter, humic fraction extracted from soils was characterised by isoelectric focusing technique (IEF) according to Canali et al. (1998). IEF peaks were numbered and the peaks' area was determined for each soil IEF profile, assuming as 100% the area under the entire IEF profiles. The sum of peaks' areas focused at pH>4.5 (corresponding to more humified organic matter) and was calculated and named A_s%.

N content and mineralization: Total nitrogen (N_{tot}., $mg \times kg^{-1}$) was measured by Kjeldahl's procedure. Soil inorganic N ($mg \times kg^{-1}$) in 1:10 soil-KCl (2M) extracts were estimated by continual flow colorimetry. Potentially mineralisable N (NPM) was estimated from the NH_4-N ($mg \times kg^{-1}$) accumulated after 7 days of anaerobic incubation at 40°C, according to Sahrawat and Ponnamperuma (1978), slightly modified by Canali et al. (2004).

Statistical analyses: Obtained results were elaborated by ANOVA (organic *vs.* conventional management).

Results and Discussion

In table 2, mean values of all investigated parameters measured in conventional and organic managed soils are reported.

Organic carbon amount and turnover: TOC values, representing one of the main parameters used to define soil fertility, were higher in organic managed soils (13322 $mg \times kg^{-1}$) in contrast to conventional ones (10776 $mg \times kg^{-1}$), even if the differences showed no statistical significance ($p = 0.15$).

Some examples of obtained cumulative curves for C mineralisation, related to organic and conventional managed citrus orchard soils, are reported in figure 1. Carbon mineralisation has been considered a reliable property to evaluate soil microbial activity (Anderson and Domsch, 1985), being able to inform of soil metabolic status and organic matter turnover (Trinchera et al., 2001).

For all investigated soils, first order exponential equation was able to fit experimental data and basal respiration was reached after 21 days of incubation. C_1, C_7, C_{21} and C_0 (table 2) were higher in organic than in conventional soils, being statistically highly significant in the case of C_7, C_{21} and C_0 (p = 0.01, 0.03 and 0.01, respectively). On the other hand, mineralisation coefficients, lower in organic soils, suggested a decreased energy demand and a reduction of organic matter consumption in these soil systems compared to the conventional ones (Flieβbach and Mäder, 1997).

Isoelectric focusing is an electrophoretic technique, which is commonly used to investigate humic matter extracted from soils (Ciavatta e Govi, 1993), fertilisers (Govi et al., 1991) and soil conditioners (Canali et al., 1998). It is based on the separation of different humic substances on the basis of their isoelectric point and their molecular weight. It is well known the more is humified the organic matter, the higher is its isoelectric point, so that the organic molecules focus at higher pH values (Govi et al., 1994). Comparing the IEF patterns of each soils pair (figure 2), differences in the less acidic part of the profiles, corresponding to the pH values higher than 4.5, were noticed. In order to quantitatively evaluate these differences, we calculated the area's sum of the peaks focused at pH>4.5 (A_s %). A_s parameter was higher in organic soils in contrast to the conventional ones (table 2) and, even if this difference was not statistically significant, it was verified in 75 % of the total cases. Since more humified organic compounds focus on correspondence of higher values of pH, this finding indicated that organic matter extracted from organic soils was characterised by higher level of humification.

N content and mineralization: N_{tot} was higher in organically managed soils (1289 $mg \times kg^{-1}$) in contrast to conventional ones (1083 $mg \times kg^{-1}$), even if the differences showed no statistical significance (table 2). Although, for this parameter, a strong tendency to an increase of N content in organic soils was revealed by the low p values (0.20), very close to the significance. This finding seemed to indicate an increase of the long term storage of this nutritive element in organically managed systems. No significant differences were also detected about the other tested parameter describing N turnover in soil.

All results reported above referred to cumulative mineralised carbon, higher in organic managed soils. Together with the lower values of mineralisation coefficients, this suggested an increased metabolic efficiency in organic citrus orchards, which corresponded to a better ability to conserve energy (higher C content) and to storage nutrient (higher N content). Moreover, the higher values of A_s% in organic managed soils could be due to i) the tendency to prevent more humified organic matter fraction from mineralisation or ii) the presence of humic matter of neo-formation. In any case, obtained data confirmed a positive humic balance in organically managed systems. Obtained results allowed us to affirm that C-mineralisation could represent the most prompt indicator able to evidence changes on soil biological fertility, due to the different farming management.

Conclusion

The chemical and biochemical parameters considered in this work furnished information on differences in soil quality and fertility between organic and conventional managed systems. In fact, organic soils were characterised by a higher C-mineralisation (higher C_7, C_{21}, C_0), a higher humification level (higher values of A_s), an increase in soil nutrient (N) and energy (C) pools (higher TOC and N) and a better efficiency in organic matter turnover (lower C-mineralisation coefficients). These findings suggest that organic managed soils could be considered as more conservative systems. Generally, as theorised in Odun's hypothesis (1969), natural ecosystems show a balance in energy and nutrients economy, being characterised by an equilibrium between the organic matter input and the residual organic matter amount (Pinzari et al., 1999). Thus, organic managed soils seem to be ecosystems in which transformations toward a new status, more similar to that of natural self-regulating systems, have begun.

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Table 1. Main physical and chemical parameters (mean values).

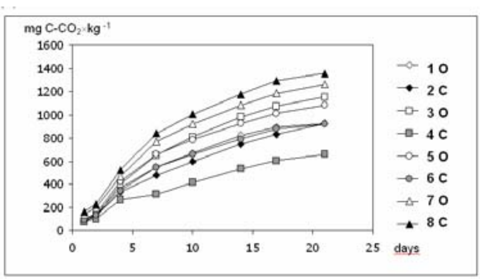
Parameter	**Organic**	**Conventional**
Clay (%)	33.9	31.7
Silt (%)	21.6	20.7
Sand (%)	44.5	47.6
pH	8.0	7.9
$EC_{1:2}$ (mS cm^{-1})	0.34	0.39
Active lime (g kg^{-1})	57	46

From: Intrigliolo *et al*., 2000.

Table 2 Farming management effect on tested soil chemical and biochemical parameters.

Parameter	Conventional	Organic	*p*-level	Sign
TOC ($mg \times kg^{-1}_{soil}$)	10776	13322	0.15	ns
C_1 ($mg \times kg^{-1}_{soil}$)	102	120	0.30	ns
C_7 ($mg \times kg^{-1}_{soil}$)	347	514	0.01	*
C_{21} ($mg \times kg^{-1}_{soil}$)	552	827	0.03	*
C_0 ($mg \times kg^{-1}_{soil}$)	575	894	0.01	*
C_1/TOC (%)	1.01	0.89	0.28	ns
C_{21}/TOC (%)	6.69	6.14	0.64	ns
A_s (%)	54.70	59.30	0.27	ns
N_{tot} ($mg \times kg^{-1}_{soil}$)	1083	1289	0.20	ns
NO_3^--N ($mg \times kg^{-1}_{soil}$)	2.44	2.22	0.85	ns
NH_4^+-N ($mg \times kg^{-1}_{soil}$)	7.19	8.0	0.32	ns
NPM ($mg \times kg^{-1}_{soil}$)	34.10	39.0	0.76	ns

Mean values, *p*-level and relative significance are reported



Figures 1: Some cumulative curves of C-Mineralisation for organic (O) and conventional (C) soils

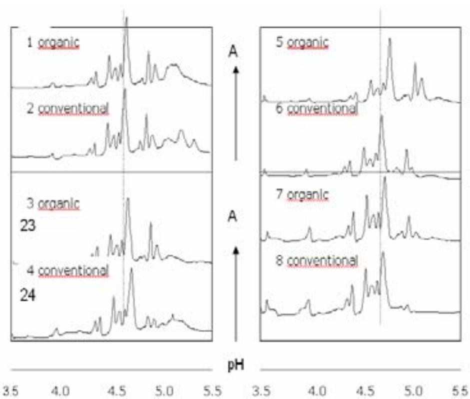


Figure 2: IEF profiles of humic matter extracted from some organic and conventional soils.

BALANCING FERTILIZATION STRATEGY WITH CROP REQUIREMENTS IN ORGANIC GREENHOUSE CULTIVATION OF SWEET PEPPER

W.J.M. Cuijpers, (1), W. Voogt (2) and C.J. Koopmans (1)

(1) Louis Bolk Institute, Hoofdstraat 24, 3972 LA Driebergen, The Netherlands, Tel. +31-343-523860, E-mail: w.cuijpers@louisbolk.nl, Internet: www.louisbolk.nl

(2) Applied Plant Research, Kruisbroekweg 5, 2650 AA Naaldwijk, The Netherlands

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Abstract

An on-farm field trial was set up in an organic greenhouse in order to balance the N-uptake by a sweet pepper crop and the mineralization of the organic fertilizers was applied. The effects of six fertilizer treatments were compared regarding yield, nutrient availability and mineral balance. Application of high levels of compost turned out to be favourable in order to reduce surpluses of available-N on the short term. On the long term, such high levels of compost are unfavourable as a high pool of mineralizable-N in the soil organic matter restricts the possibilities for precise fertilization adapted to plant uptake. Application of lower levels of farm yard manure in combination with additional fertilization with feather meal turned out to be a good fertilization strategy both on the short and the long term unless there is a need for minimizing salt levels in the applied fertilizers.

Introduction

The production of typical glasshouse crops like sweet pepper, tomato and cucumber demands very high levels of nutrient supply to cover the high nutrient uptake. Unlike conventional glasshouse crops grown in substrates and applying a (partially) closed system, organic farming is restricted to cultivation of soil and may be prone to environmental losses when such high nutrient levels are involved. Supply and demand of nitrogen should be balanced in order to prevent leaching and denitrification. The BIOKAS project is a participatory research project, involving 11 organic growers in on-farm monitoring and research. One of the aims is to develop fertilization strategies that support both soil quality and plant production, with a minimum of nutrient emission to the environment. In the experiment, 6 fertilization strategies were tested and analysed regarding plant production, nutrient availability, and mineral balances.

Methodology

An on-farm field trial was carried out in an organic greenhouse with a hot-airheating system during one growing season of sweet pepper. The greenhouse is located in the south-western part of the Netherlands on young sea clay at Sint Annaland, Tholen. The soil is a light, calcium rich loamy soil with at shallow depth (49 cm) a sandy subsoil, classified as a Poldervaaggrond. The soil organic matter contents is 3.4 percent. N, P and K requirements of the crop were estimated based on a yield expectation of 14.5 kg/m2 sweet pepper. Two types of commercially produced Yard Waste Compost (YWC1 and YWC2) based on pruning and trimming materials and Farm Yard Manure (FYM) of composted, straw-rich cattle manure were used as providers of organic material in the soil. In order to obtain a fast-available source of nitrogen, two treatments were chosen: either feather meal (FEM) or a mix of two soluble fertilizers (SOL): Aminosol™ (a rest product of gelatine production) and Fontana Potash™ (a rest product of sugarbeet-processing). Sulphate of Potash (SOP) was used as an additional source of potassium. Nutrient contents and C-turnover rates of organic amendments were determined in laboratory analysis. From the C-turnover rate, the initial-age (I-age) of the organic fertilizers was calculated according to Janssen (1986), as input data for the NDICEA model. Before the start of the experiment, estimations of the nitrogen supply by the soil organic matter, previous fertilizations and crop residues were made using NDICEA, as well as estimations of nitrogen supply by the applied organic fertilizers, using default values for the initial age as set in the NDICEA programme (Koopmans and Bokhorst, 2002). Yields of 12 plots were measured weakly. Pruning material was collected during the season from 6 plots as a pool sample in open woven bags to become air-dry. Poolsamples were further dried and analysed for nutrient contents. At the end of the growing seasons, plants of all plots were collected, weighed, dried and analysed. On 4-week intervals, soil samples were taken from

12 plots at 0-25 cm depth. Plant and soil samples were analysed for nutrients and trace elements. The following 6 treatments were compared (Table 1): (1) YWC1-HS; high supply of compost (type I) as base dressing (224 tonnes/ha); (2) YWC1-HB; high supply of compost type I (100 tonnes/ha as base dressing and 124 tonnes/ha in 5 batches as top dressing); (3) YWC1-LS; low supply of compost (type I) as base dressing (100 tonnes/ha), supplemented with FEM and SOP as top dressing; (4) YWC1-SOL; low supply of YWC (type I) as base dressing (100 tonnes/ha) supplemented with a combination of commercial soluble fertilizers (SOL) as top dressing. (5) FYM; cattle manure (30 tonnes/ha) as base dressing supplemented with FEM and SOP as top dressing; (6) YWC2-FT; low supply of compost (type II) as base dressing (Farmer Treatment) (100 tonnes/ha) supplemented with FEM and SOP as top dressing.

Table 1. Overview of fertilizer treatments. The field trial includes two plots per treatment, each plot measuring 32 m2. Supply fertilization was carried out in week 14. Application of additional fertilizers in solid form (FEM and SOP) is done in batches in 4-week intervals at weeks 14, 19, 23, 27 and 31. Application of the additional soluble fertilizers (SOL) Aminosol ™ and Fontana Potash ™ is done in two-week intervals. [1] Composted material type 1; [2] Composted material type 2.

Code	Organic fertilizers	Amount (tonnes/ha)	Timing	Additional fertilizers	Amount (kg/ha)	Timing
FYM	Farm Yard Manure	30	Supply, before start season	Feathermeal Sulphate of Potash	5 x 531 kg/ha 5 x 500 kg/ha	5 batches
YWC1-HB	Yard Waste Compost [1]	224	100 tonnes at start season, 4 batches of 31 tonnes at 4-week intervals	Feathermeal	5 x 313 kg/ha	5 batches
YWC1-SOL	Yard Waste Compost [1]	100	Supply, before start season	Fontana ™ Aminosol ™	10,450 kg/ha 688 kg/ha	10 batches
YWC2-FT	Yard Waste Compost [2]	100	Supply, before start season	Feathermeal Sulphate of Potash	5 x 500 kg/ha 5 x 500 kg/ha	5 batches
YWC1-HS	Yard Waste Compost [1]	224	Supply, before start season	Feathermeal	5 x 313 kg/ha	5 batches
YWC1-LS	Yard Waste Compost [1]	100	Supply, before start season	Feathermeal Sulphate of Potash	5 x 500 kg/ha 5 x 375 kg/ha	5 batches

Results and brief discussion

The N, P and K uptake of sweet pepper were estimated to be 552, 63 and 735 kg/ha respectively, based on a yield expectation of 14.5 kg/m2. The mean yield that was actually obtained in the six treatments was 13.7 kg/m2 and varied between 13.4 and 14.0 kg/m2. Mean values of measured nutrient uptake from peppers, crop residues and plants were 455 kg N/ha, 58 kg P/ha and 655 kg K/ha respectively. N-mineralized was estimated using NDICEA modelling and initial age as determined in lab experiments. Mineral balances of N-mineralized, total-N, P and K varied considerably between the different strategies (see figure 1). The N becoming available during the growing season (26 weeks) through mineralization of soil and fertilizers was in all cases lower than the total plant uptake. This resulted in a decrease of the stock of readily available N-mineral in the soil. The most favourable strategy regarding N-mineralized was the application of 224 tonnes/ha of yard waste compost applied in batches (YMC1-HB), with very little additional fertilizers (FEM). The amount of N becoming available through mineralization of soil and fertilizers in 26 weeks was 217 kg N/ha <u>less</u> than the total plant uptake. The strategy using 100 tonnes of type II compost (farmer treatment) and additional fertilizers (YMC2-FT) was least favourable (55 kg N/ha <u>less</u> mineralized than total plant uptake). The commercial compost type II turned out to have much higher turnover rates in the lab experiments, as well as higher nutrient contents. When analysing the results regarding total N supply of the fertilization strategies, results differ. In the case of total N supply, the treatments using high amounts of compost turned out the most unfavourable, with N-surpluses of 874 kg N/ha (YWC1-HB) and 811 kg N/ha

(YWC1-HS) respectively. Calculations are based on total N-contents of harvested peppers, plants and pruning material. The application of farm yard manure (FYM) was most favourable, providing a surplus of only 45 kg total-N/ha. Mineral balances of K where not fine-tuned as the application of SOP was not diminished after having obtained the results of the nutrient analysis of the organic fertilizers. P-balances are highly unfavourable in case of YWC1-HS, YWC1-HB (where 224 tonnes/ha was applied) and YWC2-FT, as the compost type II contained much higher P levels than the commercial compost type I.

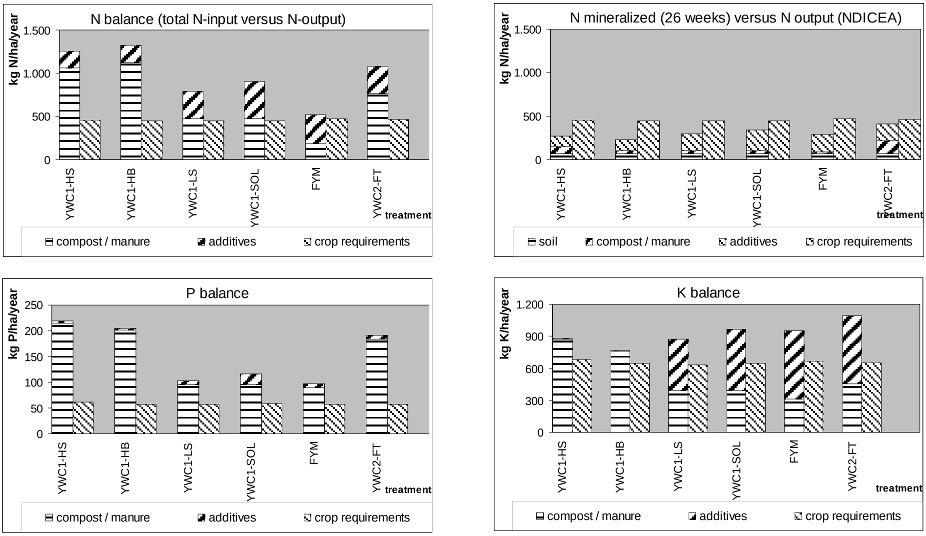

Figure 1. Mineral balances of total-N, N-mineralized, P and K for the different treatments during the growing season (26 weeks). Left columns indicate supply of fertilizers, right columns indicate total plant uptake (peppers, pruning residues and plant contents at the end of the season). N-mineralized was calculated by NDICEA.

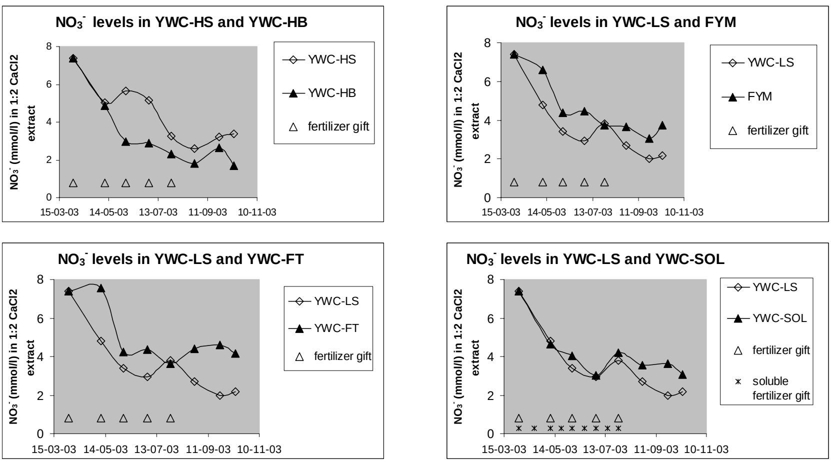

Figure 2. Monitoring of nitrate in 1:2 volume $CaCl_2$ extract during the growing season of sweet pepper. Each graph shows a comparison of two treatments.

Monitoring of nutrient levels (see figure 2 for NO_3^-) showed that both nitrate and potassium levels were lowest in the strategy were compost was applied at a high level, but in batches during the season (YWC1-HB). Also salt levels (sulphate) were lowest using this strategy.

When compost is applied as top dressing without tillage during the growing season (YWC1-HB), decomposition is likely to be restricted. On the short-term, this strategy prevents high nutrient levels and reduces losses to the environment. However, the compost will be mixed into the soil at the end of the growing season and will as yet contribute to the available N-pool. The highest levels of nitrate (average level of 4.7 mmol l^{-1}) were found in the strategy were type-II compost (YWC2-FT) was applied. The highest potassium and sulphate levels (average levels of 4.2 and 10.2 mmol l^{-1}) occurred in the FYM treatment. High levels of potassium and salts will contribute to a higher EC level in the soil, but may also hold the risk of salination. High amounts of compost contribute to a large pool of quickly decomposing organic matter in the soil. This pool is a continuous source of N-supply, also in those periods of the growing season where crop demands are low; for example at the very start and end of the growing season. From the BIOKAS project followed that high peaks of N-mineral occur often at the start of the growing season. (Cuijpers *et. al.*, 2005) From the environmental point of view, it is preferable to reduce compost gifts to the minimum amount necessary to maintain soil organic matter levels at an adequate level. Preference should be given to compost types with slow C-turnover rates, low N-contents or a high C/N ratio. In all strategies the total quantity of available N was higher than the crop requirements. This was due to lower yields than calculated, and lower N contents in plant tissue on the one hand, and higher N availability from the composts on the other. Denitrification in this investigation was estimated using the NDICEA model. From research closely connected to this experiment followed that denitrification losses in organic greenhouses can be substantial, although precise measurements are difficult due to high variability in soil water contents caused by the applied irrigation systems (de Visser *et.al.*, 2004). Hence for practical application, fertilization strategies aiming at a certain surplus are unavoidable. In greenhouse production, with high cost levels, it is unacceptable for growers to take the risk of yield reduction caused by N-shortage. For further improvement of sustainable organic farming, it is necessary to further develop adequate models for prediction of the N-cycle in greenhouse soils. Next to the problem of finetuning the N-availability with crop requirements in total and during the growing period, there is the problem of P accumulation. In all strategies under investigation, the P supply was much higher than the demand. Improving the P-balance in organic farming must be the next step to be taken.

Conclusions

Application of high levels of compost turned out to be favourable in order to reduce surpluses of available-N on the short term. On the long term, such high levels of compost are unfavourable as a high pool of mineralizable-N in the soil organic matter restricts the possibilities for precise fertilization adapted to plant uptake. Application of lower levels of farm yard manure in combination with additional fertilization with feather meal turned out to be a good fertilization strategy both on the short and the long term unless there is a need of minimizing salt levels in the applied fertilizers.

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GENOTYPE AND ENVIRONMENT INTERACTION ON YIELD AND QUALITY PARAMETERS OF ORGANICALLY GROWN WINTER WHEAT – TRITICUM AESTIVUM L. GENOTYPES

Ichinkhorloo Dashbaljir (1), P. Liebhard (2), W. Hartl (3), F. Löschenberger (4), M. Weinhappel (5)

(1) Mongolian State University of Agriculture, P.O. B-260, 211137, Ulaanbaatar, Mongolia, +976-11633371, d_ichin@yahoo.com
(2) Institute for Agronomy and Plant Breeding, University of Natural resources and Applied Life Sciences Vienna, Gregor Mendel Strasse-33, A-1180, Vienna, AUSTRIA,+43-1-476543303, peter.liebhard@edv1.boku.ac.at
(3) Ludwig Boltzman Institut, Rinnböckstrasse-15, A-1110 Vienna, AUSTRIA,+43-1-7951497943, wilfried.hartl@univie.ac.at
(4) Saatzucht Donau GesmbH&Co KG, Saatzuchtstraße-11, A-2301 Probsdorf, AUSTRIA, +43 6645126105, franziska.loeschenberger@saatzucht-donau.at
(5) Institute for Seed, Agricultural Inspection Service and Research Centre Vienna, Spargelfeldstrasse-191, A-1226, Vienna, AUSTRIA,+43-1-732164229, manfred.weinhappellwvie.ages.at

Key Words: Organic farming, winter wheat, yield parameters, quality parameters

Abstract

The interaction of genotype and environment upon yield and quality parameters of eight winter wheat (*Triticum aestivum* L.) genotypes was studied under organic conditions in Austria over two growing periods, 2001/2002 and 2002/2003, respectively. Two sites that have significantly different climatic conditions, Innviertel and Marchfeld, were chosen for the field experiment.

Study site weather and soil conditions are important yield-affecting factors. Although the yield of Marchfeld-grown genotypes were lower, they had shown higher quality parameter values. Soil moisture conditions increase the grain yield but decrease its quality. To obtain seed with higher quality, a production site with favourable climate conditions should be chosen.

Introduction/Problem

Agriculture in industrial countries over the last 20 years has been going through strong structural change. Increasing operating costs and surplus production are seen in many sectors. The intensive application of synthetic plant treatment products and water-soluble nitrogen fertilizers can lead to higher yields, but also to the pollution of ground water. This in turn reduces the natural soil fertility and creates soil erosion.

Organic farming is one of the key issues in reshaping European agricultural policy, with economic and political questions of organic farming becoming increasingly important. Organic farming can be seen as an approach to agriculture where the aim is to create integrated, humane, environmentally and economically sustainable agricultural production systems.

Organic farming is more than just an environmentally friendly production method. It is also seen by consumers as producing ‘wholesome’ food. Consumers most often refer to the fact that organic crops are not treated with chemical pesticides, i.e. that they are free of chemical residues (De Waart, 1998).

The organic farming system differs fundamentally from conventional agriculture in the management of soil fertility, weeds, diseases and pests. This implies a greater need for ‘reliable’ varieties, which means varieties with a greater buffering capacity and flexibility to cope with such conditions compared to conventional farming systems (Lammerts, 2003).

Methodology

Field experiments were conducted with eight winter wheat (*Triticum aestivum* L.) genotypes. These were carried out at two different study sites, detailed in Table 1, which differ significantly with regard to climatic conditions. The growing periods were 2001/2002 and 2002/2003, hereafter termed 2002 and 2003, respectively.

Table 1. The study sites' environmental condition

Study sites	Elevation, m	Location in Austria	Soil type	Annual mean rainfall, mm	Annual mean temp., °C
Innviertel	350	Upper Austria	Eutric cambisol	834	8.5
Marchfeld	150	Lower Austria	Chernozem	500	9.2

Ear emergence data was recorded in day numbers (after May 1) when 80% of ears had emerged. Yield was recorded in dt per hectare (dt/ha) after combine harvesting. Thousand kernel weight (TKW) and hectolitre weight (HLW) were determined according to the ICC standard method. Kernels were milled to flour using an AQC 109 lab mill (Agromatic AG, Laupen, Switzerland). The milled samples were put in the dryer at 104°C for 4 hours.

Kernel and straw nitrogen content were analysed by C/N Analyser LECO (USA) equipment. The raw protein content was expressed as:

Kernel protein (%) =Nitrogen (%)*5.7 (5.7 = conversion factor for raw protein content)

Kernel gluten content was determined by NIT (Near Infrared Transmission) according to the ICC standard method. The wet gluten content is recorded in percent.

Combined analysis of variance (ANOVA) was used to determine the effects of genotype, year, study site, genotype-by-year, genotype-by-site, site-by-year, and genotype-by-year-by-site interactions for the relevant parameters. Pearson's correlation coefficients (r) were used as measure of the phenotypic association between the parameters.

Results and discussion:

Table 2. Mean values and ranges of the EED, yield and quality parameters

Location of harvest	Innviertel 2002		Innviertel 2003		Marchfeld 2002		Marchfeld 2003	
	Mean	Range	Mean	Range	Mean	Range	Mean	Range
EED (days after 1 May)	23	21-24	26	24-28	22	17-28	25	23-26
Yield (dt/ha)	64.86	56.5-75.5	66.15	62.0-71.5	47.12	44.7-52.7	45.58	36.3-50.1
TKW (g)	41.53	38.9-42.1	40.89	39.0-41.8	38.78	32.7-42.4	36.69	35.0-38.5
HLW (g)	83.38	81.6-86.1	83.51	81.7-84.8	79.98	73.1-82.0	83.13	81.0-84.5
Protein (%)	12.18	11.0-13.1	12.53	11.5-13.5	15.82	15.2-16.8	12.99	12.0-13.0
Gluten (%)	25.82	21.8-31.8	27.00	24.0-30.5	35.71	33.7-38.4	26.70	24.7-29.3

Table 2 shows that yield and TKW were higher for the genotypes grown in Innviertel. According to Jones and Singh (2000), Olesen et al. (2000), and Wheeler et al. (2000), factors like weather and soils are important causes for crop yield variability. Kravchenko & Bullock (2005) report that soil properties explain about 30% of yield variability, with soil organic matter content influencing yield the most. Despite Marchfeld's better soil conditions (chernozem), its lower yield is connected with soil water availability.

Protein content was relatively high for the Marchfeld genotypes. Soil moisture conditions increase the grain yield of winter wheat but decrease its quality (Ozturk & Aydin, 2004).

ANOVA revealed significant site and year effects on the EED. The result is consistent with previous findings Talbert et al. (2001), reported that environment is a significant source of variation for grain fill duration and other traits. Only genotype-by-year interaction was significant on the EED.

Table 3. ANOVA results for the EED, yield and quality parameters

		EED			Yield		
Source	DF	MS	F	Pr>F	MS	F	Pr>F
GEN	7	17.13	5.73	0.0001***	41.79	0.76	0.6262
SITE	1	13.68	4.58	0.0385*	5087.73	92.12	<0.0001***
YEAR	1	143.23	47.94	<0.0001***	42.04	0.76	0.3881
GEN*YEAR	7	8.15	2.73	0.0206*	15.85	0.29	0.9553
GEN*SITE	7	6.58	2.20	0.0544	12.18	0.22	0.9783
SITE*YEAR	1	1.59	0.53	0.4604	62.04	1.12	0.2933
GEN*SITE*YEAR	7	5.40	1.81	0.1101	20.52	0.37	0.9128
		TKW			HLW		
GEN	7	10.74	14.32	<0.0001***	13.56	141.52	<0.0001***
SITE	1	206.25	275.00	<0.0001***	62.04	647.45	<0.0001***
YEAR	1	30.06	40.09	<0.0001***	49.09	512.27	<0.0001***
GEN*YEAR	7	4.74	6.32	<0.0001***	4.94	51.61	<0.0001***
GEN*SITE	7	7.37	9.82	<0.0001***	4.08	42.59	<0.0001***
SITE*YEAR	1	8.25	11.00	0.0019***	38.73	404.13	<0.0001***
GEN*SITE*YEAR	7	10.05	13.39	<0.0001***	8.45	88.20	<0.0001***

***p ≤ 0.001, **p ≤ 0.01, ≤ 0.05

Site effect was only significant for the yield. The result is consistent with previous findings reported by Hiltbrunner et al. (2004), who found a significant site effect on the yield of organic winter wheat in Switzerland. The interactions of genotype, year and site affected both TKW and HLW. There was a Type III (cross-over) interaction for both TKW and HLW.

Table 4. ANOVA for quality parameters

		Kernel protein			Wet gluten		
Source	DF	MS	F	Pr>F	MS	F	Pr>F
GEN	7	1.91	2.42	0.036*	21.13	2.13	0.062
SITE	1	76.51	97.16	<0.0001***	414.82	41.76	<0.0001***
YEAR	1	31.51	40.02	<0.0001***	262.09	26.38	<0.0001***
GEN*YEAR	7	0.95	1.22	0.316	7.49	0.75	0.627
GEN*SITE	7	0.50	0.64	0.72	15.03	1.51	0.191
SITE*YEAR	1	47.88	60.8	<0.0001***	469.70	47.29	<0.0001***
GEN*SITE*YEAR	7	0.8	1.02	0.43	10.22	1.03	0.42

***p ≤ 0.001, **p ≤ 0.01, ≤ 0.05

ANOVA revealed a significant genotype effect only for kernel protein content. The single effect of the site, year and site-by-year interaction was significant for both kernel protein and wet gluten content.

Table 5. Correlation coefficients of the EED and yield parameters

	Innviertel 2002			**Innviertel 2003**		
	EED	Yield	TKW	EED	Yield	TKW
Yield	-0.33***			-0.16		
TKW	-0.13	0.46***		-0.06	0.17	
HLW	-0.43***	0.07	0.11	-0.39***	0.28**	0.21*
	Marchfeld 2002			Marchfeld 2003		
Yield	-0.52***			0.18		
TKW	-0.24	0.31*		0.24**	0.13	
HLW	-0.28*	0.05	0.41**	-0.42**	0.15	0.72**

In 2002, the EED was significantly correlated with the yield at both study sites (r=-0.33***; -0.52***). But this result is inconsistent with others (Yildirum et al., 1996) who reported a positive correlation between yield and EED in wheat. EED was significantly correlated with the HLW at both study sites in both years, respectively. Yield was significantly correlated with the TKW (r=0.46***; 0.31*) only in 2002. This result is consistent with previous findings reported by Ozturk & Aydin (2004), who found a positive correlation between yield and TKW. However, that was not the case in 2003. There have been reports by Housley et al. (1982) and Bruckner & Frohberg (1987) of no association between grain yield and kernel weight.

TKW was significantly correlated with the HLW at both study sites in both years. Previous studies (e.g., Ozturk & Aydin, 2004), found a significant positive correlation between TKW and HLW.

Table 6. Correlation coefficients for the yield, protein and wet gluten content

	Innviertel 2002		Innviertel 2003		Marchfeld 2002		Marchfeld 2003	
	Yield	Protein	Yield	Protein	Yield	Protein	Yield	Protein
Protein	-0.48**		-0.37*		-0.39**		-0.09	
Gluten	-0.44**	0.94***	-0.39**	0.89***	-0.37**	0.96	-0.11	0.87***

Table 6 shows yield (dt/ha) was significantly correlated with both quality parameters at the Innviertel site. In agreement with our results, Simmonds (1996) and Ozturk & Aydin (2004) found a negative correlation between yield and kernel protein and kernel gluten content. Since grain yield and protein content are related, the grain protein contents also vary considerably within the paddock (Strong et al., 2003; Stewart et al., 2002). Kernel protein content was correlated with wet gluten content (r=0.94***; 0.89***) for the genotypes grown in Innviertel. This was not the case at the Marchfeld site in 2002.

Conclusions

Study site weather and soil conditions are important yield-affecting factors. Although, the yields of the genotypes grown in Marchfeld were lower, they showed higher quality parameter values. Soil moisture conditions increase the grain yield but decrease its quality in organic condition. To obtain seed with higher quality, a production site with favourable climate conditions should be chosen.

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MICONUTRIENT STATUS IN TWO LONG-TERM TRIALS WITH FERTILISATION TREATMENTS AND DIFFERENT CROPPING SYSTEMS

Meike Fischer[(1)(4)], Joachim Raupp[(1)(*)], Paul Mäder[(2)], David Dubois[(3)], Volker Römheld[(4)]

(1) Institute for Biodynamic Research, Brandschneise 5, D-64295 Darmstadt, Germany, +49-6155-8421-19, raupp@ibdf.de, www.ibdf.de

(2) Research Institute of Organic Agriculture (FiBL), Ackerstrasse, 5070, Frick, Switzerland, Tel. +41 62 8657232, paul.maeder@fibl.org, www.fibl.org

(3) Agroscope FAL Reckenholz, Reckenholzstrasse 191, 8046, Zürich, Switzerland, Tel. +41 1 3777220, david.dubois@fal.admin.ch, www.reckenholz.ch

(4) Institute for Plant Nutrition, University of Hohenheim (330), D-70593 Stuttgart, +49-711-459-2347, roemheld@uni-hohenheim.de

(*)corresponding author

Key words: Manganese, copper, zinc, farmyard manure, mineral fertiliser, conventional farming, organic farming

Abstract

Although organic fertilisers always contain micronutrients, we have to pay attention to the question of whether continuous fertilisation will lead to lower contents in plants or lower availability in the long run. We investigated topsoil samples from long-term trials with farmyard manure and mineral fertilisation and with different organic and conventional farming systems. Input of micronutrients via organic fertilisers was obviously more significant in the case of poor sandy soil than in that of loamy soil with high total contents and higher mineralising potential.

Introduction

For macronutrients it is well known that proper management is needed to avoid deficiencies. Usually, we are far less aware that the same is true for micronutrients. Their function is not only to support plant growth and disease resistance (Kirkby and Römheld, 2004), but also to prevent a reduction of soil fertility, especially on sandy soils with naturally low contents of total and available micronutrients. Although organic fertilisation always entails an input of micronutrients, in the long run even low annual deficits could result in a noticeable decrease of micronutrients in the soil.

As long-term trials show, organically fertilised soils or soils of organic cropping systems have higher organic carbon contents and a higher microbial activity than those treated by mineral fertilisation or soils of conventional cropping, respectively (Mäder *et al.*, 2002; Raupp, 2001). Such findings may have implications for micronutrients, as soil organic matter enlarges the sorption capacity of a soil. Consequently, micronutrient availability may be lowered if their adsorption to organic matter is too strong (e.g. for Cu).

This paper deals with the question of whether organic and mineral fertilisation for many years can influence the total contents of manganese (Mn), copper (Cu) and zinc (Zn) in the soil as well as their plant-available fractions. We investigated soil samples collected in a long-term fertilisation trial in Germany comparing different farmyard manure and mineral fertilisation treatments and in another long-term trial in Switzerland comparing different organic and conventional farming systems.

Methodology

Starting in 1980, the long-term fertilisation trial in Darmstadt, Germany, has examined the effects of mineral fertiliser (MIN, i.e. calcium ammonium nitrate, super phosphate, potassium magnesia) and composted cattle manure (CM). As a third fertilisation type CM with all biodynamic preparations is applied (CMBD). Both manure treatments are identical as regards manure origin, composting period (approx. 5-6 months) and conditions, and differ only as regards use of the preparations. All three types of fertilisers are given at three different levels, corresponding to 50, 100 and 150 kg ha^{-1} total N. In this way, fertiliser types and levels are combined to give nine treatments, implemented in four replicates. Except for fertilisation, all other elements of cultivation are the same in all treatments and follow normal organic farming practices. The site is characterised by a very sandy soil and a dry, warm climate (590 mm precipitation per year, 9.5°C annual mean air temperature).

In Therwil, Switzerland, the DOC trial started in 1978 on a loamy soil under site conditions of 792 mm precipitation and 9.5°C air temperature. The DOC trial examines three farming systems, i.e. biodynamic (D) and organic (O) with organic fertilisation, and a conventional system with combined manure and mineral fertilisation (C). These systems are compared with a conventional treatment using mineral fertilisers solely (M) and a control treatment without any fertiliser but with application of all biodynamic preparations (N). Each farming system purchased its farmyard manure from a different farm according to its cultivation guidelines.

Soil analysis for total Mn, Zn and Cu (aqua regia extraction) contents and plant available Mn, Zn, Cu ($CaCl_2$/DTPA extraction) contents in topsoil samples from Darmstadt and Therwil were carried out in 2004 at the Institute for Plant Nutrition at the University of Hohenheim, Germany. Where appropriate, analysis of variance was calculated with the aid of the SAS program (SAS Institute Inc., USA) using the MIXED procedure for Darmstadt and GLM for the DOC trial.

Results and brief discussion

1. Long-term fertilisation trial, Darmstadt

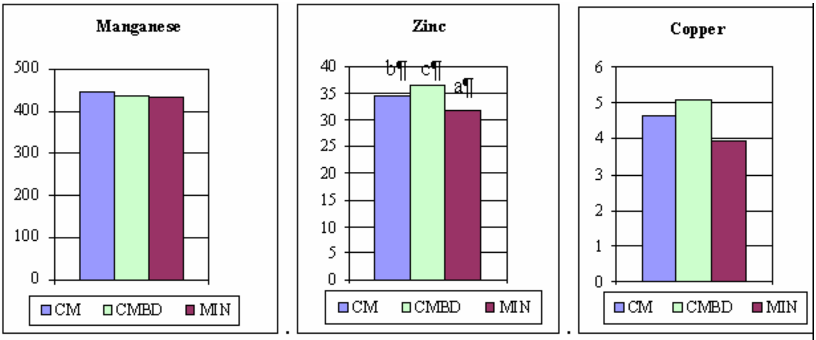

Figure 1: Total contents of micronutrients (mg kg^{-1} dry matter) in topsoil in the year 2004, depending upon fertilisation; results with different letters are statistically different ($p<0.05$)

Total soil contents of Mn and Cu were about the same with all types of fertiliser (Fig. 1). Total Zn content was highest with manure fertilisation and application of biodynamic preparations. The lowest total Zn content was observed with mineral fertiliser, while manure without the preparations yielded an intermediate result between those of the two other treatments. Organic fertilisation gives a higher input, especially of Zn and Cu, than do inorganic fertilisers, as both these elements contained in feedstuffs are excreted by animals to a large extent.

An enhanced content of organic matter in the CMBD treatment was observed earlier (Raupp, 2001). Mainly Cu, but also Zn and to a lower extent Mn can form stable complexes with soil organic matter, so that the content of organic matter in the soil can influence the total contents of micronutrients.

Table 1: Amounts of plant-available micronutrients in topsoil (mg kg^{-1} dry matter) and soil pH values, by fertilisation; results with different letters are statistically different ($p<0.05$)

	Mn	**Zn**	**Cu**	**pH**
CM	101	5.4 a	1.7	6.7 a
CMBD	94	5.4 a	1.7	6.7 a
MIN	97	4.0 b	1.4	6.5 b

The available Mn did not differ among the treatments (Table 1). A lower pH of 6.5 with the mineral treatment as against 6.7 after organic fertilisation may have caused Mn mobilisation. This may have offset the potentially positive effect of Mn supplied by organic fertilisers. Cu also showed no significant differences in availability. The amount of available Zn was distinctly lower in the mineral treatment than in the organic treatments. Regarding mineral fertiliser, a higher availability can be expected because of its slightly pH-lowering, physiological effect, which can mobilise Cu and Zn. Altogether, the micronutrients availability status is very good, considering the poor sandy soil conditions (VDLUFA, 2002).

2. DOC trial, Therwil

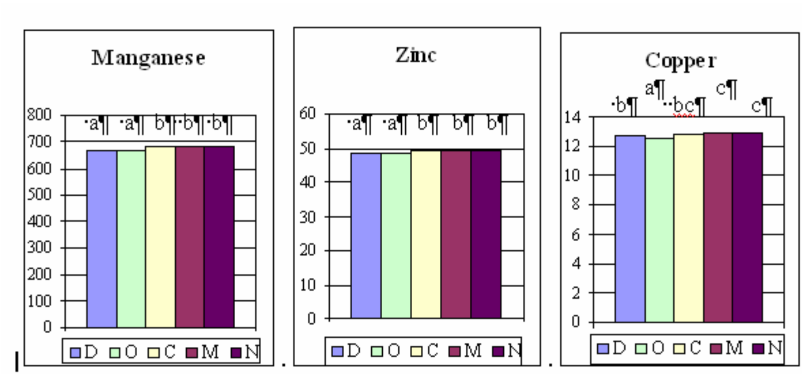

Figure 2: Total contents of micronutrients in topsoil (mg kg^{-1} dry matter) in the year 2004 in different cropping systems; results with different letters are statistically different ($p<0.05$)

Total contents of micronutrients in the topsoil of the DOC trial were rather high for Mn, but those for Cu and Zn corresponded to the background values for loamy soils. Total content of Mn was significantly lower in the exclusively organically fertilised soils than in those that received the C, M and N treatments. Although statistically significant, the difference is less than 2% and can be interpreted as negligible for plant nutrition. Total contents of Zn and Cu differed, the patterns being similar to that for Mn, but much less pronounced. Organic fertilisation was not able to produce similar total contents of micronutrients as in the other systems with mineral fertilisers, although farmyard manure and slurry is regarded as the main input of micronutrients in the trial.

On the Therwil site, the loess soil with higher amounts of micronutrients shows slightly lower contents in the organically treated plots, whereas the Darmstadt site, with its sandy soil, sometimes has higher contents of micronutrients with the organic treatments. Input of micronutrients via organic fertilisers seems to be more important for the poor sandy soil than for the loamy soil.

Table 2: Amounts of plant-available micronutrients in topsoil (mg kg^{-1} dry matter) and soil pH value in different cropping systems in the year 2004; results with different letters are statistically different ($p<0.05$)

	Mn	Zn	Cu	pH
D	97	4.0	4.0	6.8 a
O	96	4.0	4.3	6.6 ab
C	96	3.9	4.1	6.5 bc
M	96	3.4	4.2	6.2 dc
N	96	3.0	3.5	6.0 d

The availability of Mn did not differ significantly among the treatments, nor did that of Zn or Cu (Table 2), although there are striking differences in pH, which is known to have an influence on the availability of micronutrients. For Zn there is a tendency for higher availability in organic treatments despite the higher pH in these plots. Organic fertiliser, especially biodynamically composted farmyard manure, has shown positive effects on microbial activity and supports humus formation in soil (Mäder et al., 2002). These components can form complexes with micronutrients that are not plant available; Cu and Zn are known to form stable complexes with organic matter in soil. On the other hand, a high microbial activity can enhance the plant-serving pools. The extent of the processes responsible can exceed the effects of pH and fixation by organic matter. According to the literature (VDLUFA, 2002), the loess soil has a high micronutrient status with all treatments,

Plant uptake of micronutrients is much more dependent on rhizosphere conditions than on bulk soil conditions. Differences in rhizosphere conditions could appear even without any differences in bulk soil, and they would influence the uptake of micronutrients by plants. In fact, first results of plant analysis show lower micronutrient contents in organically fertilised plants than in minerally fertilised plants (results not presented here). Further research on the rhizosphere is needed to explain these results. According to the lower micronutrient concentrations in plants under organic fertilisation, it would be of interest for organic farming systems to enhance the micronutrient status of the plants to achieve a higher tolerance against abiotic and biotic stress. Some strategies based on rhizosphere management that might be implemented to enhance plant acquisition of micronutrients are improved rotation with crop plants that have a high capability for micronutrient mobilisation in the rhizosphere, e.g. oats as preliminary crop, application of micronutrient-mobilising microorganisms such as *Trichoderma* spp., or selection of micronutrient-efficient cultivars and seeds with higher micronutrient contents.

Conclusions

Input of micronutrients via organic fertilisers was more important in the case of poor soils such as are seen at the Darmstadt site than for soils with high total contents and therefore higher mineralising and weathering potential, as in Therwil. In both trials available Zn appeared to be the most limiting of the examined micronutrients. To enhance micronutrient acquisition of the plant, the rhizosphere is an important factor that should be considered, and several management strategies can be developed.

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FATE OF *ESCHERICHIA COLI* O157:H7 IN MANURE AND AMENDED SOIL: EFFECTS OF CATTLE FEEDING, MANURE TYPE AND DAIRY MANAGEMENT

Eelco Franz, Anne D. van Diepeningen, Anna A. Visser , Wim J. Blok and Ariena H.C. van Bruggen

Biological Farming Systems Group, Department of Plant Sciences, Wageningen University and Research Center, Marijkeweg 22, 6709 PG Wageningen, the Netherlands. Eelco.franz@wur.nl

Key Words: E. coli O157:H7, manure, soil, management, survival

Abstract

In the present study, we studied the effect of cattle diet on the survival of *E. coli* O157:H7 in manure from dairy cattle subjected to 6 different feeding regimes consisting of 3 different roughage types and 2 levels of crude protein concentrates. In addition, the rate of survival of *E. coli* O157:H7 in manure-amended soil as a function of manure type (manure vs. slurry) and dairy farm management (organic vs. conventional) was determined. The roughage type affected significantly the decline rate of *E. coli* O157:H7: decline was faster in manures with relative higher pH and fiber content. Decline was faster in slurry compared to manure and in organic slurry compared to conventional slurry.

Introduction/Problem

It is widely accepted that apparently healthy cattle serve as a reservoir for various human pathogens like *Escherichia coli* O157:H7 (Chapman 1993). Most cases of human infection by this pathogen have been primarily linked to the consumption of animal food products. Because of an increased number of disease cases associated with the consumption of raw vegetables (Sivapalasingam 2004), the potential contamination of raw vegetables is a growing concern. One possible mechanism of vegetable contamination with these pathogens is the land application of manure as fertilizer. Organic vegetable production is at the centre of attention with respect to the microbiological safety of the products, because animal manure is here the major source of fertilization. However, it is not demonstrated that organic vegetable production implies a higher risk. Possible contamination of vegetables will depend on the survival capabilities of the pathogen in manure, in soil and in/on plants. Differences in animal feeding regime and the absence of synthetic fertilizers, pesticides and routine use of antibiotics may lead to differences in pathogen prevalence and survival between organic and conventional farming systems. The cattle feeding regime is regularly proposed as a potential management factor for controlling pathogen shedding. Grain feeding can create a more acidic environment in the gut of cattle which leads to the selection of acid-resistant generic *E. coli*, which may include the considerably acid-resistant *E. coli* O157:H7 (Diez-Gonzalez 1998). However, nothing is known concerning the effect of cattle feeding regime on the survival of *E. coli* O157:H7 in manure. We first investigated the effect of cattle diet on the survival of *E. coli* O157:H7 in manure (experiment 1). In a second experiment we determined survival in manure-amended soil as a function of manure type (manure vs. slurry) and dairy farm management (organic vs. conventional) (experiment 2).

Methodology

Strain: Strain *Escherichia coli* O157:H7 B6-914 *gfp*-91, expressing green fluorescent protein (GFP), lacking Stx1 and Stx2 and ampicillin resistance, was used for inoculation. The survival characteristics of the GFP-labeled strain were found to be indistinguishable from those of the wild-type strain (Fratamico 1997) and lack of Stx1 and Stx2 does not influence the bacterial survival (Kudva 1998). *E. coli* gfp-91 inoculum was prepared in Luria Bertani broth (50 µg/ml ampicillin) and was harvested from an at 37°C overnight grown culture by centrifuging (9000*g* for 5 min at 20°C). A solution of 1 X 10^9 cells/ml was made by re-suspending the pellet in 0.1% peptone buffer and diluting to an OD_{630} of 0.7 in the spectrophotometer.

Experiment 1: Holstein Frisian dairy cows were housed under identical conditions and fed 3 different roughage types for 9 weeks: a ½-½ mixture of young grass silage and maize (GM), 100% older grass silage (GO) and 100% straw (S). Diets were supplemented with concentrates high (H) and low (L) in nitrogen. Fresh manure (without urine) was collected and stored at 5 °C in 20-liter containers. Cells were added to the manures with final density of 1 X 10^7 colony forming units (cfu) per gram manure dry weight (gdw^{-1}). The inoculated manure was put in plastic pots enabling gas exchange. Survival over time at 15°C was determined by regularly taking samples from each pot which were appropriately diluted in 0.1% peptone buffer and plated on Sorbitol MacConkey agar. The number of cfu were counted after 20 h at 37°C using a dark-blue lamp.

Experiment 2*:* Manure and urine were collected from a Dutch conventional and organic dairy farm, both feeding roughly the same diet of grass silage, corn silage and additional products. Slurry was made by mixing the solid manure with urine (1:1). Organic and conventional, conventional manure and resulting organic and conventional slurry were mixed with a Dutch conventional sandy soil (1:9). Next to the fertilized soils, one soil without manure and one autoclaved soil were used as treatments. Methods of inoculation, storage and sampling were used as described under experiment 1.

Chemical analyses: Evaporation was checked by weighing before and after sampling. Moisture content remained constant during the experiment (on average around 85%). Manure samples were analyzed for their pH, NO_3, NH_4, total N, total C, fiber and dry-matter contents. In addition total soluble organic C and N were determined for manures and slurries of experiment 2.

Statistical analyses: The rate of decline in the manure of experiment 1 and the manure-amended soils of experiment 2 was estimated by fitting the data of each replica to the following logistic equation using nonlinear regression (SAS version 8, SAS Institute, Cary, NC, USA): CFU(t) = a + [b / (1 + exp (c – dt)], where CFU(t) is the log number of cfu gdw^{-1} on day t, a is the lower asymptote, (a+b) is the upper asymptote, d is the slope of the regression curve and c is the y-intercept. A pseudo-R^2 of the fits was determined: 1-[$SS_{residuals}$/$SS_{total\ corrected}$]. Multivariate analysis of variance (MANOVA, significant level of 5%) followed by contrast analysis was conducted with both regression parameters. We compared treatments according to the values of the slope parameter (*d)* since this variable overrules the y-intercept parameter with respect to the determination of the curve shape. Correlation analysis and stepwise multiple regressions with the slope values and the chemical data were conducted. Variables left in the regression model are significant at the 0.1500 level and models are restricted to a maximum of 2 parameters.

Results and brief discussion

Experiment 1:

Except for a short initial rise in some manure types, *E. coli* O157:H7 declined continuously trough time and was not detected by plate counting anymore after 84 days in both manures derived from a straw diet (SH, SL) and after 133 days in the other manure types (Fig. 1A). Non-linear logistic regression resulted in good fits of the survival data for all six manure types (average pseudo-R^2 over 3 replicates: GMH: 0.92, GOH: 0.92, SH: 0.89, GML: 0.82, GOL: 0.93 and SL: 0.95). The number of days needed to reach the detection limit of 10 cfu/gdw^{-1} according to the fits was for GMH, GOH, SH, GML, GOL and SL respectively 128 ± 8, 105 ± 8, 76 ± 5, 126 ± 18, 92 ± 12 and 71 ± 8.

Only roughage type had a significant effect (Wilks' Lambda =0.060, p=0.000) on the combined slope and position parameters. Moreover, roughage type had a significant effect on the slope of decline (p=0.000) whereas crude protein level did not. Decline rates in manures based on the same roughage type, but different crude protein levels, did not differ. All three roughage types differed significantly from each other with respect to the slope of decline, irrespective of crude protein level, when the manure types from the high and low CP groups were aggregated to roughage type: *E. coli* O157:H7 declined faster in manure derived from a diet of straw (S) compared to old-grass-silage (GO) (p=0.007), straw (S) compared to young-grass-silage /maize (GM) (p=0.000) and old-grass-silage (GO) compared to young-grass-silage /maize (GM) (p=0.0272). The crude protein level was not affecting the rate of decline, most likely because most (excess) nitrogen is secreted by the urine.

There is a trend in more sustainable and organic dairy farming of feeding a diet with increased fiber content consisting of lower concentrations of cytoplasmic carbohydrates (sugars, starch) and more so-called cell wall carbohydrates (hemicellulose, cellulose, lignin). This is often accompanied by a higher C/N ratio, consequently reducing nitrogen losses to the environment. According to our research, this should result in lowering the survival of *E. coli* O157:H7 and *Salmonella* serovar Typhimurium and consequently in a lower risk of transfer of these pathogens into the vegetable production chain.

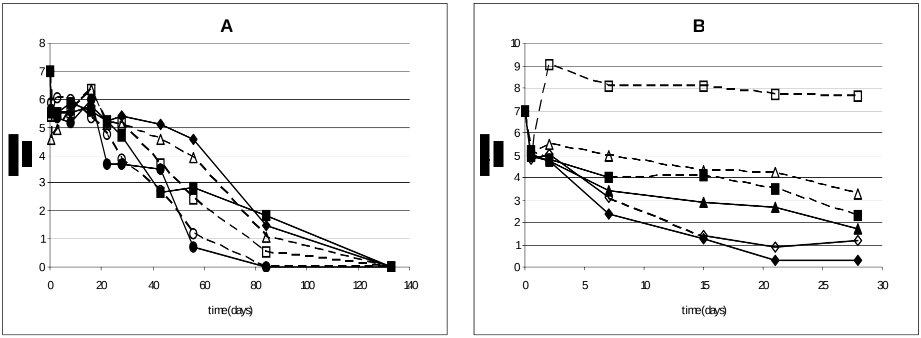

Fig.1. A) Survival of *E. coli* O157:H7 in 6 different types of inoculated cattle manure resulting from different diets: GMH (▲ solid line), GOH (■ solid line), SH (● solid line), GML (Δ dashed line), GOL (□ dashed line) and SL (○ dashed line) B) Survival of *E. coli* O157:H7 in autoclaved (□ dashed line), non-autoclaved sandy soil (■ solid line), conventional manure (Δ dashed line), organic manure (▲ solid line), organic slurry (◇ dashed line) and conventional slurry (◆ solid line).

The rate of decline (absolute value of slope) was positively correlated with pH (p=0.003) and fiber content (Acid Detergent Fiber: p=0.032 and Neutral Detergent Fiber: p=0.017) (Table 4). The GM-manures had the lowest pH and lowest decline rates while the S-manures had the highest pH and the highest decline rate (Fig.3). The GO-manures had intermediate pH and intermediate decline rates. The rate of decline showed a negative linear relationship with ammonium level (p=0.024). Stepwise multiple regressions revealed that pH explained most of the variation in decline rate: slope [model R^2=0.97] = -1.80 X 10^{-2} [pH; partial R^2=0.91, p=0.003] + 1.06 X 10^{-4} [drymatter content; partial R^2=0.06, p=0.056] + 7.03 X 10^{-2} [intercept]. Alternatively, when excluding pH, the neutral detergent fiber (NDF) content served best to explain the variation in decline rate: slope [model R^2=0.93] = -2.19 X 10^{-3} [NDF; partial R^2=0.80, p=0.016] + 7.05 X 10^{-4} [C:N ratio; partial R^2=0.13, p=.093] – 3.35 X 10^{-3} [intercept]. The pH and NDF content were not correlated.

Cattle diet is considered to be a potentially important factor in controlling the presence of *E. coli* O157:H7 in cattle. Feeding hay to cattle may be a way to reduce shedding of acid resistant *E. coli*. Diets high in grain are thought to create a more acidic rumen environment because the starch is incompletely digested and is fermented in the colon, which in turn should lead to the selection of more acid-tolerant *E. coli*, including the acid tolerant pathogenic *E. coli* O157:H7. We showed that *E. coli* O157:H7 is more persistent in manure derived from cattle fed a higher energy diet containing starch (grass silage + maize) with low pH and low fiber content, in comparison to manure derived from a lower energy diet (straw) with high pH and high fiber content.

Experiment 2:

With all treatments *E. coli* O157:H7 populations first declined rapidly by 2 log, probably as a stress reaction (Fig. 1 B). Within the autoclaved soil, pathogen numbers rapidly increased by 4 log before stabilizing at a level around 1 x 10^8 cfu/gdw, indicating the potential effect of competition by the microbial community in the decline which is normally observed with the community present. In all other treatments there was a continuous decline after. A trend that *E. coli* O157:H7 numbers decrease more rapid in slurry than in solid manure, which is consistent with other studies (Maule 2000), and that organic management results in a more rapid decrease can be read from the survival curves. The survival of *E. coli* O157:H7 in autoclaved soil was not included in further analysis because of the inability to fit the curve to the logistic decline function. Non-linear logistic regression resulted in satisfying fits of the survival data (average R^2's over 3 replicates: non-autoclaved soil 0.73, conventional manure 0.72, organic manure 0.61, conventional slurry 0.90 and organic slurry 0.94). Both manure type (Wilks' Lambda 0.126, p=0.001) and management (Wilks' Lambda 0.182, p=0.003) showed a significant effect on the combination of both regression parameters. Furthermore, both manure type and management had a significant effect on the rate of decline (p= .000 and p=0.028). The four manure treatments differed significantly from each other with respect to the combination of both regression parameters (Wilks' Lambda 0.019, $P = 0.000$). In addition, *E. coli* O157:H7 showed a significantly higher rate of decline in organic slurry than in organic manure (p=0.002), and conventional slurry showed a significantly faster decline compared to conventional manure (p=0.008). *E. coli* O157:H7 declined faster in organic slurry compared to conventional slurry (p=0.019), while there was no difference between organic and conventional manure.

When only taking into account the manure-amended soils, no chemical parameter was correlated with the rate of decline. Stepwise multiple regressions revealed that the nitrate content was the only chemical compound that explained a significant amount of variance: slope [model R^2=0.90] = 7.79 X 10^{-2} [nitrate; partial R^2=0.90, p=0.052] – 0.57 [intercept]. Alternatively, when excluding the nitrate content, the total nitrogen explained most of the variation: slope [model R^2=0.99] = 5.48 X 10^{-2} [total nitrogen; partial R^2=0.85, p=0.075] – 1.17 x 10^{-4} [total carbon; partial R^2=0.14, p=0.10] – 5.42 [intercept]. Including the non-autoclaved soil, decline rate was positively correlated with the ammonium content (r=0.90, p=0.036). Ammonium content was indeed significantly higher in slurry than in solid manure (p=0.016). Stepwise multiple regressions revealed that the ammonium content was the only chemical compound that explained a significant amount of variance: slope [model R^2=0.82] = -6.64 X 10^{-3} [ammonium; partial R^2=0.82, p=0.036] – 1.67 X 10^{-2} [intercept]. Ammonium may have an indirect toxic effect on *E. coli* O157:H7 when it is converted to ammonia. Alternatively, when not taking into account the ammonium content and factors correlated with it (total nitrogen content, r=0.91, p=0.031) the total organic soluble nitrogen content (TON) explained most of the variation: slope [model R^2=0.99] = -3.75 X 10^{-3} [TON; partial R^2=0.69, p=0.082] + 2.44 X 10^{-4} [total organic soluble carbon; partial R^2=0.30, p=0.01] + 0.11 [intercept]. Indeed, nitrogen related parameters were higher in the slurries (faster decline) than in the manures due to the presence of urine.

Conclusions

The feeding regime of dairy cattle not only influences the shedding of *E. coli* O157:H7, but also determines the decline rate in the excreted manure. The pathogen declined fastest in manure resulting from a pure straw diet characterized by a relatively high pH and fiber content. This is in line with studies reporting that hay feeding reduces pathogen shedding and pathogen acid resistance (Diez-Gonzalez 1998). By revealing the difference between pathogen decline in autoclaved and non-autoclaved soil, we demonstrated the importance of the microbial community in the population dynamics of *E. coli* O157:H7 in soil. The effect of dairy management type must be the subject of further research, which is currently undertaken in our laboratory.

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EFFECTS OF PLOUGHING IN AND REMOVING LITTER LEAVES FROM THE GROUND ON THE DEVELOPMENT OF SCAB EPIDEMICS IN AN ORGANIC APPLE ORCHARD

Christelle Gomez (1), Laurent Brun (2), Dominique Chauffour (2), Damien de le Vallée (2)

[1]GRAB (Research Institute for Organic Farming), Domaine de Gotheron, 26320 Saint-Marcel-lès-Valence, France, tél : +33.(0)4.75.59.92.08, e-mail : grab.ra@free.fr

[2]INRA-UERI, Domaine de Gotheron, 26320 Saint-Marcel-lès-Valence, France, tél : +33.(0)4.75.59.92.04, e-mail : lbrun@avignon.inra.fr

Key Words : apple scab, apple orchard, organic apple, sanitation practice, leaf ploughing in, leaf removal.

Abstract

Ascospores produced on scabbed leaves in the leaf litter are the main source of scab primary inoculum, causing scab infections in apple orchards. The purpose of this experiment, carried out during two years in a commercial organic orchard, was to assess the combined effect of removing leaves from the alleys and ploughing in leaves within the row on scab primary inoculum and therefore on scab epidemics. Scab lesions were monitored on leaves and fruits by assessing scab incidence and scab severity. In 2003, scab severity was monitored at different distances from the unremoved leaf area, in order to estimate ascospore spreading. At fruit harvest, during two years with low (2003) and high (2004) levels of scab development, the leaf litter ploughing in / removal method reduced fruit scab incidence by 82% and 54% respectively, and fruit scab severity by 74% and 68%. Measures of ascospore spreading indicated that the spreading was not important beyond 20 m from the area where leaves were not removed.

Introduction

Apple scab, caused by *Venturia inaequalis* (Cooke) G. Wint., is one of the most serious diseases of apple worldwide (MacHardy, 1996). Ascospores released from pseudothecia on overwintered infected leaves in the leaf litter are the main source of scab primary inoculum, causing scab infections in commercial apple orchards. During the late 1880s, growers and horticulturists apparently thought that overwintering scabbed leaves somehow contributed to the development of scab lesions in early spring, because raking and burning leaf litter or treating it with a chemical was recommended in addition to fungicide applications. However, it was not scientifically proved that leaf litter was the source of primary inoculum until near the end of the nineteenth century and it was not until 1924 that a study designed to relate the effect of sanitation practices on scab buildup was published (in Holb *et al.*, 2004). Several studies showed that sanitation practices can decrease ascospore release by reducing apple scab inoculum in orchards. When apple leaves are destroyed by shredding, scab risk may be reduced by 90% in the northeastern USA (Sutton *et al.*, 2000). However, because of operational difficulties in shreddin all the orchard leaves, the effective reduction in scab risk ranges from 50% to 65%. Urea applied to the leaf litter in November reduces the number of trapped ascospores by 50% (Sutton *et al.*, 2000). Combining leaf shredding with urea or fungal antagonist treatments could enhance leaf decomposition, increase microbial competition, or restrain pseudothecia maturation (Carisse and Dewdney, 2002; Carisse *et al.*, 2000). Urea and leaf shredding reduce ascospore production by 92.1% and 85.2% respectively. Shredding combined with urea resulted in 90.5% reduction of ascospore production (Vincent *et al.*, 2004). Removal of litter leaves from the ground in autumn can also reduce primary scab lesions (Longpré, 2003, personal communication). All the experiments about shredding or removing the leaf litter mainly eliminate leaves from the alleys, because it is more difficult to eliminate leaves within the row, even though their elimination would favour apple scab inoculum reduction. The purpose of this experiment was to assess the effect of combining leaf removal from the alleys and ploughing in leaves within the row on scab primary inoculum and therefore on scab epidemics.

Methodology

Experimental orchard. The study was carried out during two years, in 2003 and 2004, in a 2.5- ha commercial organic orchard located in Loriol (Drôme, France). The orchard, sown with grass in the alleys, was planted in 1994 with two apple cultivars, Smoothee2832T® and Fuji. Smoothee2832T® is a mutant of Golden Delicious, rated as susceptible to scab in France (Trillot *et al.*, 2002). Cultivars were grown on M.9

rootstock and trained to vertical axis. Planting distances were 4 m between rows by 2 m within the row. The experimental orchard was divided into three blocks of 3600 m², each with two leaf litter managements :

(i) On 2/3 of the block (2400 m²) called "leaf ploughing in / removal area", removal of litter leaves from the alleys was combined with ploughing in leaves within the row. All these farming methods were done immediately after leaf fall. Removal of leaves was done with a lawn sweeper Wiedenmann® coupled with a tractor. A rotatory brush at the back of the tractor collected the leaves left at the edge of the alleys.

(ii) On 1/3 of the block (1200 m²) called "unremoved leaf area", litter leaves were left unremoved from the alleys and within the row. This treatment was considered as control.

Fungicide applications consisted of copper and sulphur sprays in the whole orchard.

Disease assessment. The risks of infection were those defined by Mills and Laplante (1951), and the risk of light infection called "Angers" (Olivier, 1986). The dates of lesion appearance associated with each risk were calculated following Calmejane's curve (Dionnet, 1982) and used to program disease assessment. Each year, from the first recorded scab infection period to harvest, scab lesions were monitored on leaves and fruits by assessing scab incidence and scab severity. Leaf and fruit scab incidence is the percentage of scabbed leaves and fruits respectively. 192 shoots were assessed in the orchard. For each block, two shoots per tree were randomly selected on 16 trees from the "leaf ploughing in / removal area" and on 16 trees from the "unremoved leaf area". For each block, 20 fruits per tree were randomly selected on 16 trees from the "leaf ploughing in / removal area" and on 16 trees from the "unremoved leaf area". Leaf scab severity is the number of scab lesions per shoot. Sporulating lesions were counted on the upper and lower leaf surfaces. Fruit scab severity is the number of scab lesions on 20 fruits per tree. In 2003, for two blocks, scab severity was monitored at different distances from the unremoved leaf zone, in order to estimate ascospore spreading. In 2004, ascospore projection was monitored for each leaf litter management with two spore traps (Burkard Manufacturing Co. Ltd., Rickmansworth Hertfordshire, England) located within a row of one of the blocks.

Statistical analysis. Leaf and fruit incidence and severity were tested by analysis of variance (ANOVA).

Results and discussion

Interest of the leaf ploughing in / removal method. Leaf scab incidence and severity monitored in June 2003 and June 2004, as well as fruit scab incidence and severity at harvest in 2003 and 2004, were significantly ($P \leq 0.05$) lower in the "leaf ploughing in / removal area", compared to the "unremoved leaf area". In June 2003, 7% and 23% of leaves were scabbed in the "leaf ploughing in / removal area" and in the "unremoved leaf area" respectively.

In June 2004, 28% and 47% of leaves were scabbed in the "leaf ploughing in / removal area" and the "unremoved leaf area" respectively. Leaf scab incidence was reduced by 69% and 41% respectively in June 2003 and June 2004. Leaf litter ploughing in and removal reduced the number of scab lesions on leaves by 67% and 61% in June 2003 and June 2004 respectively (Table 1).

At fruit harvest, 0.7% vs. 4% (2003) and 30% vs. 66% (2004) of scabbed fruits were counted for the "leaf ploughing in / removal area" and the "unremoved leaf area" respectively. The leaf ploughing in / removal method reduced fruit scab incidence by 82% and 54% at fruit harvest in 2003 and 2004 respectively. Fruit scab severity was reduced by 74% and 68% respectively at fruit harvest in 2003 and 2004 (Table 2).

The results pointed out the interest of the leaf litter ploughing in / removal method in autumn to reduce scab epidemics. During this two-year study, the reduction of scab infections was important in spite of incomplete removal of litter leaves in 2003 because leaves were stuck to the ground by the snow, and even though a lot of leaves were blown by the wind from the "unremoved leaf area" to the "leaf ploughing in / removal area" in 2004. Measures of ascospore spreading in 2003 indicated that the spreading was not important beyond 20 m from the "unremoved leaf area" (Figure 1).

In 2004, from 15 March to 10 May, respectively 24,452 and 1288 ascospores were trapped in the "unremoved leaf area" and the "leaf ploughing in / removal area". The leaf litter ploughing in / removal method reduced ascospore projection by 95% from March to May 2004. The reduction of ascospore projection in the "leaf ploughing in / removal area" was higher than the reduction of the number of scab lesions per shoot observed in June 2004 (61%). Such results were not expected because it was supposed that scab primary inoculum was only caused by ascospores produced on scabbed leaves in the leaf litter. Two main hypotheses could explain the differences observed in 2004 :

(i) Ascospore projection was not equal within the orchard and spore trap monitoring was not representative of the orchard mean spore projection, but only of the part of the orchard that was monitored.

(ii) A recent study proved that in orchards with high levels of apple scab, overwintered conidia were viable on shoots or on the inner tissues of buds and could contribute to early spring epidemics (Holb *et al.*, 2004). This source of scab inoculum could explain the differences observed in 2004 between the reduction of ascospore projection and the reduction of the number of scab lesions per shoot.

Feasibility of the method by growers. The removal of leaf litter can be performed with sweepers available on the market that are used in gardens. Prototypes might be soon developed and available.

It might be easier to shred leaves than remove them, and shredding is another sanitation practice that could be done in order to reduce scab primary inoculum. Many farmers use a commercial shredder to shred wood after pruning or to control weeds in the orchard alleys. Nevertheless, depending on the topography of the orchard and fall weather conditions, it might be difficult to shred enough leaves to have an effect. MacHardy (2004) suggested that after shredding, apple leaves should be removed from the orchard. However, this requires additional machinery.

Ploughing in leaves within the row is complementary to removal of leaves in the alley. Ploughing in leaves can be easily adopted in organic farms because farmers generally use tillage machinery to control weeds. After leaf fall, soil tillage within the row could be used both to control weeds and to plough in leaves that can’t be shredded or removed.

Conclusion

The leaf litter ploughing in / removal method in autumn reduced the number of leaf and fruit scab lesions in the study apple orchard during two years with different levels of scab development (low in 2003 and high in 2004). This method reduced fruit scab incidence and fruit scab severity at fruit harvest in 2003 and 2004. Shredding or removing leaves in the alleys and ploughing in leaves within the row can therefore be beneficial for growers.

The spreading of ascospores indicated that potential inoculum in infected surrounding apple orchards is not likely to reduce the effect of leaf litter ploughing in / removal method.

Table 1. Percentage of scabbed leaves and leaf scab severity in June 2003 and June 2004.

	2003, 11 June		2004, 10 June	
	Unremoved leaf area	Leaf ploughing in / removal area	Unremoved leaf area	Leaf ploughing in / removal area
Percentage of scabbed leaves	23	7	47	28
Leaf scab severity (number of scab lesions per shoot)	10.8	3.6	79	31

Table 2. Percentage of scabbed fruits and fruit scab severity at harvest 2003 and 2004.

	2003, 12 September		2004, 15 September	
	Unremoved leaf area	Leaf ploughing in / removal area	Unremoved leaf area	Leaf ploughing in / removal area
Percentage of scabbed fruits	4	0.7	66	30
Fruit scab severity (number of scab lesions on twenty fruits per tree)	15	4	62	20

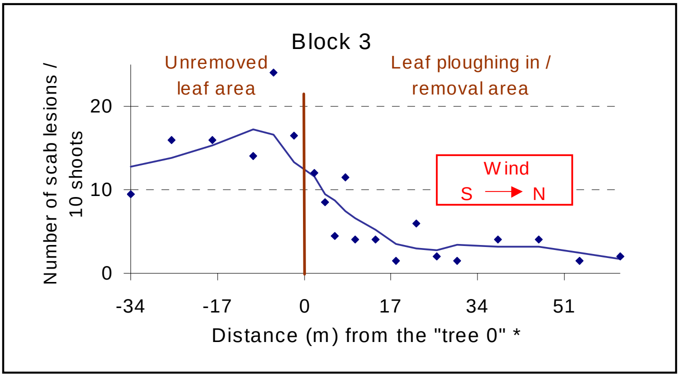

Figure 1. Ascospore spreading, 19/05/03. * "tree 0" : the tree located between the two areas.

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NDICEA AS A USER FRIENDLY MODEL TOOL FOR CROP ROTATION PLANNING IN ORGANIC FARMING

Chris J. Koopmans and Geert-Jan van der Burgt

Louis Bolk Institute, Hoofdstraat 24, 3972 LA Driebergen, The Netherlands, tel +31-343-523860, e-mail c.koopmans@louisbolk.nl, www.louisbolk.nl

Key Words: mineralization, modelling, organic, precision farming, rotation, sustainable

Abstract

For organic farming systems, the challenge is to become more specific in practices to maintain high standards in sustainability. Soil processes need to be clearly understood if rotations and manure applications are to become more precise. Simulation models like the NDICEA model help in the design and maintenance of these farming systems. These models play a key-role in the design of organic precision farming.

The NDICEA model has been calibrated for a number of long-term crop rotation experiments. Recently, the model was validated using research data from more than 35 organic farms all over the country. The model is used to calculate soil-specific mineralization rates in precision applications. In a new easy-to-use application, it was developed to design crop rotations and evaluate performance of crop rotations. This application is used to evaluate the sustainability of farming systems.

Introduction

For organic farming systems, the challenge is to become more specific in manuring practices, taking into account the characteristics of crop residues, green manures, organic manures and composts as a source of nutrients and as a contributor to the formation of organic matter. Management of sustainable soil fertility is of paramount importance for organic farming systems. It is therefore essential in the design and maintenance of these systems that we gain the greatest possible insight into soil fertility at the process level. Simulation models like the NDICEA model, will help in the design and maintenance of these farming systems. Organic farms profit from developments of precision farming techniques (Koopmans and Zanen, 2005). Soil processes however, need to be clearly understood if rotations and manure applications are to become more precise and sustainable.

Methodology

The NDICEA model was designed to simulate processes of nitrogen mineralization and organic matter turnover in organic farming systems. The model has been calibrated for a number of long-term crop rotation experiments. The model was recently validated using research data from more than 35 organic farms across the country (Figure 1).

Nitrogen and organic matter dynamics at arable and vegetable farms throughout the Netherlands have been monitored for inorganic nitrogen levels. Laboratory incubations and extractions were used to characterize organic fertilizer decomposition rates of fertilisers used at the farms.

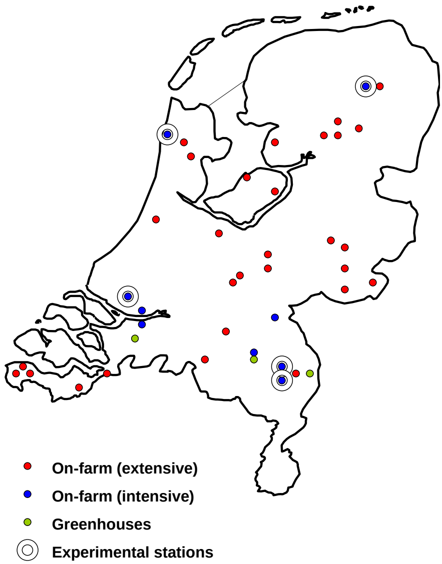
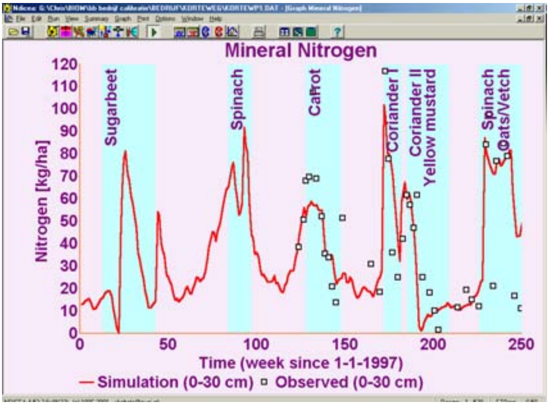


Figure 1. Sites with application of the NDICEA model in the Netherlands

To investigate nitrogen and organic matter turnover levels at these farm fields, results were combined using the dynamic simulation model NDICEA (Koopmans and Bokhorst, 2000; Van der Burgt et al., 2005). To design crop rotations and evaluate performance of crop rotations in the sustainability debate, a user-friendly model application was developed (Figure 2). This application uses standard environmental data for different regions of the country and standard nitrogen contents of the crops.

Figure 2. Example of the farmer's version of the NDICEA model for modelling complete crop cycles but no single field evaluations



	Soil layer 0-30 cm	
	Non calibrated	Calibrated
Number of observations	777	777
Mean of observations	39,1	39,2
Average error	-0,5	-0,8
Root mean square error	41,7	30,3
Normalised root mean square error	1,1	0,8
Modelling efficiency	0,1	0,5
r2	0,2	0,5

Figure 3. Example of visual and statistical model performance evaluation (after Koopmans and Heeres, 2002)

Results and Discussion

Model performance was evaluated visually as well as by statistical measures (Figure 3). The model was able to describe the nitrogen dynamics in the soil of fields who had been in organic rotations for several years and on several soil types (Koopmans and Bokhorst, 2002; Koopmans and Heeres, 2002). Using the model as a tool, we first identified soil-specific mineralization rates (Figure 4).

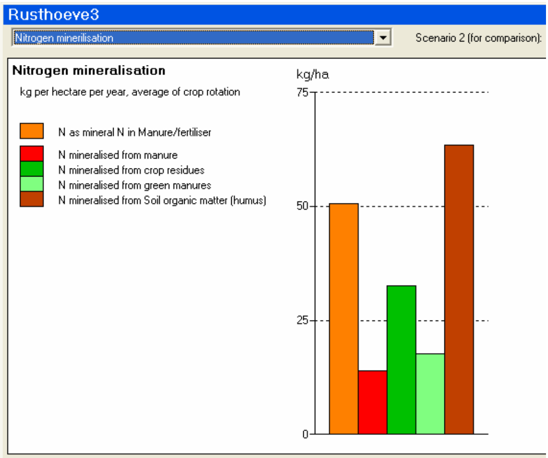


Figure 4. Example of the NDICEA model indicating nitrogen mineralization from different sources

Second, the use of a simple simulation model helped to determine the relative importance of each process in the system (Figure 5). Third, the model was used to evaluate alternative management strategies with respect to their impact on the nitrogen availability for the crop, the level of organic matter in the soil, and the nitrogen leaching potential. With the model, organic production has the potential to be attuned to each specific farm, site and soil. The model is used in developing precision farming techniques in organic farming. Comparison of the NDICEA model with other models (Koopmans and Heeres, 2002) shows that the NDICEA model describes nitrogen mineralization in the soil and organic matter turnover in such a way that it is a good-performing tool for applied research in organic and sustainable farming.

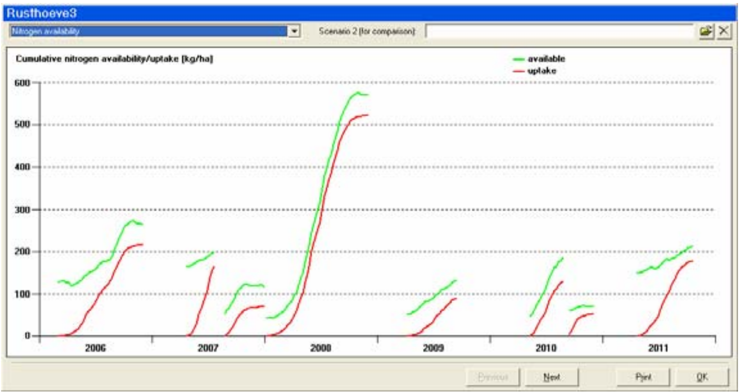


Figure 5. Example of model output from the NDICEA model indicating nitrogen availability in the soil and nitrogen uptake by the crops for several years of rotation

Conclusions

Nitrogen mineralization potentials from soils, manures and plant residues are required management information for farmers who want to optimize their nutrient management and want to close nutrient cycles at their farm. The NDICEA model has a performance that is necessary to develop precision farming techniques for organic farming. The model is a useful tool in evaluating the sustainability of farming systems and the development of indicators like soil fertility levels and leaching losses of nitrogen from farms.

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COMBINATION OF DIFFERENT METHODS FOR DIRECT CONTROL OF *VICIA HIRSUTA* IN WINTER WHEAT

Pavel Lukashyk, Ulrich Köpke

Institute of Organic Agriculture, University of Bonn, Katzenburgweg 3, D-53115 Bonn, Germany, E-mail: iol@uni-bonn.de, Internet: www.iol.uni-bonn.de

Key Words: Organic farming, hairy tare, kainite, flame weeding, harrowing

Abstract

Combinations of three different direct methods for controlling *Vicia hirsuta* (kainite application, flame weeding and harrowing) were investigated in field experiments. They were based on different strategies at early growth stages of *V. hirsuta* and standardised harrowing at late growth stages. The highest efficacy of kainite application and flame weeding was achieved at the one leaf stage of *V. hirsuta*. Winter wheat regeneration from damage caused by both kainite and thermal control was satisfactory when treatments were applied at early growth stages (GS 23). *Vicia hirsuta* plants that survived kainite application or flame weeding were successfully controlled by repeated harrowing at later crop growth stages; crop growth was not affected. Seed production of *V. hirsuta* declined with increasing harrowing in all treatments; however the strongest and most reliable reduction was achieved when flame weeding had been previously applied. All combinations of direct measures reduced winter wheat grain-yield losses and enhanced thousand-grain weight more efficiently than the use of a single method only. The highest wheat-grain yield was gained after repeated harrowing (3 times) both with and without kainite application.

Introduction/Problem

Under organic farming conditions in Germany, hairy tare (*Vicia hirsuta* (L.) S. F. Gray) is a very common weed, especially in low-competitive winter cereals. Heavy infestation with this climbing legume can cause serious problems at harvest, resulting in reduced crop yield and product quality. Indirect control measures are often not sufficient to suppress it efficiently (Eisele 1996). Results of former investigations (Lukashyk *et al.* 2004) show that a single direct weed control using either kainite or flame weeding at early growth stages was not sufficient to reduce seed production of *V. hirsuta* when the infestation level was high. Moreover, *V. hirsuta* plants surviving the treatment were able to produce a higher amount of biomass and a larger number of seeds. Consequently, there is also an urgent need to control *V. hirsuta* at later growth stages. During 2001 and 2003, the efficacy of single applications of the three measures kainite application, flame weeding and harrowing were compared in field trials. The main aim of the investigations presented here was to test combinations of the different direct methods to reduce *V. hirsuta* density in early crop growth stages (kainite, flame weeding) and to control residual surviving *V. hirsuta* plants by harrowing in later growth stages.

Methodology

A one-factorial field experiment combining kainite application, flame weeding and harrowing as control measures was conducted in winter wheat with four replications and plot sizes of 1.5 x 9 m. The trial site was located at the Organic Research Farm 'Wiesengut' in North-Rhine Westphalia, Germany (50°48'N, 7°17'O). Kainite application and flame weeding were performed on the basis of former experiments in the years 2002 and 2003. The treatments with flame weeding (Reinert Company, A 311 HB, 3 burners SB 500/i) and kainite (59 % NaCl, 17 % KCl and 16 % $MgSO_4$, Kali & Salz GmbH 2002) were applied once at growth stage (GS) 23 of winter wheat under dry weather conditions. The concentration of the kainite solution was 350 g L^{-1} (230 kg kainite ha^{-1} = 21 kg K ha^{-1}, 660 L ha^{-1}). Flame weeding was conducted at low speed (1.5 km h^{-1}, gas consumption 41 kg ha^{-1}) in order to ensure sufficient damage to the weeds. The crop ground cover at GS 23 was relatively high at about 50-55 %. The spring-tine harrow (Einböck) was applied at GS 32, 47 and 61 of the crop once, repeatedly and in combination with kainite or flame weeding, respectively. Winter wheat was harrowed with soil contact at GS 32 and combed (10-15 cm above soil surface) at GS 47 and 61. Harrowing speed was 5 km h^{-1} (speed limit of equipment). Hand-weeded control plots were used to estimate the influence of *V. hirsuta* on grain yield. The parameters assessed were plant density and seed production of *V. hirsuta*, crop ground cover, crop damage, and regeneration and yield of winter wheat.

Results and brief discussion

The efficacy of the kainite application was substantially lower than that of the thermal weed control (42 and 88 %, respectively). This was probably due to the poor adhesion of the kainite solution. The optimal application of kainite solution still requires further investigation. Growth stage of *V. hirsuta* at treatment time strongly influenced the efficacy. The highest reduction of *V. hirsuta* plants was achieved at the one-leaf stage of the weed, with an efficacy of 76 and 96 % after kainite application and flame weeding, respectively (Figure 1). The higher kainite and thermal sensitivity of younger plants was also found in investigations of Vasters & Remy (1914), Ascard (1994) and Leroux *et al*. (2001), which are in agreement with our results. The younger plants are more susceptible, mainly due to thinner leaves, thinner layers of hairs and wax, lower biomass and less well protected meristems compared with older plants (Lien *et al.* 1967, Parish 1990, Vester 1990).

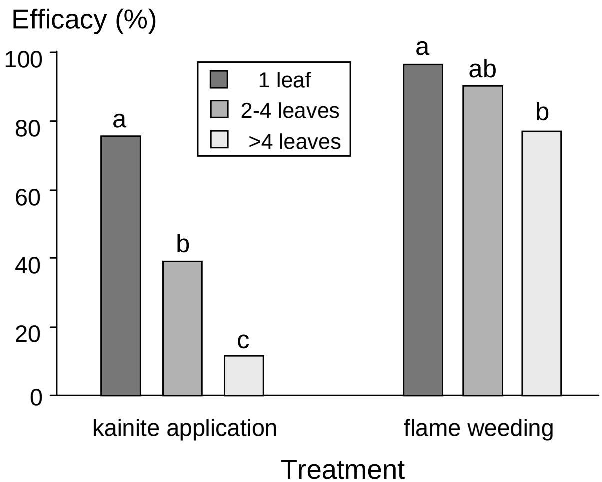

Figure 1:Efficacy of kainite application and flame weeding on density of *V. hirsuta* in winter wheat (GS 23), 8 days after treatment. Weed density of control (no weed control) = 47 plants per m^2. Different letters within treatments indicate significant differences (Tukey test, α = 0.05).

Treated *V. hirsuta* plants with more than 4 leaves were able to regenerate even after complete desiccation of the shoots. The ability of these damaged plants to regrow was likely due to a larger amount of assimilates in the roots, higher water availability, and low competition by neighbouring plants.

Leaf area of winter wheat was reduced by 20 % and 60 % after kainite application and thermal weeding, respectively. Wheat stands recovered rapidly from theses injuries. Three and 6 weeks after the application of kainite and flame weeding, crop ground cover in the treated plots was not significantly different compared to that of the untreated plots. These findings confirm the results of Ascard (1995). Monocots like winter wheat with protected growing points that are located near the soil surface were able to reproduce shoots rapidly after damage.

Two weeks after kainite application and flame weeding, a considerable number of *V. hirsuta* plants germinated (average 16 plants per m^2). Surviving and newly germinated *V. hirsuta* plants were successfully controlled by single or repeated harrowing, which damaged the plants especially by breaking off branches or pulling out the stems. The winter wheat was not affected by repeated harrowing.

Single harrowing at both GS 32 and GS 47 was also able to control *V. hirsuta* sufficiently. However, the efficacy was lower than that of a combination of different direct control methods, because a high number of entwining *V. hirsuta* plants were not reached by the tines. The winter wheat was sometimes injured by the harrow, which frequently pressed down the crop stand.

Both kainite application and flame weeding significantly reduced *V. hirsuta* biomass and seed production (Figure 2). Weed seed production in plots treated with kainite was higher than in the plots treated with flame weeding. This can be explained by the lower efficacy of the kainite application with respect to *V. hirsuta* density compared with that of flame weeding (Figure 1). Seed production of *V. hirsuta* generally declined with increasing harrowing intensity due to higher efficacy in reducing biomass, e.g., broken off branches of *V. hirsuta* resulted in a decline in photosynthesis (Kemball *et al*. 1992). The severest decline of seed production (95 %) compared to the untreated control was achieved by the highest intensity of combined weed control (3 times harrowing + flame weeding) (Figure 2).

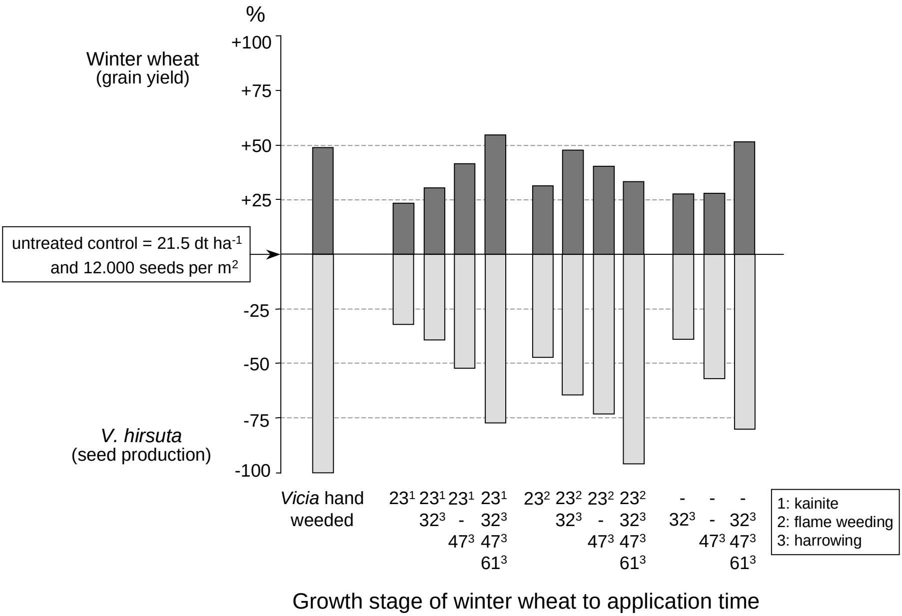

Figure 2: Relative increase of grain yield (winter wheat) and decrease of seed production (*V. hirsuta*) after weed treatments at different crop growth stages in relation to untreated control.

In the present study, a high infestation of *V. hirsuta* in a low competitive winter wheat stand caused a high reduction of grain yield in the absence of any direct control. Hand weeding of *V. hirsuta* reduced crop grain yield losses by 49 % compared with the untreated control (Figure 2). All direct control methods resulted in reduced yield loss and enhanced thousand-grain weight (data not shown). Grain yield losses declined with increasing harrowing intensity.

The highest grain yield (33.3 dt ha^{-1}) in our experiment was achieved after kainite application combined with repeated harrowing (3 times). This effect was caused by the successive reduction of weed biomass due to harrowing. On the other hand, in plots previously treated by kainite this high grain yield could be the result of the fertilising effect of kainite (21 kg K ha^{-1}) on the crop. The yield of the kainite + three times harrowing treatment was significantly higher (55 %) than that of the untreated control and even 10 % higher than in the hand-weeded control (not significant).

According to Wehsarg (1931), kainite can be used for both weed control and overhead potash fertilisation of the crop. However, kainite broadcast for fertilisation purposes only (53.5 kg K ha^{-1}) resulted in a reduction of the crop yield due to enhanced growth of *V. hirsuta* (Lukashyk *et al*. 2004).

Conclusions

Results show that a combination of different direct weed control methods (kainite application, flame weeding and harrowing) can significantly increase the efficacy of controlling the density and seed production of V. hirsuta when compared to the single or repeated use of single methods only. In early crop growth stages, the effect of kainite application or flame weeding on V. hirsuta density is higher than that of harrowing. However, in later crop growth stages, harrowing (combing) is much more effective in reducing the number of surviving and newly emerged V. hirsuta plants than kainite application or flame weeding. Nevertheless, three times harrowing/combing resulted in nearly the same grain yields and the same efficacy in reducing weed seeds as when this treatment was combined with flaming or kainite application. Kainite application as well as flame weeding is recommended for patches with high infestation of *V. hirsut*a in early spring, whereas harrowing/combing can be used efficiently in later growth stages and on larger areas.

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THE EFFECT OF SEED MOISTURE CONTENT AND THE DURATION AND TEMPERATURE OF HOT WATER TREATMENT ON CARROT SEED VIABILITY AND THE CONTROL OF *ALTERNARIA RADICINA*

Charles Merfield (1), John Hampton (1), Murray Hill (2), Steve Wratten (1)

(1) Bio-Protection and Ecology Division, PO Box 84, Lincoln University, Canterbury, New Zealand, 00 64 3 325 3838, charles@merfield.com, hamptonj@lincoln.ac.nz, wrattens@lincoln.ac.nz
(2) Seed Technology Institute Australia Pty. Ltd. P.O. Box 410, Blackwood, SA 5051, Australia

Key Words: Carrot, Daucus carota, seed, Alternaria radicina, hot water treatment, germination, seed moisture content.

Abstract

Hot water treatment of seeds to control seedborne pathogens is an important tool for organic seed production. Reducing seed moisture content may have the potential to increase carrot (*Daucus carota* L. var. *sativus* D.C.) seed tolerance to treatment. Two hot water seed treatment experiments were conducted. The first studied the effect of seed moisture content (SMC), treatment temperature and treatment duration on germination. Maximum safe treatment temperature and durations were established at 50°C and 30-40 min. Germination decreased slightly from 68% at 5% SMC to 63% at 20% SMC (LSD 1.2) for all durations. The second experiment studied the effect of initial SMC and treatment durations on infestation of seed by *Alternaria radicina* and seed germination. Treatment at 50°C for 30 min for all SMC compared to the control resulted in a decrease in *A. radicina* infestation from 69.2 to 1.7%. Reducing SMC from 20 to 5% for all durations resulted in a small decrease in infestation from 25% to 18% (LSD 1.5). Reducing SMC to 5% prior to hot water treatment may be a commercially viable means of minimising reductions in seed viability and decreasing fungal infestation levels.

Introduction/Problem

Non-organic seed has been routinely treated with synthetic biocides to control seed borne pathogens and pests. These treatments are prohibited in certified organic production and alternative treatments, such as hot water or treating seed with biological control agents (Schmitt *et al.* 2004), are being investigated and used. To be effective, heat treatment of seeds requires the thermal tolerance of the seed to be greater than that of the pathogen. To be a practical option, the ‘tolerance window’ that is, the difference between the tolerance of seed and pathogen needs to be sufficiently large so that heat treatment causes a large reduction in viable pathogens with minimum impact on seed viability. Techniques that can increase the size of the tolerance window could improve heat treatments. Research into seed vigour tests has shown that SMC affects seed’s heat tolerance (TeKrony 1995). Altering SMC might have the potential to increase the tolerance window and therefore make hot water treatment more effective.

The use of standard germination tests (ISTA 2004), which measure percentage germination under controlled conditions, to assess the effects of heat treatment is somewhat limited. This issue has been recognised in the area of seed vigour where seed lots that have the same percentage germination in laboratory tests can show significantly different percentage emergence in the field (Hampton 1999). This means that there are aspects of seed quality that a laboratory based analysis of germination cannot measure. One approach used in seed vigour tests is to stress the seed by subjecting it to elevated temperatures and humidity for a period of time, often several days. For example, the accelerated ageing (AA) test for soybean (*Glycine max* (L.) Merr.) exposes the seed to 41°C ± 0.3°C at 100% RH for 72 h ± 15 min (ISTA 2004). There are noteworthy similarities between the AA test and hot water treatment in that both expose seeds to elevated temperatures and moisture. It is therefore possible that heat treatment may have negative impacts on seeds that are not detected by measuring germination. A possible means to detect more subtle effects of hot water treatment could be to conduct a seed vigour test on the heat-treated seed. However, the current means of vigour testing carrot seed is the same as for soybean, described above, which means that the seed would be subjected to two sequential heat treatments. This repeated exposure to deleterious conditions means the result could be questionable. An alternative approach is to analyse the rate of germination. This avoids subjecting the seed to further harmful conditions while providing a potentially more sensitive measure of the effects of heat treatment.

Methodology

Experiment 1: Effect of hot water treatment on carrot seed viability in the absence of pathogens.

Carrot seeds, of an unknown F1 hybrid cultivar known to be free of *A. radicina* were used in a three factorial hot water experiment, with factors being initial SMC (5, 10,15 and 20%), duration of treatment (0 (control), 10, 20, 30, 40, 50 and 60 min) and temperature (45, 50 and 55°C). SMC was determined using an internationally standardised method (ISTA 2004). SMC was adjusted by either placing seed in a 30°C oven until the target weight was reached (for 5%) or adding the required amount of sterile distilled water and holding for 24 h at 5°C (for 10-20% SMC). Seeds were contained in stainless steel tea infusers and placed in a hot water bath containing 11 l of water, which was agitated by a shaker plate. After treatment, all seeds were immediately plunged into 15 l of tap water at 15°C for five minutes to rapidly cool them. A germination test (ISTA 2004) was then immediately conducted on the seeds except the seeds were placed on rolled towels instead of the surface of a blotter. Seeds were incubated in alternating 8 h/30°C light and 16 h/20°C dark cycles. The number of normal seedlings (ISTA 2004) was counted each day for 14 d.

Experiment 2: Effect of hot water treatment on infestation levels of *A. radicina* on carrot seed and carrot seed viability.

Carrot seed infested with *A. radicina* was obtained from plants that had been inoculated by spraying laboratory-produced conidia onto them two months prior to harvest. A two factorial experimental design with SMC of 5, 10, 15 and 20% and duration of 0 (control) 10, 20, 30 min was conducted using the same methods used for experiment one. In addition to measuring germination, percentage *A. radicina* infestation was determined: ten seeds were placed on blotter paper that had been moistened with sterile distilled water in a 9 cm petri dish, incubated for three days in darkness at 20°C, then killed by placing in a -20°C freezer for 24 hours and then incubated for 7 d at 20°C with alternating periods of 12 h near ultra violet light and darkness. Ten petri dishes (replicates) were completed for each treatment. Infestation was determined by visual identification of conidia on the seeds (ISTA 2004).

Germination and infestation data were arc sine transformed before analysis with ANOVA to ensure equal variance. Germination curve data were not transformed. All data and LSD values presented here are untransformed while the p values are from the transformed data. Results with a p value greater than 0.05 are considered not significant, a p value between 0.05 and 0.001 is considered significant, while $p<0.001$ is considered highly significant. Germination curves were calculated and fitted to a logistic model (Equation 1), where y is the number of germinated seeds and x is days. The values γ, β and μ for each curve were analysed with ANOVA. γ is a measure of final germination (number of seeds out of a total of 50), β is the germination rate coefficient and μ is the point of inflexion of the curve which is a measure of the 'average' time to germination and is measured in days.

Equation 1. Logistic curve formula.

$$y_i = \frac{\gamma}{1 + \exp(-\beta(x_i - \mu))} + \varepsilon_i$$

Results and brief discussion

Experiment one. Germination was significantly reduced by increasing treatment duration and temperature, and there was a significant interaction between these two factors (Table), in that at 45°C germination did not differ among treatment durations, but at 50°C was reduced after 50 minutes, and at 55°C after 20 minutes. Germination fell from 68% at 5% SMC to 63% at 20% SMC. The average time to germination (μ) tended to increase as treatment duration increased, and there was a significant interaction between treatment duration and SMC (Table). Increasing treatment temperature also increased μ (data not presented)

Table 1. Effect of duration × temperature on germination (%) (LSD 4.3)

		Duration (mins)						
		0	10	20	30	40	50	60
Temp°C	45	82	84	81	77	81	80	82
	50	81	81	81	80	80	72	65
	55	78	77	62	38	19	5	1

Table 2. Effect of SMC × duration on μ (days) (LSD 0.81)

		Duration (mins)						
		0	10	20	30	40	50	60
SMC	5	3.9	3.6	4.1	4.8	4.6	6.1	6.2
	10	4.0	3.9	4.1	4.9	5.0	4.8	6.9
	15	4.2	3.8	4.5	4.5	4.7	6.0	6.2
	20	4.5	3.6	4.5	4.8	5.7	5.0	7.0

Experiment two. SMC (2) had a significant effect and duration (4) had a highly significant effect on infestation levels. The effect on percentage germination was not significant for either SMC or duration; however, the interaction was highly significant (data not presented). The grand mean for germination for the whole experiment was 16%.

Table 3. Effect of initial SMC on infestation of seeds by *A. radicina* (LSD 1.5)

	SMC			
	5	10	15	20
Infested seeds %	18	23	20	25

Table 4. Effect of treatment duration on infestation of seeds by *A. radicina* (LSD 1.5)

	Duration (mins)			
	0	10	20	30
Infested seeds %	69	9	5	2

The first experiment established the thermal treatment limits of carrot seed. Fifty-five degrees Celsius was clearly too hot causing a significant decrease in germination after just 20 min. In comparison, germination started to decrease only after 40 min at 50°C, so 50°C is taken to be the maximum safe temperature and 40 minutes the maximum duration.

The germination rate analysis conducted in this experiment is in general agreement with the percentage germination data. However, the average time to germination (μ), while following similar trends to percentage germination for treatment temperature and duration, demonstrated an earlier onset of negative effects (after 30 min for all SMC). This may indicate that damage to seeds is occurring more quickly than can be detected by percentage germination. The experience of seed vigour tests suggests that laboratory and field based percentage germination of heat treated seeds may not be in agreement and that treatments found to be ‘safe’ under controlled condition tests may not be ‘safe’ when the seed is planted in the field.

While treatment temperature and duration were highly significant for germination rate (β) there was no clear trend. The high level of significance gained where no clear trend exists is due to the large statistical power of the experimental design. This is also partly true of SMC where, although the change in germination data is highly statistically significant, biologically the change is not sizeable, especially when compared to the large effects of temperature and duration on germination. However, at the 5% SMC level there was a slight increase indicating that lowering SMC before treatment could be beneficial in improving percentage germination.

The second experiment showed treatment duration had a very large and biologically highly significant effect on the infestation levels of *A. radicina* reducing them to very low, agronomically acceptable levels. The effect of SMC on infestation was less clear because there is no apparent trend in the data. Although the difference between the lowest and highest SMC was biologically significant, this needs qualifying as the SMC of carrot seed in ambient conditions is around 10%, so such a large reduction would not be gained in commercial operations. The high infestation levels and low overall germination of the infested seeds limits the ability to draw any clear conclusions from the germination analysis.

There is a methodological issue that should be considered, in that the process of altering SMC may have a direct effect on the pathogen, as it does on the carrot seed. To be precise, the experiment measures the effect of altering SMC on the pathogen as well, and to be completely thorough the effect of altering MC should be tested on the pathogen in isolation. However, the experiment is aimed at understanding and simulating a commercial practice so it is suggested this issue does not overly impinge the value of the study.

Conclusions

The safe treatment duration and temperature established for carrot seed is much greater that that required to cause a large reduction in viable A. radicina, showing that it is a practical and effective means of reducing the infestation levels of carrot seed lots. The effect of altering SMC prior to treatment was less pronounced, but there was an improvement in germination of treated seed and a decrease in the infestation level. It may be commercially and practically valuable to decrease SMC to 5% prior to treatment to reduce the loss of seed viability while also reducing viable fungal infestation levels. Even if this is not the case, care should be taken to ensure that SMC is not raised above ambient levels prior to treatment, as this will reduce the effectiveness of the treatment. Further work using seed that has infestation levels more likely to be found in commercial practice would be valuable to confirm the observed effects of altering SMC. It would be valuable to also test the method on other seed borne carrot pathogens such as A. dauci and C. carotae.

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REGULATION OF CLOVER CONTENT BY CHOICE OF RYEGRASS VARIETY OR BY MIXING VARIETIES IN SHORT ROTATION LEYS

Nilla Nilsdotter-Linde (1) & Göran Bergkvist (2)

(1) Swedish University of Agricultural Sciences, Unit of Applied Field Research, Box 7043, SE-750 07 Uppsala, Sweden, Tel. +46 18 67 14 31, E-mail Nilla.Nilsdotter-Linde@ffe.slu.se
(2) Swedish University of Agricultural Sciences, Department of Ecology and Crop Production Science, Box 7043, SE-750 07 Uppsala, Sweden, Tel. +46 18 67 29 10, E-mail Goran.Bergkvist@evp.slu.se

Key Words: Organic farming, mixed swards, dry matter yield, legume content, white clover, competitiveness

Abstract

The legume content in short rotation mixed leys is generally larger in organic production than in conventional, because application of mineral nitrogen favours grasses in competition with legumes. A large proportion of white clover in the diet of ruminants may cause problems with bloat. The purpose of this study was to test the effect of grass varieties or combinations of varieties on clover percentage and ley yield. Different varieties of perennial ryegrass (*Lolium perenne* L.) and Festulolium (*Festulolium braunii* Richt.) were compared in mixed swards with white clover (*Trifolium repens* L.) in a field experiment in east-central (Uppsala) and south-west Sweden (Rådde). The clover DM proportion of total yield was usually more than 50% at Rådde, but generally less than 50% at Uppsala. At Uppsala, an increase in grass yield resulted in a corresponding decrease in clover yield. At Rådde, grass performance affected total yield, but not clover yield. It was concluded that the clover content in short-rotation leys can be restricted by using competitive and persistent varieties of grass, but it could not be shown that grass mixtures are more competitive than their constituent components.

Introduction

In organic farming, the large clover and protein content in leys caused by limited availability of soluble nitrogen is often unfavourable for silage-making and/or grazing. The ryegrass family generally competes better with clover in mixed leys than the fescue family (Nilsdotter-Linde, 1996). Furthermore, late diploids of perennial ryegrass are considered to be more competitive in regrowth than tetraploids. In this project the yield, persistence and botanical composition were determined in mixtures with different varieties of perennial ryegrass (*Lolium perenne* L.) or Festulolium (*Festulolium braunii* Richt.) and white clover (*Trifolium repens* L.) for silage. The purpose was to determine whether the white clover content could be effectively regulated by choosing grass varieties or combinations of varieties with different traits and whether the difference in clover percentage among treatments depended on differences in clover or grass biomass. Another purpose was to determine whether the clover content was generally reduced by mixing varieties. The grass varieties tested differed in ploidy, earliness and growth rate.

Methodology

In a study conducted at organic experimental farms at Uppsala (59°50'N) in east-central Sweden and Rådde (57°37'N) in south-west Sweden, three replicates with white clover were sown in mixtures with either perennial ryegrass or Festulolium in late April 2002. The grasses varied in growth rate, earliness and ploidy (Table 1). The Festulolium variety Hykor is derived from tall fescue (*Festuca arundinacea* Schreb.) and Italian ryegrass (*Lolium multiflorum* Lam.). Hykor has broader leaves than the perennial ryegrasses, i.e. less light is assumed to be transmitted through these swards. The seed rates in the different treatments were chosen to achieve the same relative plant density. The soil at the Uppsala site is clayey and very rich in organic matter (8.8% by weight), while the soil at Rådde is a sandy loam, also rich in organic matter (6.0% by weight). The average precipitation 1961-1990 was 544 mm at Uppsala and 975 mm at Rådde and the corresponding mean temperatures were 5.6ºC and 6.1ºC. The experiments were fertilised with manure in the establishment year. So far, they have been harvested in the two years following establishment.

The swards were cut on June 17, July 23 and Sept 17 in 2003 and on June 16, July 22 and Sept 14 in 2004 at Uppsala, and on June 25, Aug 1 and Sept 22 in 2003 and on June 6, July 20 and Sept 16 in 2004 at Rådde. The herbage was analysed plot-wise for DM yield and botanical DM composition. The samples consisted of

0.5 kg herbage, which was separated into white clover, other legumes, sown grasses and a residual fraction before drying. The total annual yields of clover and grasses were determined.

Table 1. Seed mixtures (species, variety, characteristics and seed rate (kg ha-1))

PR Herbie 2n late	17	+	WC	4								
PR Condesa 4n late	19	+	WC	4								
PR Helmer 4n intermediate	18	+	WC	4								
Herbie 2n late	8	+	Condesa 4n late	9	+	WC	4					
Herbie 2n late	8	+	Helmer 4n intermediate	9	+	WC	4					
Condesa 4n late	9	+	Helmer 4n intermediate	9	+	WC	4					
Herbie 2n late	6	+	Condesa 4n late	6	+	Helmer 4n intermediate	6	+	WC	4		
Festulolium Hykor	19	+	WC	4								

PR = perennial ryegrass. WC = white clover Ramona. 2n = diploid. 4n = tetraploid.

Results and discussion

The mean total DM yields were 6.6 and 11.1 Mg ha^{-1} at Uppsala, and 7.5 and 4.2 Mg ha^{-1} at Rådde in the first and second year, respectively. The small yields in the second year at Rådde were due to severe winter damage, probably caused by temperatures below zero without any protective snow cover. However, the sward had recovered by the second cut. Large precipitation and low temperatures delayed the first cut considerably in the first harvest year at Rådde. The second growth in the first year at Uppsala was restricted by a severe drought.

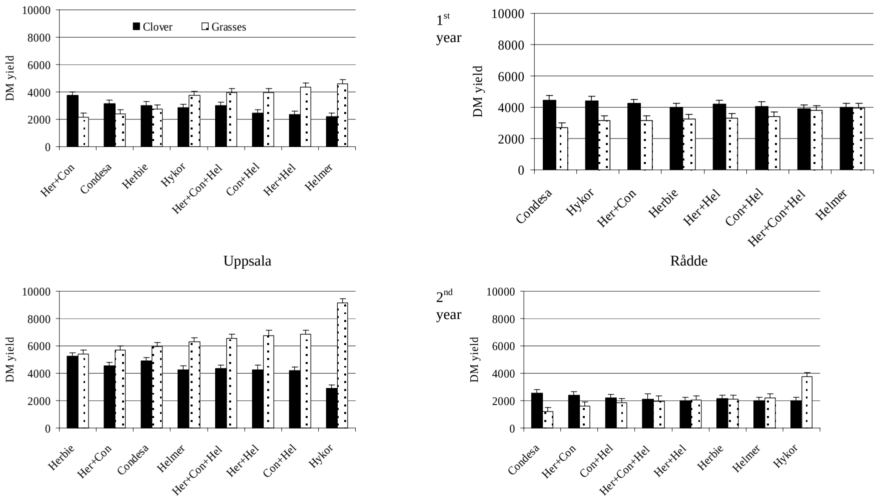

Figure 1. DM yield (kg ha^{-1}) in mixed swards with clover and ryegrass in the first and second years at Uppsala and Rådde, presented in order of increasing grass DM yield. Bars are standard error of the differences between means (SED).

The clover DM proportion of the total yield was usually more than 50% at Rådde, but generally less than 50% at Uppsala (Figure 1). The Rådde site is favourable for white clover, with high precipitation and soils with low clay content (Nilsdotter-Linde & Bergkvist, 2004). Self-seeded red clover (*Trifolium pratense* L.) constituted almost 50% of the clover biomass at Uppsala. Red clover is more competitive in relation to white clover in dry regions than in moist (Frankow-Lindberg *et al.*, 2004), which may explain the success of the self-seeded red clover at the Uppsala site.

At Uppsala, the clover DM content was smaller with the intermediate tetraploid Helmer than with Herbie and Condesa in both the first and second year (P<0.10) (Figure 1). At Rådde, the clover DM content in the sward was similar in both years, but the grass DM content with Condesa was smaller than with Helmer in the first year (P<0.01) and smaller with Condesa than with the other grasses in the second year (P<0.05), probably because Condesa suffered more during the harsh second winter than the other varieties.

In the second year, the grass content was largest with Hykor at both sites (P<0.001) and the clover content was smallest with Hykor at Uppsala (P<0.001), an effect probably associated with effective shading of the clover. Halling (2002) confirms good persistence of Hykor compared to perennial ryegrass. However, according to unpublished data (Nilsdotter-Linde, 2005), Hykor is to a larger extent rejected by grazing cattle than the other grasses, indicating restricted palatability of Hykor. This corresponds to findings in Denmark (Søegaard *et al.*, 2001).

On the fertile soil at Uppsala, grasses and clover competed strongly for resources so that an increase in the grass yields resulted in a corresponding decrease in the clover yields. In the first dry summer, yield was probably restricted by access to water, while in the second year light was probably limiting. Yields larger than those obtained in the second year at Uppsala are rare in this area. At Rådde, the performance of the grass affected total yield, but there was no evident effect on the clover yield. This indicates that yields were limited by access to nitrogen and that the grass varieties differed in their ability to acquire nitrogen. In the second year the ability to acquire nitrogen was probably affected by the extent to which the different varieties were damaged by the harsh winter. The experiment continues and more results are expected.

Conclusions

The clover content in short rotation mixed leys can be restricted by using competitive and persistent varieties of the companion grass. It could not be shown that grass mixtures are more competitive than their constituent components. In situations when water or light was assumed to have limited growth, increased grass content was associated with a decrease in clover content and not with an increase in total yield. The choice of variety affected total yield in situations where the resource potential did not seem to have been fully utilised, e.g. because of damage caused by harsh conditions during winter.

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USE OF LIOHUMUS EXTRACT FOR ECOLOGICAL CONTROL OF POTATO LATE BLIGHT

E.E Patsaki[1], V.A. Bourbos[1], C. Balis[2] and E.A. Barbopoulou[1]

(1) NAGREF, Institute of Olive Tree and Subtropical Plants of Chania, Laboratory of Plant Pathology and Ecotoxicology of Plant Protective Products, Agrokipio, 73100, Chania, Crete, Greece, Tel. +30 28210 83410, E-mail: vbourbos@nagref-cha.gr

(2) Agricultural University of Athens, Laboratory of Agricultural Microbiology, Iera Odos 75, Votanicos, Athens, Greece

Key Words: ecological control, potato late blight, Phytophthora infestans

Introduction

Ecological control of potato late blight caused by the fungus *Phytophthora infestans* (Mont) de Bary is based on forecasting programs, cultural practices (Shea and Broadbent, 1983), use of resistant cultivars (Umareus *et al*., 1983; Williams and Williams, 1994; Bradshaw *et al*., 1995) and application of suggested plant protective products.

Copper products are used only as preventatives and in limited quantities in order to avoid accumulation in the soil. Control of the pathogen has been reported with the use of *Fusarium sambucinum* (Klukov *et al.*, 1983) and *Pythium ultimum* (Kuznetsova *et al*., 1995) extracts. Bacteria of *Bacillus* genus were successfully used in tomato plants *in vivo* (Sadlers, 1996). *Pseudomonas fluorescens* strain AP33 and other bacteria isolated from the phylloplane and rhizosphere of potato and canola plants significantly controlled pathogen (Daayf *et al*., 2003). Skytalidine, antibiotic from *Skytalidium pesante* fungus, restricted pathogen development (Cook and Baker, 1983). Patatin that codifies resistance to *Phytophthora infestans,* inhibited spore germination by 70% (Sharma *et al*., 2004), while similar effects were reported for the alkaloid derivatives pipernonaline and piperidine from *Piper longus* (Lee *et al*., 2001).

The purpose of this work was to study the possibility of controlling potato late blight with the use of a compost extract made from olive mill waste water, olive pomace and olive leaves, known by the Greek term "liohumus".

Methods and materials

The experiment was conducted in a spring potato cultivation (cv. Spunta) at the area of Chania, Crete. Potato plants are infected during spring by late blight only in the early vegetative stages, since the climatic conditions do not favor pathogen development. Usually, two applications with plant protective products are sufficient to control the disease under local conditions.

The strain of the pathogen used was isolated from a potato cultivation in the same area. Liohumus was prepared through specific treatment of co-composting of olive mill waste water, olive pomace and olive leaves (Bradshaw *et al*., 1995; Balis, 1996; Papadimitriou and Balis, 1996; Papadimitriou *et al.,* 1997).

Metalaxyl 7.5% and mancozeb 56% were used in the form of the commercial product Ridomil MZ 63.5 WP, at a dose of 3 kg/hectare. Liohumus was used in 10 and 20% extracts. Experimental plots of control were sprayed with water. Each experimental plot included 33-36 plants in 5 replications. Observations were made in 10 marked plants per plot.

Products were applied twice, in 9-day interval, with the use of a low-pressure hand operated sprayer, late in February and early in March, when the plants had developed five fully-developed leaves and had no infection by pathogens. Mean temperature and humidity during the spraying period were 9-14 oC and 58-75% respectively.

Artificial inoculation was performed right after the first application of the products. Inoculant was prepared from two-week-aged pathogen cultivation that was developed in petri dishes with nutrient substrate made from 50 g coarse-ground oat and 25 g agar per liter of sterilized water and incubated in dark growth chamber at 20 ^{o}C. In order to achieve better detachment of sporangia from conidiophores, 1 ml of sterilized water was placed in every dish (Horodecka, 1989). The inoculant was incubated for 1 hour at 7°C and then placed at room temperature for achieving zoospore release. The suspension-dilution of spores that was used for the inoculation contained 1-2 x 10^3 spores/ml. Estimation of effectiveness was based on the measurement of infected leaflet before the first and 8 days after each product application, as well as on the percentage of infected tubers at the end of the growing season.

Results

Spraying the potato leaves with liohumus extract notably restricted late blight infection. The number of infected leaflets ranged from 10.5 (20% extract) to 18.6 (10% extract) in the experimental plots where the extract was applied. Percentage of infected tubers was 1.92% and 2.74% respectively. Therefore, the effectiveness ranged from 46.1 to 69.8% regarding infected leaflets, and from 83.6 to 88.5% regarding infected tubers.

The 20% extract of liohumus was more effective for pathogen control. Moreover, taking as criterion the infected tuber percentage, the effectiveness of 20% liohumus (88.5%), did not differ significantly compared to the reference product (88.5%).

Table 1. Effectiveness of liohumus extract to control potato late blight (*Phytophthora infestans*).

Treatments	Infected leaflets	% Effectiveness	% Infected tubers	% Effectiveness
Control	34.5 a	0.00 a	16.67 a	0.00 a
metalaxyl 7.5% + mancozeb 56%	1.08 d	96.87 d	1.91 b	88.54 b
Liohumus extract 10%	18.6 b	46.09 b	2.74 b	83.56 b
Liohumus extract 20%	10.5 c	69.57 c	1.92 b	88.48 b

Conclusions

The above mentioned results indicate that the liohumus extract was effective in reducing potato tuber infection by *Phytophthora infestans*, but not in reducing leaflet infection. It is possible that the use of liohumus extract might enhance the plant defense system, especially in tuber tissues. Recent reports have showed that teas made from horse or cow manure (Farrell, 1997) and extracts from the plants *Potenilla erecta, Salvia officinalis, Cymbopogon citratus, Allium sativum, Achyranthes japonica*, *Rumex crispus* and algae *Ascophyllum nodosum* (Cao and van Bruggen, 2001; Böhm and Cerny, 2002; Neuhoff *te al.*, 2003; Kim *et al.*, 2004) controlled effectively potato late blight. Results obtained from this experiment are particularly interesting, since liohumus is an organic material that might be produced at low cost and in high quantity. Further biochemical research should be conducted for clarifying a possible role of liohumus in induced resistance. Moreover, the possibility to control soil infectivity of the pathogen by using liohumus as soil amendment should also be investigated.

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MANAGEMENT EFFECTS ON NITROGEN FIXATION AND WATER USE OF LUCERNE UNDER DRY SITE CONDITIONS

Gabriele Pietsch, Jürgen K. Friedel, Bernhard Freyer

Division of Organic Farming, Department of Sustainable Agricultural Systems,
University of Natural Resources and Applied Life Sciences, Gregor Mendel Strasse 33, A-1180, Vienna, Austria, 0043-1-47654-3764, gabriele.pietsch@boku.ac.at, http://www.boku.ac.at

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Abstract

Biological nitrogen fixation is the main source of nitrogen in organic farming systems. There is little known about the impacts of cultivation techniques in pannonic regions on the capacity of biological nitrogen fixation (BNF) and the water use efficiency (ETC: evapotranspiration coefficient) of lucerne. From 1999 to 2001, pure lucerne crops and lucerne-grass mixtures were investigated with respect to the effect of the utilization system (harvested = forage production; mulched = green manure; pure lucerne crops versus lucerne-grass mixtures) on yield, BNF, soil N balance and water use efficiency. The amount of total fixed N was 124-150 kg N ha^{-1} in 2000 and 178-197 kg N ha^{-1} in 2001. The proportion of N derived from the atmosphere (% N_{dfa}) ranged from 26 to 79%. When the proportion of grass yield in lucerne-grass mixtures was high enough (exceeding 20%), mixtures showed a higher water use efficiency than pure crops by using site resources more efficiently than the pure lucerne crops. The release of nitrogen from the legume mulch was inhibited due to unfavourable conditions for mineralization in both years. Therefore green manure legumes did not decrease nitrogen fixation and the proportion of nitrogen derived from the atmosphere. Nevertheless, mulching the legumes reduced the water consumption of the crops compared to the evapotranspiration of the forage legumes.

Introduction

Lucerne (Medicago sativa L.) cultivation, used as green manure or as forage legume, is important on organic arable farms under dry site conditions. The annual nitrogen fixation rates of lucerne range from 85 to 360 kg N ha-1 (Frame et al. 1998). Mulched lucerne crops have the ability to fix 210 kg symbiotic N ha-1 yr-1 (Loges et al. 1999). Environmental factors and management practices (e.g. cutting and removal versus cutting and mulching) will affect the amount of N fixed and also the fixation process. In a cutting regime, much of the fixed N is removed by harvest the forage legumes and the benefit to subsequent crops is reduced. On the contrary, with green manures where the cut material is returned to the soil as mulch, a proportion of the fixed N will be returned to the soil with the legume debris. Nitrogen fixation is likely to be affected by the additional mineral N released from the decomposing debris. Although the use of green manure legumes is the main agricultural practices on stockless farms in Eastern Austria, there is a surprising lack of information in the literature on the critical evaluation of this utilization system compared to forage production under dry, pannonic site conditions.

Methodology

Lucerne (cv. Orca) was sown as pure crop (seeding rate 30 kg ha^{-1}) and in mixture with grasses (seeding rate 24 kg ha^{-1} lucerne, 30 kg ha^{-1} grasses) in August 1999/2000 at Raasdorf (organically cultivated fields of the University of Natural Resources and Applied Life Sciences, Vienna). The climate in the Marchfeld region is characterised by hot, dry summers with little dew, and cold winters with little snow. The mean annual temperature is 9.8°C, the average sum of precipitation 554 mm. The precipitation during the vegetation period in 2000 (501 mm) and 2001 (502 mm) was reduced compared to the long-term values. To estimate symbiotic N_2 fixation (according to McAuliffe *et al.* 1958), a low-level application of ^{15}N enriched fertilizer (1 kg potassium nitrate ha^{-1}, 10 at% ^{15}N) was conducted onto marked 2.25 m² subplots. ^{15}N marked plots with reference plants (grass-mixture: tall oat grass, red fescue, sheep´s fescue, meadow fescue) were established as well. The plants were harvested/mulched three times per year (May, July and August). At seeding, before and after winter, and to all harvesting dates, soil samples for determining inorganic N (nitrate-N) and gravimetric soil water content were taken (3 layers: 0-30 cm, 30-60 cm, 60-90 cm). The field plots were laid out in a completely randomised block design with four variants (LCH: lucerne pure crops harvested, LGH: lucerne-grass mixture harvested, LCM: lucerne pure crops mulched, LGM: lucerne-grass mixture mulched) in four replicates. The shoot and stubble dry matter (DM) yield were determined by harvesting 2 x 1 m² of each plot and drying an aliquot at 105 °C until the weight remains constant. Part of the plant material was dried at 60 °C for 48 h, ground up to a fine powder, and analysed for N content and ^{15}N isotope ratios (ThermoQuest Finnigan DELTA^{plus}) in the laboratory of the University of Göttingen. The actual evapotranspiration of the crops was estimated by using the climatic water balance (Ehlers & Goss 2003).

Results and discussion

Soil nitrogen status

In spring 2000, a strong increase in nitrate-N under the legumes occurred (0-90 cm: 102 – 164 kg N ha^{-1}). Generally, we found no differences between the nitrate-N content under the pure crops and mixtures in both vegetation periods. Soil nitrate-N of the pure crops and mixtures did not differ at the second and third harvest 2000, because the grass yield proportion in the mixtures was below 20%. In spring 2001, the nitrate-N contents in soil were reduced compared to the values in spring 2000 (pure crops: 50 kg N ha^{-1}, lucerne-grass mixtures: 51 kg N ha^{-1}). The soil nitrate-N of green manure and forage legumes did not differ in both years. This suggested that the environmental conditions (especially precipitation) in spring were suboptimal for the mineralization of the legume mulch. At the second and third harvest 2001, where the precipitation was according to the long-term means, the soil nitrate-N under the mulched variants (second harvest: 39, third harvest: 24 kg N ha^{-1}) was twice as high as under the harvested variants (second harvest: 20, third harvest: 12 kg N ha^{-1}), but they did not differ significantly because of the high standard deviation.

Plant growth and yields

The lucerne/grass content of the harvested shoot matter in the mixtures varied strongly during both production years (grass proportion of the yield in 2000: 39% at the first harvest to 18% at the third harvest; 2001: 21% at the first harvest to 1.5% at the second and third harvest). Generally the legume/grass ratio in mixtures is dependent on temperature (Clark *et al.* 1995), the access to plant available nitrogen in soil as well as other nutrients (Marschner 1995) and water. Thus legume-grass mixtures are intrinsically unstable (Parsons *et al.* 1991). Furthermore more herbage is harvested from a top grass at a fixed cutting height of 5 cm above the crown, e.g. tall oat grass, than from a bottom grass, e.g. red fescue. The other grasses in the mixture (red, sheep's and meadow fescue) obviously were not compatible with lucerne because the grasses did not meet the needed requirements, in particular a sufficient development of shoot biomass after defoliation. The total shoot DM yield of the lucerne-grass mixtures (LGH, LGM) was significantly higher than that of the pure crops (LCH, LCM) in the year 2001 (Table 1) because the shoot DM yield of the variant LGM at the first harvest was very high (10.8 t ha^{-1}) compared to the variant LCM (7.3 t ha^{-1}) and the proportion of grass yield in LGM was 25%. In general, mixtures profit by their varied intensity of using water and nutrients, where they utilise the site resources efficiently. The mulched variants reached more shoot and root yield at the first harvest 2001 than did the harvested crops. Since mulching did not start before the first harvest, this difference was obviously due to inhomogeneous soil properties on the trial site. Thus, the shoot, stubble and root DM yield was not affected by the utilization system in both years of investigation. This suggests that the shading effect of the legume mulch had no impact on the shoot yield of the green manure legumes.

Nitrogen fixation and proportion of nitrogen derived from atmosphere (N_{dfa})

The total nitrogen fixation (first to third harvest) reached from 124 (LG) to 150 (LC) kg N ha^{-1} in 2000 and from 178 (LC) to 197 (LG) kg N ha^{-1} in 2001. As a consequence to the soil nitrate-N contents, nitrogen fixation at the first harvest 2001 was twice as high as the respective BNF in 2000. In general, inorganic N is known to have negative effects on N_2 fixation in legumes (Vessey & Waterer 1992). Pure lucerne crops fixed a similar amount of N as did the lucerne-grass mixtures in both years (see Table 1). The proportion of nitrogen derived from the atmosphere (N_{dfa}) was significantly higher in the mixtures (57%) than in the pure crops (36%) at the third harvest 2000, when the grass proportion of the yield was 18% in the mixture. The high proportion of grasses in the mixture obviously increased N_{dfa} in the lucerne crops due to a reduced water consumption (see section “water use efficiency”). There were no significant differences in BNF and N_{dfa} between pure crops and mixtures in the year 2001 because the proportion of grass yield in the mixtures was too low to have an effect on these parameters.

Table 1: Shoot dry matter yield, nitrogen fixation and N_{dfa} (in shoots) of lucerne crops over a two year experimental period (2000 and 2001)

	Date	Shoot dry matter yield (t ha^{-1})				Nitrogen fixation (kg ha^{-1})				N_{dfa} (%)			
		LH	LM	LC	LG	LH	LM	LC	LG	LH	LM	LC	LG
00	10.5.	3.3^a	3.2^a	3.0^a	3.7^a	52^a	61^a	59^a	48^a	50^a	48^a	49^a	53^a
	5.7.	1.3^a	1.0^a	1.1^a	1.3^a	10^b	23^a	16^a	10^a	26^a	79^a	53^a	26^a
	4.9.	2.1^a	2.2^a	2.1^a	2.2^a	45^b	126^a	75^a	66^a	35^a	37^a	36^b	57^a
	Total	$\mathbf{6.6^a}$	$\mathbf{6.4^a}$	$\mathbf{6.2^a}$	$\mathbf{7.2^a}$								
01	14.5.	5.3^b	9.1^a	6.3^b	8.1^a	66^a	110^a	76^a	100^a	39^a	59^a	49^a	67^a
	26.6.	2.7^a	2.3^a	2.6^a	2.4^a	66^a	42^b	58^a	50^a	67^a	55^a	61^a	58^a
	10.8.	1.9^a	2.1^a	2.1^a	1.9^a	47^a	44^a	44^a	47^a	44^a	19^a	32^a	40^a
	Total	$\mathbf{9.9^b}$	$\mathbf{13.4^a}$	$\mathbf{11.0^b}$	$\mathbf{12.3^a}$								

LH = mean of LCH + LGH, LM = mean of LCM + LGM, LC = mean of LCH + LCM, LG = mean of LGH + LGM; shoot nitrogen fixation at first / second harvest, total plant nitrogen fixation at third harvest;
abc: Means within one row and date followed by the same letter are not significantly different (P > 0.05)

In the present investigation, the climatic conditions in both investigation years were suboptimal for fast mineralization of the legume mulch due to the little precipitation. As a result, BNF of green manures was generally not reduced. Under the dry conditions in the Marchfeld region, Farthofer (2004) noticed that mulching fodder legumes did not increase the N mineralization potential and inorganic nitrogen content in soil under the first and second subsequent crop compared to harvesting. As a result, BNF of green manures was generally not reduced. BNF of the green manure variants (LM) was increased compared to the harvested variants (LH) at the second and third harvest in 2000. This significant difference could be due to a methodical problem (see Pietsch 2004), but is not substantiated by higher herbage yields of the green manures compared to the harvested crops. The nitrogen fixation of the mulched variants was significantly lower than that of the harvested variants in the following production year (e. g. second harvest in 2001: harvested variants 66 kg N ha^{-1}, mulched variants 42 kg N ha^{-1}). Loges *et al.* (2000) also found higher BNF rates in harvested lucerne-grass mixtures compared to mulched lucerne grass-mixtures. The yield independent N_{dfa} value was not influenced by the utilization system in both production years.

Water use efficiency

The average evapotranspiration coefficient (ETC) for summer 2000 (March until August) of LGH (361 L kg^{-1}) was significantly lower than the ETC of variant LCH (539 L kg^{-1}). This difference was mainly a result of the first harvest, where the grass proportion in the mixture was high (39%). Grasses have thinner and more branched roots, rooting the soil intensely and have therefore advantages in competition with legumes regarding to nutrient and water absorption. The high water consumption of lucerne is explained by the restricted mechanism of the stomata (Haynes 1980). In the year 2001, lucerne pure crops evaporated the same amount of water as did the lucerne-grass mixtures, because the proportion of grass yield in the mixtures was very low.

Table 2: Evapotranspiration and evapotranspiration coefficient (ETC) of lucerne variants over a two year experimental period from March to August

Date of sampling		Evapotranspiration (mm)			ETC (L kg^{-1})	
Year / Month		LH	LM		LH	LM
2000	03 - 08	285^a	232^b		450^a	379^a
2001	03 - 08	309^a	306^a		312^a	235^b

LH = mean of LCH + LGH, LM = mean of LCM + LGM; abc: Means within one row followed by the same letter are not significantly different (P < 0.05)

The evapotranspiration of the green manure variants was lower than that of the harvested crops in the year 2000 (Table 2), because the legume mulch covered the soil and thus reduced the evaporation. Frye et al. (1988) confirmed also that mulching with plant material reduced evaporation and water loss to the atmosphere by shading the soil surface.

Conclusions

From this study it can be concluded that yield and nitrogen fixation of lucerne in the pannonic region depended strongly on water supply and mineral nitrogen in soil. When the proportion of grass yield in lucerne-grass mixtures was high enough (exceeding 20 %), mixtures showed a higher water use efficiency than pure crops by using site resources more efficiently than pure crops. The grass species in the mixture had little resistance to the several cuts under the dry climatic conditions. Therefore, more appropriate grass species should be used. The release of nitrogen from the legume mulch was inhibited due to unfavourable conditions for mineralization in both years. Therefore green manure legumes neither increased soil nitrogen contents nor decreased the proportion of nitrogen derived from the atmosphere. Nevertheless, mulching legumes reduced the water consumption of the crops and lead to a higher water use efficiency compared to the harvested legumes.

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POSSIBLE AGENTS FOR ORGANIC SEED TREATMENT

László Radics, Anna Ertsey

Corvinus University Budapest, Department of Ecological and Sustainable Production Systems,Villányi út 29-43, H-1118, Budapest, Hungary, Tel.: 0036-1-4826235, e-mail: laszlo.radics@uni-corvinus.hu, home page: http://anubis.kee.hu/munk/kukmunk.htm

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Abstract

The quality of seed is the basis of successful organic plant production. Since seed treatment with synthetic chemicals is not allowed in organic farming, it is important to find alternative methods for seed treatment instead of that process. The goal of our research was to find methods that retain good quality of organic seed and assure high field emergence. The experiment consisted of two parts. In the first part, the effects of the chosen materials on germination green pea (*Pisum sativum* L.) seeds was measured. In the second part, the effect of the chosen materials on the seed-borne fungi *Ascochyta* sp., and *Fusarium moniliforme* on corn seed was observed. The chosen methods were warm water, Biokál, Alginit and Vetozán -permitted fertilisers and conditioners in organic farming in Hungary - and oil of thyme. Effects on germination ability were observed in the laboratory and in the field according to international rules (ISTA 2003). The 'Poisoned agar plate' method was used to determine the effect of chosen materials on seed-borne fungi. According to our present results, Biokál enhanced germination and thyme oil gave the best inhibition on fungi.

Introduction

The role of organic farming is more and more important not only in agricultural practice but also at regional level in the European Union, including in Hungary. In the last 12 years the area of organic cultivation in our country reached 113,000 ha. The EU regulation (Council regulation (EEC) No 2092/91) and the Hungarian standards requires organic seed to be used if such seed is available. The quality of seed (germination ability, health, vigour) is the basis of successful organic plant production. Therefore it is important to find alternative methods for seed treatment instead of chemical treatment, which is not allowed in organic farming (Borgen, 2004a). There are several proposed methods including heat-treatments: hot air drying (Kristensen & Forsberg 2000) and soaking in hot water (Schachermayr *et al*., 2000). Selection of seeds to size, morphological shape or damage could make a higher and more homogeneous quality of organic seeds with better germination and higher vigour (Guberac *et al.,* 1998). There are many research programmes aiming to find materials that might replace chemical seed treatments and be permitted in organic farming (Borgen, 2004b). The goal of our research was to find acceptable methods to retain the good quality of organic seeds whilst assuring high field emergence. The first part of this project studied the relationship between the different treatments and seed germination and field emergence. In the second part, the effects of the chosen materials were observed on the seed-borne fungi *Ascochyta* sp. (on 'poisoned agar' plates) and *Fusarium moniliforme* (on infected corn seeds).

Methodology

For the seed germination test in the laboratory and in the field non-treated pea seed (*Pisum sativum* L.) was used. The variety was Marcado, with germination of 91% which fulfils the requirements of EU and Hungarian Standards for Seed. The effect of warm water and Biokál were tested on seed germination with different times of soaking. Biokál is permitted in ecological farming as a plant conditioning substance in Hungary. It contains: 57% medicinal herb extracts, 38% bio-humus extract, 5% volatile oil. Different methods of soaking were applied:

Procedure in the laboratory:

- control means germination of untreated seeds
- 4x100 seeds were soaked for 40 minutes in 600 ml 30°C warm water then dried
- 4x100seeds were soaked for 2 hours in 600 ml 30% Biokál solution.
- 4x100 seeds were soaked for 4 hours in 600 ml 30% Biokál solution.

- 4x100 seeds were soaked for 6 hours in 600 ml 30% Biokál solution.

Germination tests were carried out according to the ISTA (International Seed Testing Association) International Rules 2003 between paper (BP Roll) at 20 °C under 8 hours lighting in a germination chamber. The samples were evaluated as normal seedling and the length of shoots (hypocotyl) and roots (mm /plant) were measured on the third day.

All data were analysed with one-way analysis of variance, with Tukey test at 5% significance level.

Procedure in the field:

- control means untreated seeds.
- 4x100 seeds were soaked for 40 minutes in 600 ml 30°C warm water then dried before sowing
- 4x100 seeds were soaked for 4 hours in 600 ml 30% Biokál solutions then dried for 24 hours in air temperature and then sown.

The experiment under field conditions was carried out in Monor in the post control station of the National Institute for Agricultural Quality Control. The date of sowing was the 26 March 2003. The field emergence was followed from the first plant to appear until the 7th day. Finally the plants were collected and the dry weight of shoot and root (g/100 plants) were measured.

All data were analysed with one-way analysis of variance, with Tukey test at 5% significance level.

For the pathological test of *Ascochyta sp*. the 'Poisoned agar plate' method was used. Warm agar dextrose substrate was mixed with the chosen materials. The spores of fungi *Ascochyta* sp. was placed in the centre of the cold plate. The growth of fungi was observed.

- 10g Alginit was mixed in 1l agar dextrose
- 10 g Vetosan was mixed in 1l agar dextrose
- 30 ml Biokál was mixed in 1l agar dextrose
- 10 μl oil of thyme was mixed in 1l agar dextrose

Alginite is a type of kerogen. It is, made from decomposed algae and other plant material. Alginite is also known as "amorphous organic matter". It is a mineral of natural origin that contains neither any artificial additives nor chemicals and is permitted in Hungary in organic farming as a soil conditioner. Vetozán is a mineral of natural origin, permitted in Hungary in organic farming as a fertiliser. Oil of thyme from commercial trade was used.

For the pathological test of *Fusarium moniliforme* naturally infected corn seeds were used to see the effect of oil of thyme. 100% of seeds were contaminated with Fusarium spores. In the treatments:

4x100 contaminated seeds were soaked for 4 hours in 400 ml 30 % Biokál solution

4x100 contaminated seeds were soaked for 10 minutes in 400 ml 1% water solution of oil of thyme. We used 0,1 ml detergent to get the oil into solution.

After treatment, the seeds were placed in plates on wet paper for 48 hours at 20°C with 12 hour light –12 hour darkness. Then the seeds were frozen for 5 hours at -20°C. Afterwards, the seeds were kept at 7°C for 168 hours with changing lighting (12 hour light-12 hour dark) and UV light. We counted the number of seeds where mycelia of *Fusarium* could be observed.

Results and brief discussion

By the seed emergence tests in the laboratory (Table 1) all treatments, except the 2 hour soaking, gave statistically longer shoots than the control, with the longest being in the 4 and 6-hour soaking in Biokál, although these two were not significantly different from the warm water treatment. In the case of root growth, there were no significant differences, although there was a trend of Biokal-treated roots to be longer (Table 1). The 30% Biokal solution contains trace elements and this could be a reason for the hint of better results in this treatment.

Table 1. Length of shoot and root in laboratory conditions by different treatments.

	Time of soaking	length of shoot (mm/plant)	length of root (mm/plant)
Control		15.7 *a*	119.0 *ns*
Warm water	40 min	18.7 *b*	117.9
30% Biokál	2 hour	18.0 *ab*	117.7
	4 hour	20.0 *b*	122.9
	6 hour	20.3 *b*	129.7

Data with the same letter are not significantly different (P≥0.05). *Ns*, no significant differences (P≥0.05)

On the basis of the results of the laboratory experiment, only two treatments were carried out in the field. One was the 4-hour soaking in Biokal, the second was with warm water which is recommended for use in organic farming.

Fifteen days after sowing, the first seedling appeared. The dynamics of field emergence was observed over 7 days. Figure 1 shows that the best emergence was after the treatments with Biokal for 4 hours. The treatment with warm water also showed better results than the control.

After soaking, the seeds had a higher percentage of moisture, giving an advantage to germination in the soil. The effect of the 4-hour Biokál soaking was to stimulate emergence.

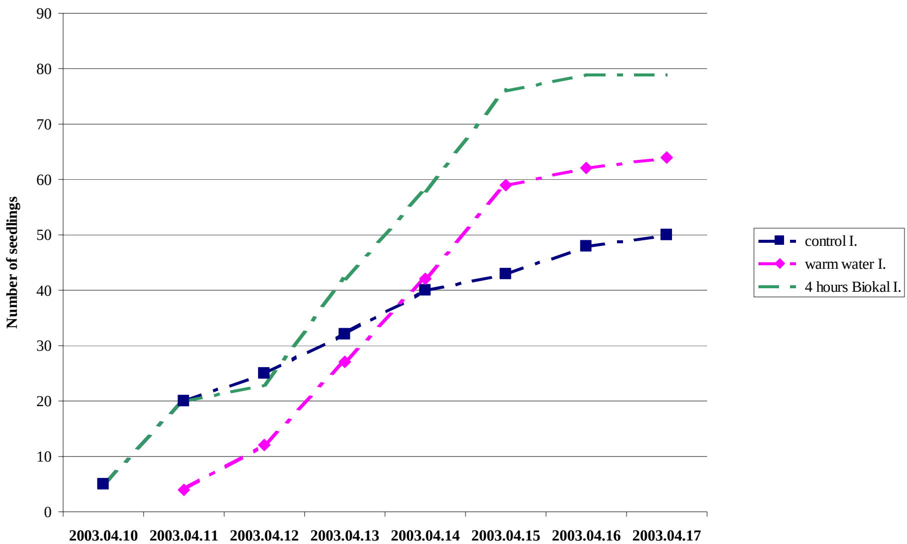

Figure 1. Dynamics of field emergence with different treatments.

From the field results, the dry weight of shoots (Table 2) treated with Biokál gave better growth than the control (the effect of warm water was not significant).

In the results of roots dry weight (Table 2), treatment with Biokál gave lower dry weight than either warm water or the control.

Table 2. Dry weight of shoots and roots under field conditions by different treatments.

	shoot dry weight (g/100 plants)	root dry weight (g/100 plants)
Control	4.96 *a*	18.51 *b*
Warm water	5.83 *ab*	19.87 *b*
30% Biokál	6.67 *b*	14.72 *a*

Figures with the same letter are not significantly different ($P \geq 0.05$).

In the pathological test by the 'poisoned agar plate method', the thyme oil showed full inhibition; no growing fungi were observed. The other treatments had no effects. Compounds of thyme oil have antifungal characteristics.

On *Fusarium*-infected corn seed, treatment with thyme oil fully inhibited *Fusarium moniliforme*, but it also inhibited seed germination. Treatment with Biokál had no effect on the fungi 100 % of seeds had mycelia on the surface.

Conclusions

Our results in the laboratory show positive effects of using a 30% solution of Biokál for seed treatment, although further research is needed to confirm results. The dynamic of field emergence also showed the positive effect of 4-hour soaking in Biokál, which stimulated emergence. The well-developed shoot and the rate of growth is of great potential benefit for field emergence. By the pathological test, the thyme oil showed full inhibition of *Ascochyta* sp on the 'poisoned agar' plates and of *Fusarium moniliforme* on the corn seeds, where it also inhibited germination. The other treatments had no significant effect. The pathological tests have to be continued to determine if thyme oil can be used safely. Thus, although Biokál may have some benefits for germination and emergence it has no benefit as an anti-microbial seed treatment.

Acknowledgement

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SELECTION OF QUANTITATIVE RESISTANCE POTATO CLONES AGAINST PHYTOPHTORA LATE BLIGHT IN KOREA

Kyoung Yul Ryu[1*], Hyeong-Jin Jee[1], Du-Hoi Choi[1], Jeom-Soon Kim[2], Juan A. Landeo[3] and Hyun-Mook Cho[3]

(1) Organic Farming Technology Division, National Institute of Agricultural Science and Technology, RDA, Suwon 441-707. Tel.,82-31-290-0551, E-mail, kyryu@rda.go.kr
(2) Environment Management Div., National Institute of Highland Agriculture, RDA, Gangwon, 232-955, Korea. Tel., 82-33-330-7981, E-mail, kimjs@rda.go.kr
(3) International Potato Center, Apartado 1558, Lima, Peru. 51-1-317-5326, E-mail, j.landeo@cgiar.org

Key Words: Organic Farming, Potato Late Blight, Resistance.

Abstract

Incidence and progress of potato late blight largely depends on susceptibility of the host in organic farming cultivation. In susceptible hosts, the disease completely destroys whole leaves within two weeks in organic farming fields. However, potato leaves of 14 quantitative resistance hosts remained healthy for 5 weeks after the first symptom appearance in the susceptible host. Area under disease progress curve (AUDPC) of quantitative resistance host ranged from 37.5 to 112.5 and slowly expanded compared with that of susceptible host. On detached leaves assay, seven clones of quantitative resistance host did not produce any sporangia against three isolates collected from different areas in Korea. Physiological races of the pathogen, Phytophthora infestans, were diversified as R0, 1,3,4,5,7,10,11 in organic farming fields and the races distributed with similar patterns in different areas.

Introduction

Potato late blight caused by *Phytophthora infestans* is the most destructive disease in potato worldwide. Disease outbreaks are more frequent and more severe in Korea. Farmers in seed potato production areas fear the pathogen because it can destroy entire fields of potatoes and tomatoes. The pathogen affects foliage and stems of plants resulting in tuber yield losses by reducing the photosynthetic capacity of the potato plant. Tuber losses due to the disease have been estimated to be about 38 to 58 percent of the total potato production in organic farming fields in 2004(Ryu *et al.* 2004). In many countries, control of potato late blight depends mainly on fungicides. Application times range from 5 to over 15 times per season in Korea. Despite spraying, the disease is relatively difficult to control in the fields, and the pathogen has developed tolerance against chemicals (Ryu *et al.* 2003). The presence of an aggressive pathogen strain destroys the field with repetitive infection cycles. For organic farming of potato, this study was carried out to find the potato breeding population with quantitative resistance against *Phytophthora* late blight and to understand the response of quantitative resistance to regional pathogen population in Korea.

Methodology

Advanced germplasm sources of late blight resistance were obtained from CIP's (International Potato Center) breeding population B. The materials were multiplied by stem cutting technique and grown in a greenhouse in the highland area in Korea. The seed tubers were planted to evaluate the resistance against late blight in the greenhouse and in fields. Detached leaves of 14 clones were obtained from the eight week old plants in the greenhouse and were inoculated with 10^4 sporangia/ml of pathogen collected from different sites. The resistance of potato clone was determined based on the sporulation rate and the amount of sporangia on inoculated leaves (Ryu *et al.* 2003). In the field, the incidence of late blight was evaluated according to the late blight rating system and AUDPC(Area Under the Disease Progress Curve) was calculated after 5 weeks from the first appearance of the disease.

Results and brief discussion

Late blight of potato caused by *Phytophthora infestans* spreads quickly under favorable climatic condition and the disease completely destroys whole leaves of the plant within two weeks in susceptible varieties in fields. However, potato leaves from quantitative resistance sources remain healthy for 5 weeks after the first symptom appearance on susceptible potato leaves. Area under disease progress curve (AUDPC) of quantitative resistance sources ranged from 37.5 to 112.5 and the lesion of symptoms was restricted to small spots on the leaves. On the other hand, the major potato varieties in Korea ranged from 1460 to 1407 in AUDPC. The relative humidity and temperature during cultivation periods were favorable to outbreak of late blight in the field and it leads to high disease incidence in potato from May to July. However, the sporulation rate of pathogen collected from different sites varied from the detached leaf assay (Table 1). Isolate HU-1 produced no sporulation on inoculated leaves of quantitative resistance and other isolates can infect potato clones with different disease severity. Physiological races of pathogen were diversified as R0, 1, 3, 4, 5, 7, 10, 11 in organic farming and commercial fields at Gangwon province in Korea. The distribution of pathogen races followed a similar pattern in different areas of potato fields, and seven clones of quantitative resistance host did not produce any sporangia against the most aggressive isolates collected from Hongchun (HC) areas.

Table 1. Response of potato clones against *P. infestans* from the different areas in Korea

Clone No.	Response of potato clone [1]							
	HG-1[2]	HG-2	HU-1	HU-2	HU-3	HU-4	HC	BP
PT-0741	-	-	-	-	-	-	-	-
PT-1055	-	-	-	-	-	-	-	++
R-5208	-	-	-	++	-	-	++	-
R-5209	+++	++	-	+	+	-	++	-
R-5212	-	-	-	-	-	-	-	-
R-3545	-	-	-	-	-	-	-	-
R-3547	-	-	-	-	-	-	+++	+
R-3552	-	-	-	-	-	-	-	++
R-5221	-	-	-	+	+	-	-	-
R-5222	-	+	-	++	++	+++	+++	-
R-5223	+++	+++	-	+	-	+	+++	-
R-3555	++	++	-	-	++	+	+++	-
R-3562	-	-	-	+	+	-	+++	+
R-3565	-	-	-	+	+	-	-	-
Superior	+++	+++	+++	+++	++	+++	+++	+++

[1] -: No sporulation of pathogen, +: Poorly growth, ++: Intermediately, +++: Vigorous
[2] Collection sites (HG; Hyeonggae, HU; Hyeongsung, HC; Hongchun, BP; Bongpyong)

In Korea, most potato varieties are susceptible to late blight and farmers apply fungicides to control the disease. However, heavy application of fungicide leads to the development of resistant pathogen strains and causes environmental problems (Peter *et al.* 1999, Ryu *et al*. 2003). Hence, the stability and adaptability of new breeding material is important in sustaining quantitative resistance against *Phytophthora infestans*. The pathogens were diversified according to the different cultural condition of crops, and aggressive strains of pathogens appeared to invade the host. So, race specific resistance can be broken down easily by new pathogen strains (Derie and Inglis 2001, Oyarxun *et al*. 1998). Quantitative resistance, unlike qualitative, permits invasion and development of the pathogen in host tissue, and makes no distinction among races of *P. infestans* (Landeo 2003). The advanced potato germplasm used in this study is useful to overcome various physiological races of *P. infestans* in organic farming fields because clones with quantitative resistance can be cultivated without fungicides.

Conclusions

In organic and conventional farming fields in Korea, the pathogen of potato late blight was isolated into eight physiological races. Because the vertical resistance can be easily broken down after the appearance of new races of the pathogen in the field, breeding of horizontal resistance against late blight is needed to prevent yield loss in organic farming fields. Based on this research, we found several quantitative resistance clones against potato late blight, which we believe can contribute to the production of organic potato seed in Korea.

Table 2. Disease progress of late blight in quantitative resistance potato clones in Korea

Clone	Incidence (%)	AUDPC[1]	Response[1]
PT-0741	0	37.5	R
PT-1055	0	112.5	R
R-5208	0	37.5	R
R-5209	0	37.5	R
R-5212	0	112.5	R
R-3545	0	75.0	R
R-3547	0	75.0	R
R-3552	0	75.0	R
R-5221	0	37.5	R
R-5222	0	37.5	R
R-5223	0	0	R
R-3555	0	0	R
R-3562	0	75.0	R
R-3565	0	37.5	R
Superior	100	1460.2	S
Jopong	98	1407.0	S

[1] Area Under the Disease Progress Curve
[2] R; resistance, S; susceptible.

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CARABID BEETLES (CARABIDAE) IN AGROECOSYSTEMS – CASE STUDY ON THE EFFECTS OF CONVERSION TO ORGANIC FARMING AND LAND STRUCTURE

Bořivoj Šarapatka(1), Milan Veselý(2)

(1) Department of Ecology and Environmental Sciences, Palacký University,
tř. Svobody 26, 771 46 Olomouc, Czech Republic, tel. +420-585634560, email:sar@prfnw.upol.cz
(2) Department of Zoology, Palacký University, tř. Svobody 26, 771 46 Olomouc,
Czech Republic, tel: +420-585631111, e-mail:vesely@prfnw.upol.cz
www.upol.cz

Key Words: Organic farming, conversion, beetles, Carabidae, land use, ecotones

Abstract

Our research compared the effects of farming systems (conventional, conversion to organic farming, resp. organic farming) and land structures (ecotones) on carabid beetles in four experimental plots during a five-year crop rotation cycle. An important factor affecting the composition of carabid communities was the type of land fragmentation contributing to a faster colonization of fields from ecotones. The factor of agricultural management, organic farming, was also significant. In the final years of the experiment we noted changes in the species composition of the carabid communities compared with the first years of the experiment, with an increase in the preference of bigger carabid species. The abundance of large carabid species was much lower in conventional fields.

Introduction

Changes induced by different agricultural management methods can be monitored in agricultural habitats using several methods. Due to the relative objectivity, and in order to cover complex changes in agro-ecosystems, biological methods (biomonitoring) are currently used in combination with chemical-analytical ones. Our research compared the effects of conversion to organic farming and land structures (ecotones) on one part of the biocenose, carabid beetles, in experimental plots during a five year crop rotation cycle. Carabids are a very suitable object for ecological surveys because:

1. this group is one of the most important part of the epigeon (as primary and especially secondary consumers),

2. carabids represent a systematically well covered group with a lot available information,

3. extensive samples of carabids can be obtained using simple standard methods (Thiele, 1977).

Carabid beetles in agroecosystems have been studied by many authors (e.g. Kromp, 1989; 1999; Eyre, Luff, 1990; Pfiffner, Niggli, 1996; Baguette, Hance, 1997; Döring, Kromp; 2003). In our study we asked whether different types of farming systems and ecotone effects were the main ecological factors influencing both the qualitative and quantitative features of the carabid communities and their distribution.

Methodology

In the experiment, four fields were studied (field I and IV – conventional, field II and III organic). The fields were situated in the same area (Litovelske Pomoravi protected area near Olomouc, Czech Republic) and abiotic factors (elevation, soil type, exposition, ground water level, type of margin etc.) of all four fields were similar as was the crop rotation cycle. In the experimental fields with organic (including the conversion) and conventional farming, the trap-lines for catching the carabids shared the same design. The traps were located in three lines, five traps in each line with a distance of 5 metre4s from each other. Lines of traps were oriented parallel to the field margin. The first line was situated at the edge of arable land (marked as "ecotone"), the second 10 m from the margin (marked as "field margin sensu lato") and the third line 100 m from the margin (marked as "field center s.l."). Jars of 0.7 l volume covered with a metal plate cover to protect the samples from rainfall were used as traps. Each trap contained approx. 200 ml of 2 % formaldehyde solution with a small amount of non-aromatised detergent. The invertebrates were collected during five seasons at regular two week intervals. At the laboratory all individuals belonging to the family *Carabidae* were sorted out and determined by available keys (Hůrka, 1996). Two data analysis methods were used to establish differences between the carabid communities: basic ecological indices (Simpson´s dominance, Shannon–Weaver´s diversity and Sheldon´s equitability) and partial redundancy analysis (CANOCO 4.0), which allows the correlation of species and environmental data.

Results and brief discussion

During the five year study more than 20,000 specimens belonging to 91 carabid species were collected. The most abundant species reaching a dominance higher than 2 per cent in at least one year of the experiment shown in Table 1 (in %). Five eudominant species are marked in bold.

Table 1: Abundant species in experiment

Species	D 1	D 2	D 3	D 4	D 5	D tot.
Anchomenus dorsalis	32.8	31.4	17.6	10.3	5.2	15.3
Bembidion lampros	1.7	2.7	3.4	2.5	2.6	2.5
Calathus fuscipes	0.0	2.6	1.3	1.6	2.5	1.8
Carabus granulatus	0.8	2.3	0.5	0.2	0.6	0.7
Carabus scheidleri	0.6	2.4	1.2	0.8	0.4	0.8
Poecilus cupreus	22.0	27.0	14.9	54.1	33.0	32.0
Pseudoophonus rufipes	11.9	3.8	30.4	17.6	35.3	23.9
Pterostichus melanarius	16.4	15.8	23.5	7.4	10.2	13.2
Trechus quadristriatus	2.3	3.2	0.7	0.1	0.2	1.0

Monitored fields did not significantly vary in Simpson's Dominance Indices (1-way ANOVA, df = 3. 56; F = 0.36, p = 0.78), Shannon-Weaver Diversity Indices (df = 3. 56; F = 0.46, p = 0.71) and Equitability Indices (df = 3. 56; F = 0.49, p = 0.71).

The multidimensional statistical analyses (RDA, CCA) gave us a more complex picture of the studied relations. Namely,

1) Significant differences were found among individual species in preference of ecotone, field margins or field centre independently on farming system. Ecotone was prefered by ecotone specialists (*Abax parallelepipedus, Leistus ferrugineus, Nothiophilus palustris, Patrobus atrorofus, Stomis pumicatus, Pterostichus strenuus, P. niger* or *Carabus coriaceus*), while other species were typical for open habitat. 2) 2) Some species in this group prefer a rather wider marginal belt (e.g. *Dyschirus globosus, Ophonus nitidulus,* or *Trechoblems micros*), the central part of field (*Clivina collaris, Harpalus signaticornis* and *Microlestes minutulus*) or show no preference, being equally abundant in both parts of field (*Bembidion lampros, Poecilus cupreus, Demetrias atricapillus*) (Fig. 1).

3) Consequently, the analysis detected the increasing ability of organic management to influence carabid communities. Despite the crop rotation circle, the presence of some species (*Carabus cancelatus, C. granulatus, Amara eurynota* etc.) had been increasing on organically managed fields in time, while other species remain constant for conventional fields (*Amara plebeja, Harpalus affinis, Calathus fuscipes* etc.) (Fig.2).

4) The final analysis confirmed significant differences in the structure of carabid communities of both organically and conventionally managed fields in the last year of experiment, when organically managed fields were prefered by. *Amara eurynota, Carabus granulatus, Carabus scheidleri, Dyschirius globosus* or *Poecilus cupreu,s* while conventionally managed fields were prefered by *Amara plebeja, Anchomenus dorsalis, Calathus fuscipes, Calathus melanocephalus, Harpalus affinis* or *Trechus quadristriatus* (Fig.3).

The most important factor affecting the composition of the carabid communities was the type of habitat. Ecotones were much more diversified and balanced than were open fields, where usually just a few dominant species occur in higher quantities, which agrees with the results of other researchers (Thomas *et al*., 1997; Desender and Bosmans, 1998). The factor of agricultural management (organic vs. conventional farming) was also significant.

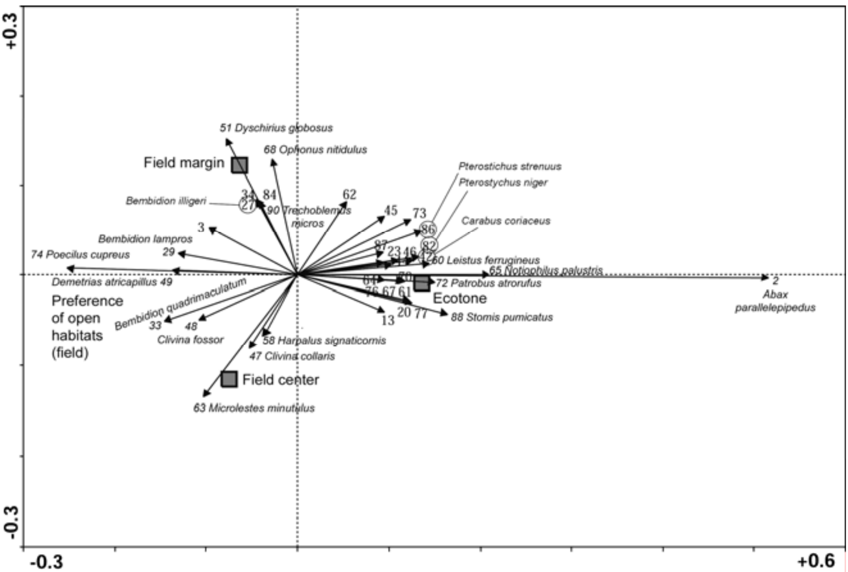
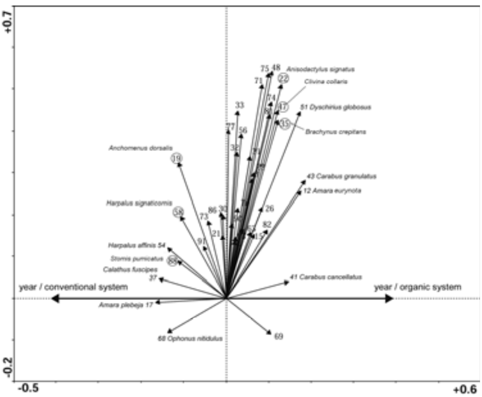


Fig. 1: RDA analysis with the position of trap line as the only variable. For reasons of space only the most important carabid species well correlated with ordination space are described.



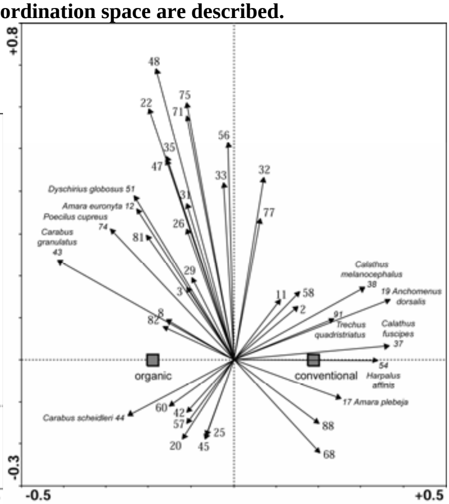


Figure 2: RDA analysis with type of farming and year of experiment as variables (left)

Figure 3: RDA analysis with type of farming as the only variable. Only data from the last year of experiment were used in the analysis (right)

Surprisingly, conversion to organic farming did not lead to an expressive increase of abundance in those carabid species present, which contrasts with data published by Pfiffner and Niggli (1996).These authors noted a higher diversity and abundance in ecologically managed plots, however their data were derived from fields 10 and 12 years after conversion to organic farming. During our study we noted rather important qualitative changes in the species composition of the carabid communities compared with the first year of experiment. Organically managed fields were mainly preferred by larger species (*Carabus cancellatus, C. granulatus, C. scheidleri* or *Abax ovalis*). Döring and Kromp (2003) found *Carabus auratus* to be the species most benefiting from organic management in Western Europe. Thishis species does not occur in the Haná region; however, it is replaced here by the related species *C. scheidleri*. The abundance of these large carabid species was much lower in conventional fields. The presence of such large predators in agriculture land is important not only for biological crop protection but also for conservation purposes, as all species of *Carabus* are protected by law in the Czech Republic.

Conclusions

During the final years of the experiment (conversion to organic farming) we observed a preference of the bigger predatory carabid species (*Carabus cancellatus*, *Carabus granulatus*, *Carabus scheidleri*) for organically-managed fields, which is important for both plant and nature protection. However, the development of more diversified and well-balanced communities connected with agricultural management changes (conversion to organic farming) requires a longer time than the landscape factor. Landscape fragmentation has been a very important factor affecting the composition of carabid beetle communities in rural landscapes in the past. In a traditional type of landscape, fast colonization of fields from the ecotone, even for flightless species (which are less adapted to field conditions, e.g. bigger carabid species), is easier. For the Czech Republic, and for other countries affected by collectivization of agriculture during the last decades, changes in agricultural systems towards more sustainable and balanced agroecosystems, are important, along with land-use optimization with increasing quantity of ecotones in landscapes. (Urban, Šarapatka, 2003). In The Czech Republic, the area of more stable plots in the rural landscape is being increased from about 50,000 to about 200,000 hectares.

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LEACHING OF MINERAL NITROGEN, ORGANIC NITROGEN AND PHOSPHOROUS IN CONVENTIONAL & ORGANIC FARMING IN KOREAN GREENHOUSE

Sang Mok Sohn (1), Young Ho Kim (1), Deok Hoon Yoon (2), Martin Kuecke(2)

(1) Research Institute of Organic Agriculture, Dankook University, 330-714, Cheonan, Republic of Korea, +82-41-550-3633, smsohn@dku.edu http://www.rioa.or.kr
(2) Institute of Crop Sciences and Grassland, FAL, Braunschweig, Germany, +49-531-596-2417, martin.kuecke@fal.de, http://www.fal.de

Key Words: Organic compost, Organic farming, Groundwater Pollution, Greenhouse, Conventional farming, Organic nitrogen, Mineral nitrogen, Organic phosphorous, Mineral phosphorous, Leaching

Abstract

The aim of this study was to receive basic data on the transport of mineral and organic N and P from the top soil to the subsoil in conventional and organic farming in Korea. It was focused to deliver the information about the environmental impact of Korean organic farming systems with regards to ground water pollution. High ammonium concentrations have been recorded in the seepage waters from the organic farming system, while the concentrations were negligibly low in the conventional farming plots as also found in other open field studies. The content of organic nitrogen in the seepage water from conventional farming systems were up to 4 % of the total nitrogen in the seepage water, while it was increased to 8% in organic farming systems. The content of total organic phosphorous is 6 times higher in the organic farming soils under greenhouse conditions compared to the conventionally fertilized soils under greenhouse. It was concluded that the Korean organic farming system shows some ecological risks in term of ground water pollution not only by nitrate and mineral phosphate, but also by organic nitrogen and phosphorus.

Introduction/Problem

Due to high application of organic composts and manures in organic farming systems in Korea, which results in high nutrient accumulation in the soils, a high potential risk of groundwater pollution from the soil has been recently assumed The aim of this study was to receive basic data on the transportation of mineral and organic N and P from the top soil to the subsoil in conventional and organic farming in Korea. It was focused to deliver information about the environmental impact of Korean organic farming systems with regards to ground water pollution.

Methodology

More than 95 % of organic farming is practiced under greenhouse conditions in Korea. Therefore 2 greenhouse soils were chosen for these investigations; one is a organic farm using exclusively organic fertilization, the second a conventional farm using only mineral fertilizers.

The experimental design for the fertilization experiment (2 replicates) was;

Conventional fertilization under greenhouse

Control : No fertilization during the experiment

CMF (conventional mineral fertilization): Recommended rate of chemical fertilizer

COF (conventional organic fertilization): Basal rate of organic fertilizer @ 3t/10a

Organic farming soils under greenhouse

OF (organic fertilization): Compost application @ 2t/10a

Nutrient leaching was measured by using Passive Capillary Samplers (PCAPS) described and constructed by KUECKE et al (in publication).

Results and brief discussion

A single application of organic compost in conventional farming systems (COF) increased the nitrate concentration only slightly compared to CMF, while regular compost application (OF) caused a dramatic increase of the nitrate concentrations in the leachates to values between 87 to 329 ppm NO3-N. In the plots where no organic fertilizers have been applied (control, CMF) concentration of less than 1ppm organic nitrogen was found in all seepage water samples. Compared to this, the concentrations reached values up to 11ppm organic N in the plot with one single compost application (COF), but reached concentrations up to 23ppm organic N in the organic farming systems (OF). From the OF field the highest TN leaching was recorded while the control plot showed the lowest nitrogen leaching. (OF > COF > CMF > control). The amount of leached nitrogen increased on the one hand with increasing fertilization, and on the other hand with increasing organic fertilizer application, but the influence of organic fertilization is obviously much more apparent. In the OF field, the TN amounts in leachate was maintained in the range of 40 ~ 100kg/ha during all sampling dates, which by the end of the experiment to totaled 300kg N/ha. Nitrate leaching was also increased in a way similar to total nitrogen and reached 15 kg NO3-N/ha in the control plot, but was extremely high in the organic farming plot with 245kg NO3-N/ha.

From this experiment, it was found that a leaching rise with high nitrate amounts in soils, and NO3-N amounts among the total leaching nitrate occupied over 90%. Moreover, TON which is not found from the conventional fertilization soils was detected over 20 times in the organic farming soils under greenhouse. Therefore, a regulation of organic fertilization is required for the over-N-accumulated soils in applying organic fertilizer.

In drainage waters the PO4-P concentrations are in a range of 50 to 2000ppb P. Since the wick sample technique has been used in this experiment, the effect of mineral and organic fertilization on the leaching of mineral and organic P could also be studied. It can easily be detected that the concentration increases with the intensity of fertilization. The concentrations in the CMF plots (510 ~ 574ppb Total P) were only slightly higher than in the control plot (466 ~ 502ppb total P), but increase after a single compost application (COF; 727 ~ 782). The organic fertilization system showed unexpectedly high concentrations of up to 2464ppb total P. The difference between the experimental treatments was much more obvious in the organic P concentrations. In the unfertilized plots, organic P concentrations in the seepage water were regularly below 4ppb, but in the conventional plot between 12 to 33ppb organic P. While one single compost application approximately doubled the OP concentrations, those in the OF plots were up to 20 times higher than in the conventionally fertilized plots.

Mineral P concentrations (PO_4-P) were also lowest in the unfertilized plot (462 to 500ppb PO_4-P) and increased slightly after application of mineral fertilizers (498 to 560ppb PO_4-P) and more after one single compost application (703 to 752ppb PO_4-P). After long term and frequent compost application the PO_4-P content in the seepage water was dramatically increased and up to 3 times higher than in seepage samples from the plot with conventional farming. The amounts of leached phosphorus have been calculated in the same way as for nitrogen. Total P leaching was less than 1kg TP/ha in the unfertilized plot and 1kg TP/ha in conventional farming plot. Phosphorus leaching was only slightly increased after one single compost application (1.53kg TP/ha) but was more than double in the organic farming plots compared to conventional plots with mineral fertilization. Most of the P is mineral ortho-phosphate. But in the plots with long term organic compost fertilization, up to 22 % of the total phosphorus leaching was organic phosphorus.

Conclusions

As known from numerous studies in the past, the intensity of nutrient leaching is dependant upon the amount and timing of fertilization, the soil type and the cropping system. Many studies have shown that the leached mineral nutrients are from either the actual fertilization or from the soil and have been accumulated by fertilization from previous years. High leaching potentials have frequently been observed and reported after long term application of organic fertilizers like liquid manure, farmyard manure, compost and municipal sludge. Organic compounds are accumulated in the soils and are mineralized over the following years to nitrate and phosphate. This accumulation of organic material in the top soil serves as a constant nutrient source for mineralization over a long term period. Sohn (1995) reported that a high risk for leaching of nitrate is caused by too high organic compost application in the organic farming system in Korea. Seo (1997) as well as Kang (2001) showed that the nitrogen applied above the optimum is not taken up by the crops and is leached into subsoil. Using excess organic fertilizer results in a high risk of leaching from the over-accumulation of nitrogen in the soils (Ahn et al., 2001). In most field situations, seepage water contains most of its mineral nitrogen as nitrate. Ammonium is usually found in very small concentrations as it is either rapidly nitrified to nitrate or is absorbed by clay minerals, so it cannot be detected in high concentrations in seepage water studies. In our study, over 90% of total leached nitrogen is dissolved reactive (mineral) nitrogen, and less than 10 % is organic nitrogen. Of the dissolved reactive nitrogen more than 90 % is nitrate nitrogen, the smaller part is ammonium nitrogen. In our study, high ammonium concentrations have been recorded in the seepage waters from the organic farming system, while the concentrations were negligibly low in the conventional farming plots as also found in other open field-studies. Reinfelder (1992) found that NH_4-N leaching is affected by the environmental conditions rather than by amounts of fertilization. From our study it can be concluded that in the organic farming soils under greenhouse conditions the high NH_4-N concentrations in the seepage water are due to a raised temperature and constant dripping irrigation. In Addition to the previous studies, in this experiment the leaching of organic nitrogen compounds could also be investigated by the use of Passive Capillary samplers. This sampling technique has been developed by Brown et al. (1986) and Holder et al. (1991) and was modified by Kuecke et al (in press). The advantage is that the salinized fibreglass wicks do not interact with the chemicals in the seepage water. In this study, the content of organic nitrogen in the seepage water from conventional farming systems was up to 4 % of the total nitrogen in the seepage water, while it increased to 8% in organic farming systems. It can be assumed that this organic fraction in the seepage water will be mineralized to ammonium and nitrate due to microbial activity in ground and will be an additional risk for groundwater pollution.

Mineral P leaching can also be studied by use of the PCAPS. As found in this study, most of the leached phosphorus (96 to 98 %) in conventional farming systems is mineral phosphate. After long term application of compost in organic farming systems, not only the total leaching of phosphorus is increased, but also the proportion of organic phosphorus is increased up to 22 %. This leaching of organic P from organic farming systems could not be detected in previous studies with the consequence that the data gained with previous sampling methods underestimate total P leaching. It can be assumed that in long-term organic farming systems the absorption capacity for mineral and organic phosphorus is saturated with the consequence that an increasing portion of the leached phosphorus was organic P. Dissolved organic phosphorous can be made in the soils with over 232 mg/kg phosphorous, and a lot of phosphorous in the high concentration soils will be leached underground (Shin, 1989). In this study, the content of total organic phosphorous is 6 times higher in the organic farming soils under greenhouse conditions compared to the conventional fertilization soils under greenhouse. Baker et al. (2002) found that the reduction rate of dissolved reactive phosphorus in leachate is greater than that of total amounts of P. Frank et al. (2002) and Calhoun (2002) reported that total organic phosphorus is a main source of groundwater pollution through the soil.

Based on the results of this investigation it must be concluded that the Korean organic farming system shows some ecological risks in term of ground water pollution not only by nitrate and mineral phosphate, but also by organic nitrogen and phosphorus. These organic compounds are also a source of ground water contamination in situations when they are metabolized by microorganisms to mineral nitrate and phosphate. With regards to this study, it can obviously be assumed that leaching of nitrogen and phosphorus occurs frequently in the organic farming soils under greenhouse. However, these results are contradictory to original targets of organic farming methods which intend to protect the environment (Elm Farm Research Centre, 1992, Koepke, 1989). To avoid groundwater pollution by leaching of nitrogen and phosphorus, Internationally recognized organic farming regulations such as Codex guidelines and IFOAM Basic Standards which suggest crop rotation including the cultivation of green manure, legumes and deep rooting crops must be practiced in Korean organic farming systems. Moreover, advanced fertilization should include a precise soil diagnosis in future.

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USEFULNESS OF SOME WINTER WHEAT VARIETIES FOR CULTIVATION IN ORGANIC FARMING

Jarosław Stalenga, Krzysztof Jończyk

Institute of Soil Science and Plant Cultivation (IUNG), Osada Pałacowa, 24-100, Puławy, Poland, tel.+48 81 8863421 ext.291, email: stalenga@iung.pulawy.pl

Key Words: winter wheat, variety selection, LAI, nitrogen nutrient status, SPAD test

Abstract

Evaluation of the usefulness of six common winter wheat varieties (Kobra, Roma, Korweta, Sukces, Zyta, Mewa) and one variety (Schwabenkorn) of spelt winter wheat (Triticum spelta) for cultivation in organic farming was the aim of the research. The research was based on a special field experiment established in 1994 on a grey-brown podzolic soil in which different crop production systems (organic, integrated and conventional) are compared. The research was conducted between 2002 and 2004 on the field of winter wheat in the organic system. The following parameters were taken into account in the research: Leaf Area Index, nitrogen nutrient status and grain yield. Average grain yields of winter wheat independently of the year and variety amounted to 4.36 t/ha. The largest yields were observed for Mewa and Kobra variety. Schwabenkorn variety of spelt wheat was characterised by the highest values of Leaf Area Index. According to 3 different tests Mewa variety was in the best nitrogen nutrient status and it seems to be the most useful one for organic farming. Efficiency of nitrogen utilization is an interesting test of usefulness of cereals varieties for organic farming.

Introduction

Selection of appropriate varieties of different crops is very important for organic farming (Eisele and Kopke 1997; Leibl and Petr 2000). Specific conditions of this system (no chemical plant protection and quick-acting synthetic fertilizers) make the selection of varieties a crucial point as related to quantity and quality of the yields. Evaluation of the usefulness of some common winter wheat varieties and one variety of spelt wheat for cultivation in organic farming was the aim of the research.

Methodology

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 between 2002 and 2004 on the field of winter wheat in the organic system. In this system (crop rotation: potato - spring barley - red clover with grass grown two years - winter wheat + catch crop) neither mineral fertilisation nor pesticides are applied. Organic fertilisation includes only manure application (30 t/ha) before potato cultivation. Area of a field covered by a particular variety was about 0.1 ha. Six different varieties of common winter wheat (Mewa, Roma, Kobra, Sukces, Zyta and Korwetta) and one variety of spelt (Triticum spelta) winter wheat (Schwabenkorn) were compared. All varieties, taken into account in the research, were characterised by different morphological and agricultural features (tab. 1).

Tab. 1. More important agricultural and technological features of selected winter wheat varieties

Variety	**Technological Type**	**Grain yield***	**Height of stalk in cm**	**1000 KW** in g**	**Cold resistance in 9" scale*****	**Lodging resistance**	**Phytosanitary status**
Kobra	Bread (B)	103	93	45.8	4.5	high	average
Roma	Bread (B)	89	112	46.9	7	low	average
Mewa	Bread (B)	97	101	47.6	6	rather low	rather good
Korweta	Qualitative (A)	96	103	44.5	3.5	rather low	good
Sukces	Qualitative (A)	103	97	46.1	2.5	high	good
Zyta	Qualitative (A)	99	110	50.3	2.5	high	good

* - 100% is a standard; **KW- 1000 kernels weight; *** - 1-the least resistant, 9-the most resistant

The following parameters were taken into account in the research to compare and select the most useful varieties for organic system: grain yield, nitrogen nutrient status and Leaf Area Index.

Grain yield was determined on the basis of samples taken from the control plots (20 m2).

To determine the total content of nitrogen in a dry matter, four shoot samples were taken for each variety. Each sample consisted of ten plants. The samples were taken in the shooting (GS 32-35) and the earing (GS 50-59) growth stages. N content was determined by continuous spectrophotometric method. Moreover dry matter yield of aboveground parts of winter wheat was determined in the same growing stages.

To evaluate nitrogen status of winter wheat Sufficiency Range method (SR), Nitrogen Nutrient Index (NNI) and SPAD test were used.

In the Sufficiency Range method (SR) the following critical range for N for the shooting stage (GS 32-35) elaborated by Bergmann (1992) was the standard: 2.3-3.8 %.

Nitrogen Nutrient Index (Lemaire i Gastal 1997) was used to evaluate nitrogen nutrient status in the shooting (GS 32-35) and the earing stages (GS 50-59).

In order to evaluate nitrogen status by a SPAD test measurements of chlorophyll content were done in four growing stages at 10 day intervals beginning at GS 32-35 by using a SPAD chlorophyll meter (manufactured by Minolta Co. Ltd.). Measurements were done in four samples consisting of thirty fully-developed leaves for each variety of winter wheat. On the basis of Fotyma (2002) research, the following critical chlorophyll contents, expressed in SPAD units, were accepted for the SPAD test: for Roma – 610, for Kobra – 635, for Korwetta - 615 and for Mewa – 628 (no data on critical contents for spelt wheat and other winter wheat varieties).

Leaf Area Index (LAI) was determined by Li 2000 measurer (firmy Li Cor, USA) in three growing stages (GS 30-35, 42-45 and 70-72). In general the higher value of LAI the better conditions of growth and development a crop has.

Tab. 2. Grain yields and other elements of yield structure for some winter wheat varieties (2002-2004)

Year	Wheat type	*Variety*	Grain yield (t/ha)	Ear density (ears/m2)	1000-kernels weight (g)
2002	Common wheat	*Kobra*	5.6 *ab**	481 *a*	40.4 *a*
		Roma	4.6 *a*	426 *a*	41.4 *a*
		Korwetta	5.5 *a*	462 *a*	40.5 *a*
		Mewa	6.1 *b*	423 *a*	43.5 *b*
	Spelt wheat	Schwabenkorn	*4.1 c*	*549 b*	-
		Average	5.2	468	41.3
		LSD $_{(0,05)}$	*0.69*	*60.33*	*1.57*
2003	Common wheat	*Kobra*	3.6 *a*	410 *a*	41.8 *a*
		Roma	3.6 *a*	330 *bc*	48.8 *b*
		Korwetta	3.1 *b*	310 *b*	43.4 *d*
		Mewa	4.4 *c*	426 *a*	45.9 *c*
		Zyta	3.3 *b*	297 *ac*	46.6 *c*
		Sukces	4.2 *d*	403 *a*	43.7 *d*
		Average	3.7	359	45.0
		LSD $_{(0,05)}$	*0.23*	*53.01*	*1.58*
2004	Common wheat	*Kobra*	4.5 *f*	390 *abc*	47.1 *b*
		Roma	3.8 *a*	359 *ab*	48.9 *c*
		Korwetta	4.1 *cd*	335 *a*	45.1 *a*
		Mewa	4.7 *e*	373 *ab*	50.0 *d*
		Zyta	4.3 *d*	467 *d*	48.0b *c*
		Sukces	3.9 *ab*	416 *bcd*	47.7 *b*
	Spelt wheat	Schwabenkorn	*4.1 bc*	*437 cd*	-
		Average	4.2	397	47.8
		LSD $_{(0,05)}$	*0.17*	*58.94*	*0.99*

The analysis of variance was done using the statistical programme Statgraphics Plus 6.0. The significance of the difference was evaluated on the 5% significance level with the help of Tukey's test.

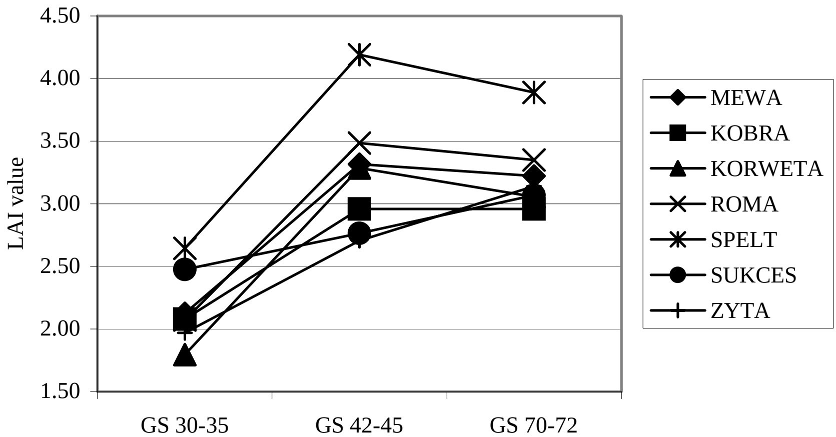
Results and discussion

Average grain yield of winter wheat for 3 years independent of the variety amounted to 4.4 t/ha.

The largest yields were observed for Mewa and Kobra variety in 2002, respectively – 6.1 and 5.6 t/ha. High ear density and large 1000-kernels weight were the main factors affecting higher productivity of these two varieties in comparison to others. Spelt wheat yielded on the level of about 4.1 t/ha of husked grain (tab. 2).

Schwabenkorn variety of spelt wheat was characterised by the highest values of Leaf Area Index, whereas within varieties of common winter wheat: Mewa and Roma reached the highest values (Fig. 1). This good result for spelt wheat might be a consequence of large density and height of its canopy. Usually the value of Leaf Area Index peaked at the earing stage (GS 50-59) to decrease in next stages. The degree of this decrease in the next growing stages was mainly affected by level of resistance on fungal pathogens.

Some authors (Eisele and Kopke 1997) point out that varieties 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. Spelt wheat seems to have such a characteristic and for this reason it seems to be better adapted to organic farming than common wheat.



LSD $_{(0.05)}$ ns =0.96 =0.65

Fig. 1. LAI values for some winter wheat varieties in the organic system (2002-2004)

Evaluation of nitrogen nutrient status of wheat done with Sufficiency Range method showed nitrogen concentrations within the limits of this range for all compared varieties. However for spelt wheat in 2002 this concentration was slightly below the lower limit of this range.

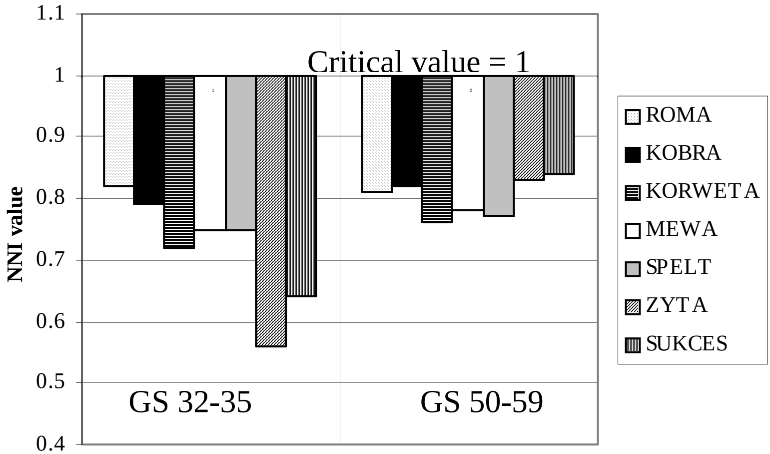


Fig. 2. NNI values for some winter wheat varieties in the organic system (2002-2003)

NNI test showed in almost all cases smaller or larger deficit of nitrogen for all varieties (Fig. 2). According to this test Roma and Kobra variety was in the best nitrogen nutrient status, whereas Korweta variety was in the worst status. However because of frost losses (the value of NNI is strictly related to the total DM yield per area unit) during winter time 2002/2003, especially serious for Zyta and Sukces varieties, diagnosis of nutrient status of NNI test done for the year 2003 seems to not be reliable.

High differentiation of SPAD readings was noted during growing seasons as well as in the investigated years. The highest differences were noted in 2003 year (Fig. 3). In this period the difference between first and the last term even exceeded 100 SPAD units. 2002 confirmed a certain regularity released in other research (Stalenga 2001), that early spring in Poland may often be a critical period for the growth of winter wheat in organic farming, because of the low intensity of microbiological processes in soil. Sometimes in such conditions even appropriate amounts of organic matter rich with nitrogen are not able to satisfy nutrient requirements of winter wheat. In 2004 none of the compared varieties reached the critical value. Very likely such a result might be a consequence of very small yields of a forecrop (clover-grass mixture).

Conclusions

The results showed that Mewa and Kobra varieties in comparison with others seem to be more useful for organic farming. Taking into account different parameters describing growth and development of winter wheat, efficiency of utilization of nitrogen seems to be an interesting test of usefulness of different varieties of winter wheat for cultivation in this system. However it should be emphasised that NNI and SPAD tests, applied in the research, were elaborated for intensive, conventional farming where obtaining high yields is the most important aim. Usually these very high yields (which are usually impossible to achieve in conditions of organic farming) are the reference point when the calibration of the test is done. As a consequence they seem to be of little use-to organic farming.

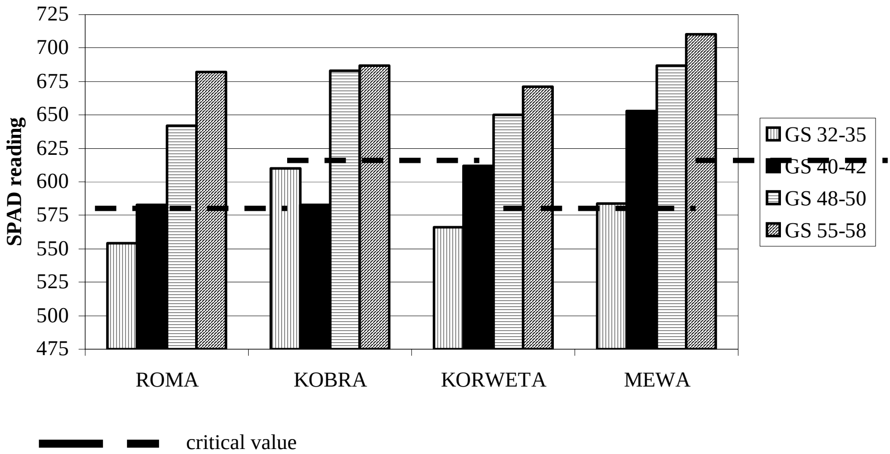


Fig. 3. SPAD readings for 4 varieties of winter wheat in the organic system in 2003

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POTENTIAL OF EXTRACTS OF SOME ETHIOPIAN MEDICINAL PLANTS FOR LATE BLIGHT CONTROL IN ORGANIC POTATOES

Mekuria Tadesse & Daniel Neuhoff

1: Ethiopian Agricultural Research Organisation (EARO) P.O. Box 2003, Addis Ababa, Ethiopia
2: Institute of Organic Agriculture (IOL), University of Bonn, Katzenburgweg 3, D-53115 Germany, d.neuhoff@uni-bonn.de, http://www.iol.uni-bonn.de/

Key Words: ethanolic plant extracts, late blight control, organic potatoes and tomatoes

Abstract

The potential of ethanolic extracts of some common medicinal plants of Ethiopia for control of late blight (*Phytophthora infestans*) in tomatoes and potatoes has been investigated *in vitro* and *in vivo*. The application of several ethanolic plant extracts resulted in a significant inhibition of mycelium growth (0.25% m/v) and an impairment of late blight disease severity *in vivo* (1% m/v). Extracts from *Hagenia abyssinica, Lepidium sativum* and *Lippia adoensis* showed the strongest suppression of mycelium growth. The application of extracts derived from the *H. abyssinica* gave the highest *in vivo* bioactivity against *P. infestans* on tomatoes, but no effect was noted in potatoes under field conditions. The general potential of these extracts for late blight control has been proved, while a practical application in organic crop production still requires further research.

Introduction/Problem

Phytophthora infestans (Mont.) de Bary, the pathogen causing late blight, is the most devastating fungal disease of potatoes and tomatoes worldwide (Birch & Whisson 2001). In Ethiopia, for example, late blight infection in potatoes caused crop losses in untreated local cultivars up to 100% (Bekele & Yaynu 1996). Apart from copper salt applications no efficient control methods are available in Organic Agriculture. For ecotoxicological reasons however a reduction or replacement of copper compounds is postulated by the EU-regulation 2092/91 on Organic Agriculture. Alternatively, plant extracts offer a promising, yet unexplored potential for sustainable, safe and environmentally sound plant protection, when used as fungicides or inductors of resistance (Jacobson & Crosby 1971). While the potential of medicinal plants of Ethiopia for medical purposes has been reported (Mirutse & Gobena 2003), information on the phytopathological potential is still missing. The objective of this work was to fill this gap and to investigate the potential of some common traditional medicinal plants of Ethiopia with respect to late blight control in tomatoes and potatoes.

Methodology

An aggressive isolate of *P. infestans* was cultured and maintained on a vegetable juice-calcium carbonate agar (200ml V8 juice, 3g $CaCO_3$, 16g agar, 800 ml aqua dest.) at 18°C in the dark. The biomass was suspended in distilled water to separate mycelium and sporangia. The suspension of sporangia was kept at 4°C for 4 hours to induce the release of zoospores. The density of zoospores/sporangia needed for an experiment was determined using a hemacytometer.

Tomatoes (*Lycopersicon esculentum* cv. ‘Rheinlands Ruhm’) and potatoes (*Solanum tuberosum* cv. ‘Nicola’), cultivated in commercial organic potting soil, were used for the bioassays.

Ethanolic crude extracts (10%m/v) from *Artemisia afra*, *Lepidium sativum, Ruta chalepensis*, *Taverniera abyssinica*, *Lippia adoensis*, *Dorstenia sp*., *Commiphora abyssinica* and *Hagenia abyssinica* were prepared and diluted according to methods described by Blaeser *et al*. (1998) and Mekuria *et al*. (1999). Additional standard plant extracts with known efficacy were produced from *Piper nigrum* (Mekuria *et al*. 2001) and *Salvia officinalis (*Neuhoff *et al*. 2002*)*. Further biotests with varied concentrations of selected extracts were performed in order to optimise the antifungal activity.

For a first screening, potentially active extracts (0.25% m/v) were mixed with a growing medium (at 50°C) in petri-dishes and incubated with a one-week-old mycelium plague of *P. infestans* at 18°C in dark. Radial growth rates of the mycelium were measured (cm).

Protective applications of different plant extracts (1.0%m/v) were tested on artificially inoculated tomato plants in greenhouse experiments. The upper and lower surface of test plant leaves were uniformly inoculated with zoospores of *P. infestans* (8×10^4 zoospores ml^{-1}) and incubated for 48 hours in a moisture chamber at 20 ± 5°C and 95% relative humidity with 4 replicates. Late blight severity was assessed after 64 hours of incubation. Field trials confirming indoor experiments were asserted with candidate products at 'Poppelsdorf' and 'Wiesengut' research sites of the University of Bonn in 2004. Crop cultivation followed standard practices including an exceptional fertilisation with 60kg N ha^{-1} (ammonia salpeter) for fertility reasons. Field experiments were carried out with repeated treatments (minimum 5) of a 1:1 extract of *H. abyssinica* and *P. nigrum* (0.5+0.5m/v, 600 l ha^{-1}) up from canopy closure and compared with standard copper treatments.

Results were statistically evaluated through ANOVA followed by Tukey's-test ($\alpha<0.05$). The efficacy of different treatments was calculated according to Abbott (1925).

Results and brief discussion

Screening of bioactive Ethiopian medicinal plant extracts in vitro and in planta

Primary screening for suppressive effects of extracts from Ethiopian medicinal plants against *in vitro* mycelium growth of *P. infestans* showed significant differences ($\alpha<0.05$) between the tested plant species. The average inhibition rate of mycelium growth of the tested extracts ranged between 10.2% (*Dorstenia sp.*) and 100% (*H. abyssinica*). *In vivo* biotests on preventive applications of selected plant extracts (1.0%m/v) indicated that only extracts of *H. abyssinica, L. adoensis* and *L. sativum* offered a promising potential to reduce the disease severity of late blight on tomatoes with efficacies of 64.2, 37.9 and 27.2%, respectively (Fig.1). With the exception of the extracts derived from *H. abyssinica*, no correlation was detected between *in vitro* and *in vivo* antifungal activities of the tested treatments.

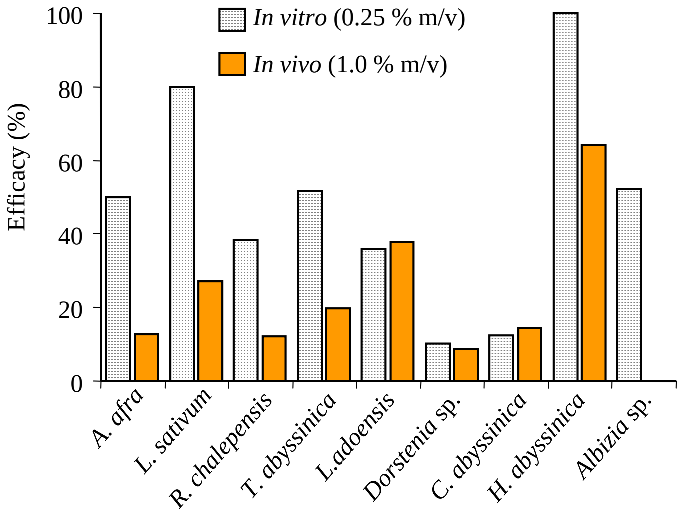

Fig.1: Comparative antifungal activity of extracts from Ethiopian medicinal plants against *in vitro* mycelium growth and *in vivo* disease severity of *P. infestans* on tomatoes, IOL lab trials 2004.

Optimisation of the efficacy of Hagenia abyssinica extracts

Tested Hagenia-extract concentrations (% m/v) and corresponding inhibition rates (%) of the mycelium of P. infestans were 2.5 (100), 1 (100), 0.5 (96.6), 0.25 (78), 0.125 (15) and 0.05 (5), respectively. The lowest effective extract dose (ED50) level responsible for an inhibition rate of fifty percent against mycelium growth of P. infestans ranged between 0.125 to 0.025%m/v. Protective applications against late blight on tomatoes of three different concentrations (0.1, 0.5 and 2.0 % m/v) of the H. abyssinica extract were compared with extracts based on a mixture (1.0 % m/v) of H. abyssinica with either S. officinalis or P. nigrum (1:1 ratio). A dose dependent efficacy was noted for the pure H. abyssinica extracts. The maximum degree of efficacy (60%) against infection pressure of zoospores of late blight was attained by an extract concentration of 2% m/v. The application of an extract mixture from Hagenia and Piper (1.0 % m/v) caused the highest level of late blight reduction amounting an efficacy of 65% (Fig.2) indicating that extract mixtures may have synergetic effects.

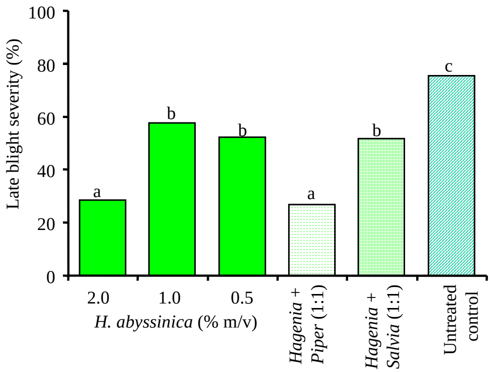

Fig. 2: Effects of different concentrations of *H. abyssinica* extracts on disease severity of *P. infestans* in comparison with mixtures with *Piper nigrum, Salvia officinalis* and an untreated control in greenhouse experiments.

On-farm verification of Hagenia extracts against late blight of potatoes

The application of a *Hagenia* / *Piper* extract mixture (1% m/v) in field trials only resulted in a slight reduction of late blight severity in potatoes, when compared with standard copper fungicides. The observations from both research stations indicated that none of the alternative late blight control agents tested showed comparable effects to the standard copper fungicide, which gave persistently over 95% efficacy (Fig. 3). However, at both sites the application of *Hagenia* extracts slightly delayed the trend in the epidemic status of the pathogen during late July, when an exponential growth phase of *P. infestans* was noted. The insufficient efficacy under field conditions may be due to the low extract concentrations applied but also to environmental factors such as removal by precipitation.

No effect of Hagenia-extracts on yield was noted. Tuber yields after Hagenia-extract application amounted 21.1 t ha^{-1} (Poppelsdorf) and 28.8 t ha^{-1} (Wiesengut) compared with 20.7 t ha^{-1} (Poppelsdorf) and 27.8 t ha^{-1} (Wiesengut) in the control plots. Repeated copper application in contrast resulted in an average increase of tuber yield of 51% (highly significant).

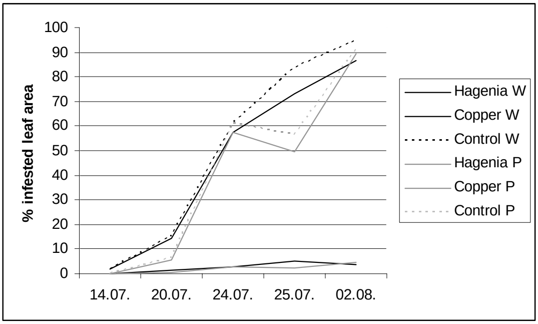

Fig. 3: Effect of different treatments on late blight disease development of potatoes cv. Nicola in 2004 (P = Poppelsdorf, W= Wiesengut research site).

Conclusions

Extracts from *Hagenia abyssinica* both under *in vitro* and *in vivo* conditions showed a promising potential for use in late blight control in potatoes. However first field experiments suggest that the suppressive effect of *H. abyssinica* extract on late blight under controlled conditions is much lower in the field, indicating that further research on the mode-of-action is necessary. Optimisation of effective concentrations, product formulation and application techniques still require further investigations. Furthermore environmental-, human- and phytotoxicity of any potential extract need to be assessed, even if medicinal plants have a long tradition in human medicine. A systematic screening of tropical medicinal plants may help to find new solutions for disease and pest control in organic crop production.

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AN OVERVIEW OF PHYTOSANITARY RISK ASPECTS OF COMPOSTING BY ORGANIC FARMERS

Aad J. Termorshuizen, Wim J. Blok

Biological Farming Systems Group, Department of Plant Sciences, Wageningen University, Marijkeweg 22, 6709 PG The Netherlands, aad.termorshuizen@wur.nl, www.dpw.wau.nl/biob

Keywords: composting, phytosanitary risks

Abstract

Usage of compost in agriculture always brings about the risk of introducing plant pathogens. By proper composting, resulting in high temperatures during the thermophilic phase, compost can be applied safely. Organic farmers often prefer to compost organic residues themselves. The advantage of such an approach is that no material of foreign origin is introduced, but a drawback is the smaller scale of composting, which brings about greater phytosanitary risks. These risks can be dealt with by increasing the composting duration and by proper turning of the compost heap. If only organic residues from farms are composted, this usually results in low-quality composts because of the low lignin contents. Therefore, addition of materials that are high in lignin, such as wood chips, is advisable. In conclusion, on-farm composting is well possible from a phytosanitary point of view, but the farmer has to be aware of the factors that affect the phytosanitation of organic waste and the quality of the compost.

Introduction

Compost is partially decomposed, stabilized organic matter that nourishes the soil microbial life for an extended period of time. Stimulation of microbial life increases the competition with soilborne plant pathogens, including nematodes. Moreover, compost contributes to maintaining the soil organic matter content and thus contributes to reducing the greenhouse effect.

Composting of organic waste is done to inactivate plant pathogens that are normally present in the waste, and, if manure is included, to inactivate animal and human pathogens as well. In the Netherlands, there are two main organic waste streams that are processed by composting. One consists mainly of woody pruning materials referred to as green compost and has a low phytosanitary risk when composting is done by professional composters. The other main stream consists of vegetable, fruit and garden waste collected from households. This type of waste varies of composition and has a higher phytosanitary risk as it includes plant pathogens present in material from small vegetable gardens. However, if composting is carried out in a professional way, the overall risk is regarded low. A separate type of organic waste is that of the food processing industry. This includes large amounts of one type of waste such as from the potato processing industry and thus may contain a relatively large amount of specific pathogens. This organic waste from the processing industry is either incinerated or sometimes, depending of its source and composition, included in the composting of vegetable, fruit and garden waste. For organic agriculture, in the Netherlands currently only some composts are certified for use by organic farmers. In addition, organic farmers may compost themselves on-farm or in small collectives of neighboring farms. The poster presented at this congress aims to analyze the phytosanitary risks of the use of compost that are specific for organic farmers. General aspects of phytosanitary risks of using composts have been dealt with in an earlier paper (Termorshuizen *et al.*, 2005) and here we will focus on aspects specific for organic farmers.

Organic waste and compost logistics

Composting of organic waste can be organized at small or at large scale and these extremes both have their pros and cons. If composting is done on-farm on a small scale, requirements needed for pathogen inactivation will be more difficult to achieve compared to professional composters. Inactivation of pathogens is nevertheless important, otherwise the farmer will recycle his own pathogens and possibly bring them even to hitherto uninfested fields. On-farm collected organic waste is usually low in lignin content which results in a poor structure and consequently insufficient aeration of the compost heap. Therefore, farmers who compost themselves usually add wood chips from municipalities (pruning residues) or the wood-processing industry. If wood chips originate from municipalities or gardeners it should be checked whether they work without pesticides or artificial fertilizer. Alternatively, if composting is done at large composting facilities, requirements needed for pathogen inactivation are more easily fulfilled, but organic wastes are collected from multiple sources and there is always some chance of introducing new pathogens, and, in general, there is less security about the origin of the waste.

Use of existing sources of compost

Currently in the Netherlands composts from vegetable, garden and fruit waste as well as from green waste are allowed for use in organic agriculture. Due to the fact that the majority of households uses inputs from conventional products, compost made from vegetable, fruit and garden waste will not be allowable in the near future for use in organic agriculture. In our opinion it remains to be investigated whether the composting process could be regarded as a way of 'cleaning' the conventional waste as it is known that most, if not all, pesticides that are allowed in Western Europe are broken down completely by composting. The same might very well be true for genes from genetically modified organisms although this will need scientific confirmation. If this is true, composting may be a way for transforming 'conventional' organic matter into 'organic' organic matter and thus for guaranteeing that, in the long term, no shortages of organic matter will develop in organic agriculture and that carbon and organic matter cycles become more tightly closed.

On-farm composting

Typically, on-farm composting is a small-scale process relative to the composting process carried out by professional composters. In small-scale composting it is more difficult to reach sufficiently high temperatures for a prolonged period of time so that inactivation of pathogens occurs. In addition, moisture content is of crucial importance as temperature sensitivity of most organisms is much higher under moist than under dry conditions. Apart from the size of the compost heap which in part determines the composting conditions, also the ability to control and measure compost process parameters are reduced with small-scale composting. Therefore, it is advisable to lengthen the composting process from the usual 3 weeks in tunnel composting by professional composters to at least 8 weeks. As forced aeration is not applied in on-farm composting, such a period of time will also be needed to achieve a sufficient level of compost stability. Still, regular measurement of temperature, regular turning of the compost heap, and checking and adapting for the moisture content are necessary. Insight into the presence of certain persistent plant pathogens may influence phytosanitary risks and thus the composting process. If certain highly persistent pathogens are known to be present on a certain crop it is advisable to exclude this material for composting. Information on the fate of a range of pathogens during composting can be found in e.g. Bollen *et al.* (1989), Noble & Roberts (2004), Ryckeboer *et al.* (2002ab), and Termorshuizen *et al.* (2005). Apart from phytosanitary aspects, composting variables such as turning frequency and moisture content also affect general compost quality and loss of nitrogen during composting (reviewed by Veeken *et al.* (2002).

Conclusions

Advantages of on-farm composting (knowledge of inputs, no transportation costs, efficient closure of carbon cycles) should be balanced against advantages of composting by professionals (well-controlled process). Composting on-farm is well possible from a phytosanitary point of view, but the farmer has to be aware of the factors that affect the phytosanitation of organic waste and the quality of the compost.

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POSTERS
ANIMAL HUSBANDRY

CONVERSION OF A LAMB PRODUCTION SYSTEM TO ORGANIC FARMING: HOW TO MANAGE, FOR WHAT RESULTS?

Marc Benoit (1), Tournadre Hervé (2), Dulphy Jean-Pierre (2), Cabaret Jacques (3), Prache Sophie (2)
With the collaboration of J. Ballet, F. Bocquier, R. Jailler, G. Laignel, JY. Pailleux, Y. Thomas

(1) INRA LEE Theix, 63122, St Genès-Champanelle, France, Tel. 0033473624134, marc.benoit@clermont.inra.fr
(2) INRA URH Theix, 63122, St Genès-Champanelle, France, Tel. 0033473624080
(3) INRA BASE, 37380 Nouzilly, France, Tel. 0033247427768

Key Words: Organic farming, lamb, meat, parasitism, economics.

Abstract

Two sheep flocks were managed organically for two years from conversion under different lambing strategies (1 lambing/year *vs*. 3 lambings every two years). The second system was tested because pf a producer's interest in high productivity, which is a guarantee of good economic results in conventional production.. Reproduction, feeding, lamb production, carcass quality, health (particularly internal parasitism), economic return of the flock, grass production, and pasture biodiversity were evaluated. The lambs were bred with low therapeutic inputs. No economic advantage of increasing lambing frequency was demonstrated, whereas this strategy complicated management and resulted in higher internal parasitic infection of the lambs, and finally showed lower stability. There were difficulties in establishing a very high feed self-sufficiency in both systems, especially the more intensive system (4 points lower), due to harsh climatic conditions. Following this five-year experiment, we are changing our strategy to provide nitrogen in the systems.

Introduction

Since 1999, the INRA (Institut National de la Recherche Agronomique) has been developing a research programme on Organic Farming-OF (Sylvander et al. 2002), with experiments on organic animal production being performed at Clermont-Ferrand (central France). The objective was to compare two reproductive systems in sheep meat production, and to explore technical solutions to the specific constraints of OF linked to reproduction (hormonal treatments forbidden), feeding (restrictions on the use of silage and concentrates), and health (restriction on chemical treatments). We used a local hardy breed (Limousin) capable of reproducing out of the usual mating season (mating at the end of May).

Methodology

We compared two lambing systems:

* The "Grassland farming system" (Grass Syst), which is based on one lambing per ewe per year and aimed at high grass self-sufficiency. This system is not particularly demanding for ewes, and was intended to limit problems relating to compliance with OF standards. It has the advantage of having counter-season reproduction to obtain two equal lambing periods (March and November), with meat produced both in summer (grass-fed lambs) and winter (stall-fed lambs).

* The "Accelerated reproduction system" (Acc Syst) is based on three lambings per ewe over two years, with each ewe mating every 8 months. The lambings were equally distributed among June, November and March, but farming techniques were adjusted to comply with OF standards, particularly concerning inputs (for health, feeding, and reproduction). Farmers are showing increased interest in this accelerated system as it is widely used in conventional farming, giving good technical and economic results.

In Grass Syst, the suckling period was as long as possible (88 +/- 19 days) whereas it was limited to 70 days (69 +/- 12) in Acc Syst because of the short interval between matings and the risk of excessive fat mobilization. In Acc Syst, lambs had access to concentrate just after lambing. In Grass Syst, lambs were given supplemental feed only when there was a grass shortage. In all cases, any concentrate provided was restricted to 600 g lamb^{-1} day^{-1}, according to basic OF standards (30% to 40% of daily ration). The spring reproduction period (seasonal anoestrus) was chosen on the basis of experimental results (Tournadre et al. 2002) testing a "ram effect", i.e. introduction of rams in the flock to improve ewe fertility. The spring mating period began in the last week of May in both systems, and was limited to 45 days in the Acc Syst because of closeness to the subsequent mating period (October).

Each flock contained 100 ewes on 24 ha, i.e. a stocking rate of 0.8 LU/ha, and 5% of the total land was used for cropping (mixture of cereal and peas). The experiment was set up in summer 1999, with the 'administrative' conversion to OF becoming effective in January 2002. We report here the results obtained in 2001, 2002 and 2003 on economic performance, health (parasitism), carcass quality, forage production, crops, flora biodiversity, and consistency of both systems (adequacy among resources, production and health). The experiment was partly performed under the severe drought conditions of 2002 and 2003.

Results and discussion

Animal performance. Economic results in sheep farming greatly depend on numerical productivity (number of lambs alive per ewe per year). Its components are fertility, lambing rate, prolificacy, and lamb mortality. Fertility was higher in Grass Syst than in Acc Syst (89.8 *vs.* 70.7%, $P<0.0001$) because of lower fertility in the June and November lambing periods in Acc Syst, and because of the required shorter mating periods in this system. When mated, replacement ewe lambs also had a lower weight in Acc Syst than in Grass Syst, (42.3 kg *vs.* 44.9 kg). The lower prolificacy in Acc Syst compared with Grass Syst (154 *vs.* 165, $P<0.05$) was due to the acceleration in reproduction. Prolificacy increased steadily under the Grass System (160, 166 and 177 for years 2001, 2002 and 2003, respectively). The highest between-system difference was recorded in November (134 *vs.* 157). Lamb mortality was 17.9% in Acc Syst *vs.* 12.9% in Grass Syst ($P<0.05$), with more mortality at birth in relation to a higher abortion rate in Acc Syst in 2001. After age 10 days, there no longer was a significant difference. Finally, numerical productivity remained steady at about 1.53 in Grass Syst (standard deviation = 0.06). It was a slightly higher in Acc Syst (1.61) due to accelerated lambing (lambing rates of 129 and 104 in Acc Syst and Grass Syst, respectively), but more importantly it was very variable (standard deviation = 0.22). The mean numerical productivity of 16 private conventional farms in the same geographical context was 1.45 in 2003 and 1.49 in 2002 (Laignel et al. 2004). Our results in OF were therefore satisfactory. Regarding numerical productivity, average carcass weight produced per ewe over the 3 years was 19.2 kg in Grass Syst and 20.4 in Acc Syst.

The lamb's average daily gain (ADG) during the suckling period depended on the usual factors (birth weight, single or twin, sex). Differences were observed between seasons (ADG from 30 to 70 days of age being 48 g day^{-1} higher in November than in March) and in relation to the diet (concentrate and hay *vs.* grass). Although there were differences in weaning age (69 *vs*. 88 days in Acc Syst and Grass Syst, respectively), subsequent ADG and live weight at slaughter did not differ. Between 70 days of age and slaughter, ADG differed markedly in March lambing (200 g day^{-1} *vs.* 172 g day^{-1} in Acc Syst *vs.* Grass Syst, respectively), because of the earlier concentrate supplementation in Acc Syst than in Grass Syst. June was a bad season for lamb growth (165 g day^{-1} between 70 days of age and slaughter in Acc Syst), even with concentrate supplementation, because of the low quality of available grass,.

Carcass quality. Three-hundred and fifty-six and 396 lambs were slaughtered under Grass Syst and Acc Syst, respectively, at an experimental slaughterhouse. We measured age at slaughter, carcass weight, fattening and conformation scores, and firmness and colour of subcutaneous fat (Theriez et al. 1997). Firmness of subcutaneous dorsal fat was measured after 24 h of shrinkage using a finger test (values ranging from 3 for oil fat to 15 for hard fat). Colour of subcutaneous caudal fat was measured after 24 h of shrinkage using a MINOLTA CM-2002 (illuminant D_{65}, observer angle 10). The colour coordinates were expressed as lightness (L*), redness (a*), and yellowness (b*) in the CIELAB uniform colour space (CIE, 1986). Carcass weights averaged 15.7 and 15.6 kg in Grass Syst and Acc Syst in 2001 and 2002, respectively. In 2003, carcass weights were 1.4 and 1.8 kg lower because of exceptionally dry weather. Mean age at slaughter was 7 days higher in Acc Syst than in Grass Syst (144 *vs*. 137 days, $P<0.05$). Fattening and conformation scores were quite similar for the two systems. Firmness of subcutaneous fat was slightly lower in Acc Syst than in Grass Syst in all three years (10.2 *vs*. 11.1, $P<0.05$). This may be explained by a lower age at weaning in Acc Syst compared to Grass Syst ($P<0.05$), as lamb growth rate before weaning was similar for the two systems (258 and 261 g day^{-1} in Grass Syst and Acc Syst, respectively). There were no differences in fat colour between systems.

Health. Several health-related problems were recorded: zinc and copper deficiencies were seen at the beginning of the conversion to OF, and the ewes were treated accordingly to compensate for this deficiency. Treatment of the cestode parasite *Moniezia* using a commercially-available phytodrug was tested in several cohorts of lambs over two years. The results were not promising, and we had to focus on regular synthetic chemical drugs. One episode of intense skin pathology was encountered, and was treated with success using essential oils. Abortions were recorded in 2001 due to toxoplasmosis. There were no other major health issues. Due to adapted pasture management and treatment organisation, the intensity of nematode and cestode parasitism in lambs remained controlled. Estimated strongyle eggs per gram were higher in the Acc Syst *vs*. the Grass Syst group (161 *vs*. 80, Benoit et al 2003). In Grass Syst, 64% of lambs had no synthetic chemical treatment, including grass-fed lambs. Ewe mortality rates for 2000-2001 were 8.4% and 7.1% in Acc Syst and Grass Syst, respectively, and subsequently decreased to 3.6% and 2.3%, respectively (2003-2004). Indicators of a need for treatment were studied; these were based on faecal egg count, anaemia score (Famacha), or diarrhoea score (Disco, Cabaret 2004). The latter system appears useful but needs to be further refined for practical on-farm use.

Grass production. No exogenous fertiliser was used, as export of minerals (N, P, K) was very low (only 6 N and 2.3 P units ha^{-1}, as 11 kg of N and 1.5 kg P were introduced per ha by food purchases during a normal year). However, we followed the plant fertility index (K/N, P/N) and tried to optimise the use of compost. Herbage production decreased dramatically during the period 2002-2003 (6.4 tDM ha^{-1} for 2000 and 2001, 4.2 for 2002, 3.8 for 2003), as was the case for total plant N content (105 to 88 g.kg DM^{-1}), associated with a marked decrease in leguminous plants. This was more linked to weather (very dry summer) than to agricultural practices, since herbage production returned to 7.0 t ha^{-1} in 2004 (and N content 110 g.kg DM^{-1} for 2004). About 60% of the production was consumed by the animals, taking into account the sorting by animals. Each ewe and its litter needed 840 kg DM of forage per year (about 320 kg hay and 520 kg grass).

Feed self-sufficiency (based on the calculation of energy requirements) of the Grass Syst was 92% in 2001, 78% in 2002, and only 64% in 2003, because of dryness conditions. On average, over the 4 years, it was higher by 4 points in Grass Syst than in Acc Syst. The part of feed self-sufficiency provided by crops was 4 to 5 points. One study objective was to enhance self-sufficiency by both adapting stocking rate and increasing forage quality. The decrease in feed self-sufficiency may also be explained by an underestimation of the quantity of forage eaten by the lambs. Indeed, in compliance with the OF standards, concentrate distribution was limited to 40% of the lambs' diet. This led to a 3.4-fold increase in the quantity of hay offered (27 kg offered versus 8), with a significant impact at the system scale: we estimate the consumption of forage by lambs (hay and grass) at 9% of the total forage produced compared to 2% in conventional systems in the same area (all lambs indoors in stalls).Production of compost (straw + faeces after maturation) was 125 kg DM per ewe per year. Composition was 24/8/43 for N/P/K, respectively (g kg DM^{-1}). The compost (35% DM) was spread on hay meadows and crops. To have proper hay, an early grazing was practised during spring and, when possible, some meadows were cut early and conserved in round-wrapped bales (30% of total conserved forages). The N supply in the system was initially based on the leguminous plants in permanent grassland and on the protein-rich plants in crop associations. In our medium upland climatic conditions, peas disappeared 3 years in 4 due to frost. In the dryness conditions, with light soils, legumes in permanent grassland did not represent a sufficient proportion of flora. Three strategies were further evaluated: i) increase the proportion of legumes in permanent grassland by direct seeding ii) improve soil fertility of permanent grassland with a mechanical treatment aiming at aeration of the surface soil layer and degradation of excess organic material, and iii) cultivate short-term meadow and pasture based on legumes (red clover, alfalfa if possible). Crop rotation was based on 3 years of crops (mixture of triticale, barley, oat, and peas) followed by 3 years of meadow. The fertilisation was carried out on the second and third year of crops with 5 t/ha compost. Grain-yield was 3.4 t/ha, with a maximum 20% peas.

Flora biodiversity increased with the introduction of crops (+17 species) and the creation of ponds (+24). The initial total number of plant species was 132 and the final count reached nearly 200 without counting short-life spring plants (vernal plants). The non-use of synthetic N fertiliser also partly explained the increase in biodiversity. For example, in comparing organic and conventional sheep production, the number of plant species on a paddock scale was 53 *vs.* 33.

Economic results. The highest production cost in sheep production in our context is feeding and, above all in OF, concentrate use (price per kg: +70% above. conventional). The total amount of concentrates used was 121 kg (Grass Syst) *vs.* 156 kg (Acc Syst) per ewe (and its litter), but this may be lower in normal weather. Concentrate use was 43 kg per lamb in Acc Syst *vs.* 28 in Grass Syst, as the weaning age is later in Grass Syst and the availability of good quality grass for lambs is higher in spring. Gross margin per ewe was 9% higher under Grass Syst than Acc Syst (65 € *vs.* 59). If we focus on the better year for Acc Syst (2002, with numerical productivity at 1.93), the gross margin per ewe was only 5% higher (89.9 in Acc Syst *vs.* 85.5 in Grass Syst), because of production costs. If we compare Grass Syst to the same system on conventional farming (by simulation), the premium price on lamb meat would have to reach 12% (0.57 € kg^{-1}) to achieve the same economic result (current earnings); the premium price received in 2003 was 15%. If we compare this to a conventional intensive system with accelerated lambings (such as Acc Syst), the necessary premium price to achieve the same final economic result would be 23% (1.07 € kg^{-1} carcass), to compensate for i) the cost of the larger pasture area corresponding to a lower stocking rate, ii) the lower numerical productivity, and iii) the extra cost of concentrates and the cost of OF certification. We did not take into account additional work for the OF system. These results are in agreement with a study performed in the same upland farming context (Benoit and Veysset, 2003) in which the required premium price for the same current earnings was 1.13 € kg^{-1} if we compare it to conventional intensive upland farming, and 0.34 € kg^{-1} if we compare it to conventional "Medium" upland farming.

Conclusions

This 4-year study showed there is no conflict between the principles of OF and high zootechnical results, insofar as the system is consistent enough. An intensive OF practice in our context showed significant instability in animal performances and results. After 5 years of conversion to OF, the Grass Syst is still evolving (soil fertility, plants on pastures, parasitism, etc.) and we will observe new global balances and the stability of results over a longer period. In the future, we will focus on parasitism (diagnosis for end-users, alternative treatments) and specific lamb meat quality (nutritional and sensorial quality and traceability). We also plan to study flows of certain greenhouse gases (CH_4, CO_2, N_2O) and the possibility of improving the biological activity of soils (meadows) by mechanical treatments. Beyond the technical performances studied and the development of techniques, this work highlights the insufficient support to OF, as the current premium price is not high enough to induce farmers to convert to OF. A continuing premium for the OF system is necessary, based, initially, on the recognition of its environmental benefits.

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GROWTH AND SENSORY CHARACTERISTIS OF ALTERNATIVE GENOTYPE BROILERS REARED IN ORGANIC ORCHARDS

Klaus Horsted[1)], Judith Henning[2)] and John E. Hermansen[1)]

1) Danish Institute of Agricultural Sciences, Department of Agroecology, P.O. Box 50, DK-8830 Tjele
2) The Royal Veterinary and Agricultural University, Department of Food Science, Sensory Science Group, Rolighedsvej 30, DK-1958 Fredericsberg C

Key words: Organic broiler production, orchard, alternative genotypes, age of slaughter, weight, eating quality

Abstract

The effects of age, sex and genotype on growth and sensory characteristics in organically produced broilers, when kept considerably longer before slaughtering, were examined. A total of 450 birds consisting of three genotypes, Light Sussex, New Hampshire, and the commercial strain I 657 were inserted at Fejoe Research Orchard. Half the birds were slaughtered at 91 days of age and half at 120 days of age. I 657 was significantly heavier compared to the slower growing breeds and Light Sussex was significantly heavier than New Hampshire. Males were significantly heavier than females across genotype, but weight ratios differed with genotype. No overall effect of genotype was found on the flavour or smell of the breast meat, but the commercial strain went towards a tougher and less tender consistency at 120 days of age, whereas the opposite was the case for the slower growing pure breeds. The positive flavour of salt was significantly improved at 120 days of age across genotype and age, with females having saltier flavour than the males. The positive flavour of sweet corn was improved in the meat from the males, but the positive smell of sweet corn was significantly improved in both males and females. No negative consequences of age were found.

Introduction

Broilers produced in orchards may have a positive effect as pest controllers (Pedersen et al., 2004) though they seem most efficient when they reach the normal age of slaughter. This may not be a good option for conventionally used broiler strains that are selected for a high capacity of growth and earlier maturing and consequently are exposed to different kinds of health problems. Also, there is a risk of the meat quality deteriorating (Nielsen et al., 2003). For that reason we examined the effects of age, sex and genotype on growth and sensory characteristics in organically produced broilers kept considerably longer before slaughtering.

Methodology

450 broiler chickens evenly distributed in three genotypes, Light Sussex, New Hampshire, and the commercial strain I 657, were inserted at Fejoe Research Orchard at 5 weeks of age. The feed during the experimental period at Fejoe Research Orchard consisted of a commercial concentrate containing 160 g protein, 7 g lysine, 3.1 g methionine and 3.0 g cystine per kg feed. The protein and amino acid concentration was a little lower than the normally used starting and growing feed for organic broiler chickens, since the chickens were meant to forage in the orchard and thus get protein feedstuffs in the form of insects, larvae and clover grass in the plantation.

At the age of 91 days and 120 days, respectively, half the broilers were slaughtered. Live weight was recorded and carcasses from each group (sex*age*genotype) were evaluated for sensory characteristics. A clinical welfare assessment was carried out and samples from the cloaca of 60 randomly chosen birds were taken and analysed for salmonella.

Sensory profiling of the breast meat was made by a trained sensory panel consisting of two men and eight women at the Sensory Laboratory at the Royal Veterinary and Agricultural University in Copenhagen. The judges in the sensory panel were trained on three successive days. After the training of the sensory panel all the samples were assessed three times, i.e. one assessment daily for three days. All samples were evaluated at a 15 cm unstructured scale. For further evaluation an average of the assessments of the 10 judges was used.

Results and discussion

The clinical welfare assessment suggests excellent welfare of the broilers when kept in an orchard. Moreover, no types of salmonella were found.

At 91 days of age as well as at 120 days, I 657 was significantly heavier than the slower growing breeds, and Light Sussex was significantly heavier than New Hampshire (table 1). Moreover, we found that considerable growth still occurred in all genotypes in the period from 91 days to 120 days of age. However, as indicated by the significant interactions sex*age and genotype*sex*age, male chickens grew faster in this period, particularly the male chickens of Light Sussex and New Hampshire. The male chickens of these slow-growing genotypes were 40-48% heavier than the females at an age of 120 days compared to 23% at 91 days of age, whereas the weight ratio of male and female chickens of I 657 was 1.32 and 1.35 at the days of slaughter, respectively. The average weight gain per day from 91 days to 120 days of age varied from 12.8 g to 31.3 g, with the Light Sussex males having the largest weight gain and the Light Sussex and New Hampshire females having the lowest weight gain.

Table 1. Live and slaughter weight of different genotypes and sex at different ages, least square means (standard errors), g/bird

	New Hampshire		I 657		Light Sussex	
	Live weight	Slaughter weight	Live weight	Slaughter weight	Live weight	Slaughter weight
Males:						
91 days	1639 *(31)*	1073 *(24)*	2590 *(28)*	1867 *(22)*	1764 *(30)*	1168 *(23)*
120 days	2406 *(30)*	1623 *(23)*	3257 *(28)*	2430 *(22)*	2671 *(34)*	1851 *(27)*
Females:						
91 days	1331 *(34)*	870 *(27)*	1957 *(28)*	1399 *(22)*	1432 *(39)*	939 *(30)*
120 days	1714 *(44)*	1168 *(35)*	2417 *(37)*	1776 *(29)*	1804 *(46)*	1225 *(36)*

Significant effects: Genotype P<0.0001; age P<0.0001; sex P<0.0001; sex*age P<0.0001; genotype*sex P<0.0001; genotype*sex*age P<0.05

The crumpling, juicy, sticking and stringy characteristics were not significantly affected by any of the factors investigated. The major source of variance for softness was breed, whereas the major sources of variance for hardness, tenderness and toughness were interactions between breed and age. The least square means of these characteristics are given in table 2 for each breed and age.

Table 2. Influence on texture and physical characteristics

	Softness (positive)	**Hardness (negative)**	**Tenderness (positive)**	**Toughness (negative)**
Breed: (P)	P<0.05	NS	P<0.05	P≈0.05
New Hampshire	9.3	4.3	10.4	4.0
I 657 (Scan Labelle)	8.5	5.0	10.0	4.0
Light Sussex	7.9	5.2	9.2	5.1
Breed and age: (P)	NS	P<0.05	P<0.05	P<0.01
New Hampshire:				
91 days	8.6	5.1	9.9	4.5
120 days	9.7	3.5	11.0	3.5
I 657 (Scan Labelle):				
91 days	8.8	4.5	10.5	3.0
120 days	8.1	5.5	9.4	4.9
Light Sussex:				
91 days	7.8	5.5	8.7	5.7
120 days	8.1	5.0	9.6	4.5

We found a tendency for I 657 to be tenderer than the slower-growing genotypes when slaughtered at 91 days of age. However, when the broilers were kept 29 days longer before slaughtering we found a significant change in the development of tenderness and toughness. Thus, the slower-growing genotypes went towards a more tender consistency of the breast meat whereas the opposite was the case for the faster growing I 657.

Since we found large growth rates in this last period only among the cockerels from the slower growing genotypes, and the interaction between genotype and sex concerning meat tenderness turned out to be non-significant, the development in meat tenderness cannot be correlated to a fast growth rate alone. Probably, the genotypes Light Sussex and New Hampshire are simply better suited for slaughtering at a higher age compared to I 657.

No overall effect of genotype was found on the flavour and smell of the breast meat. As shown in table 3, the positive flavour of salt was significantly improved at 120 days of age across genotype and age, with females having a saltier flavour than the males. The positive flavour of sweet corn was improved in the meat from the males, whereas the positive smell of sweet corn was significantly improved in both males and females. No negative consequences of age were found.

Table 3. Influence of sex, age and breed on selected characteristics of flavour and smell

	Smell of sweet corn (positive)	**Flavour of sweet corn (positive)**	**Flavour of salt (positive)**	**Flavour of iron/liver (negative)**
Sex: (P)	NS	NS	$P<0.01$	NS
Males	5.8	5.6	2.7	2.9
Females	6.1	5.5	3.2	2.9
Age: (P)	$P<0.01$	$P<0.01$	$P<0.05$	NS
91 days	5.5	5.2	2.8	3.0
120 days	6.4	6.0	3.2	2.7
Breed and age: (P)	NS	NS	NS	$P<0.05$
New Hampshire:				
91 days	5.5	5.3	2.7	2.4
120 days	6.4	6.2	3.2	2.7
I 657 (Scan Labelle):				
91 days	6.1	5.2	3.1	3.0
120 days	6.4	5.5	3.1	3.1
Light Sussex:				
91 days	5.0	4.9	2.6	3.5
120 days	6.6	6.3	3.2	2.4
Breed and sex: (P)	NS	NS	NS	$P<0.05$
New Hampshire:				
Males	5.7	5.8	2.6	2.1
Females	6.1	5.7	3.2	3.0
I 657 (Scan Labelle):				
Males	6.3	5.4	2.9	3.1
Females	6.2	5.3	3.3	3.0
Light Sussex:				
Males	5.4	5.5	2.6	3.4
Females	6.1	5.7	3.2	2.6
Sex and age: (P)	NS	$P<0.01$	NS	NS
91 days:				
Males	5.2	4.8	2.5	3.0
Females	5.8	5.5	3.1	2.9
120 days:				
Males	6.4	6.4	2.9	2.7
Females	6.5	5.6	3.4	2.8

Conclusion

We conclude that it is possible to keep broilers longer in the orchard before slaughtering without compromising the eating quality of the meat. We also conclude that alternative, slow-growing genotypes could be a particular option for future broiler production in orchards.

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MOBILE AND STATIONARY SYSTEMS FOR ORGANIC PIGS – ANIMAL WELFARE ASSESSMENT IN THE FATTENING PERIOD

Kristina Lindgren, Cecilia Lindahl

JTI – Swedish Institute of Agricultural and Environmental Engineering, P.O.Box 7033, SE-750 07 Uppsala, Sweden, +46 18 30 33 29, Kristina.Lindgren@jti.slu.se, www.jti.slu.se

Key Words: fattening pigs, slaughter condemnations, health, outdoor, rotation interval, helminths

Abstract

In Sweden, the way of housing organic fattening pigs has split into two main courses, the mobile and the stationary system. In the study, each system was represented by three farms, where animal welfare parameters were collected. Natural behaviours such as rooting, grazing, wallowing, feed-searching, locomotion and social interaction were possible and behavioural disturbances were rare in both systems. In data from the farms with specialized production (3 stationary and 1 mobile), slaughter condemnations due to Enzootic pneumonia were more frequent ($p< 0.05$) than from the farms with farrow to finish production. Joint lesions and lameness were found in both systems. In the mobile system the number of water and feeding places were too few in some groups, according to Swedish regulations. The stationary system did not fulfil the recommendations for rotation of pasture areas and housing in order to prevent accumulation of helminth contamination. We concluded that improving animal welfare, would bring about substantially more constraints in the stationary system than in the mobile system, when developing towards the goals in organic production.

Introduction

Animal welfare is defined by van Putten (2001) and animal health and a species-specific behaviour are mentioned as the most important parameters. The national rules for organic production may differ between countries and this has to be considered when comparing health status and husbandry practises. In a study from Austria (Leeb & Baumgartner, 2000) 15 farmers out of 51 used chemically synthesised antiparasitica for preventive treatment. According to the rules for organic production in Sweden and Denmark, pigs should have access to natural activities such as rooting and an active feed-searching behaviour, preventive use of anthelmintic is not permitted and the animal husbandry practises should encourage strong resistance and the prevention of infections.

Data from surveys in the UK, Denmark, Austria and The Netherlands suggests that the health and welfare problems in organic pig production in different countries are affected by differences in production system and national disease situation (Hovi *et al.* 2003). On Austrian farms, the prevalence of pneumonic lesions at slaughter was 74 % in conventional pigs and about 25 % in organic pigs (Leeb & Baumgartner, 2000). The pig population in Sweden, Norway and Finland has a high health status (Wallgren *et al.* 2004), when compared to other national populations. In Sweden, the prevalence of lesions notified at slaughter decreased significantly between 1996 and 2001 due to the introduction of age segregated production and networking operations (Holmgren & Lundeheim, 2002). The most pronounced decrease, from 17-18 % to 2 %, was found for the Pneumonia SEP (Swine Enzootic Pneumonia). Among organic pig producers, the main health concern appears to be endo- and ectoparasites (Hovi *et al.* 2003): the risk of endoparasitic infections has been confirmed in Denmark (Carstensen *et al.* 2002; Roepstorff *et al.* 1992). The prevalence of intestinal helminths was generally lower in the 1999 survey made by Carstensen *et al.* (2002) than those found 1990-1991 by Roepstorff *et al.* (1992). The authors (2002) interpret this as due to better pasture rotation, improved hygiene and better buildings.

In organic pig production in Sweden, the mobile system, with huts and long rotation intervals of pig pasture areas, was originally the most common system. In addition, there was an intention to keep the animals in one farm during the whole lifetime, i.e. farrow to finish production, among other things to reduce stress and risks of contagious diseases. Simultaneously, the prevalence of respiratory diseases was reduced in organic compared to conventional herds (Kugelberg *et al.* 2001). However, many farmers found the mobile system to be labour intensive, especially during cold and wet seasons. Some producers have tried to reduce labour by using a more conventional approach with stationary stables, and the pig pasture restricted to the area that can be connected to the stable: older stables without age segregation have often been used. Experience from conventional pig production reveals that respiratory diseases increase where younger animals are housed in the same section as older ones and where simultaneous cleaning of the whole section cannot be performed (Done, 2000). The choice of system affects both animal and working environment as well as nutrient management and this work was one part of a larger project with the aim to identify a joint strategy. The aim of this part was to compare animal welfare, in terms of health and behaviour in the mobile and the stationary system.

Methodology

The study was conducted in Sweden on six commercial organic pig farms with a production of 200- 800 fattening pigs per year. Three of the farms had a mobile system (M1-M3), with huts, where the pigs were included in the crop rotation during the summer. During winter, the pigs were housed in a stable with a connected concrete yard. The other three farms had a stationary system (S1-S3) with a stable, where the pigs were housed all year round with access to connected outdoor pastures during summer and a concrete yard during winter. One farm with a mobile system and the farms with stationary systems had specialized fattening pig production (weaners were bought from other herds). Information on: health, behaviour, system and management was collected during a visit to each farm during summer 2004. Data and observations of health and behaviour refer directly to the animals themselves while measurements of housing system provide information on how the system and management may affect animal welfare and focus on risk of welfare problems and potential of good welfare (Bonde, 2003).

Health: farm data of lesions notified at slaughter (condemnations) for three years (2002-2004) were collected to identify possible health problems connected to the housing system. On the day of the visit, all fattening pigs at the farm were examined for body condition, skin lesions, lameness and diarrhoea.

Behaviour: an animal-approach test was conducted on each group before the health examination. A test person entered the enclosure, approached and stopped at a distance of 7 m from the herd. The time for the first pig to make physical contact with the test person was registered. The test lasted a maximum of five minutes. Groups that made no physical contact were given the maximum time and groups that were indifferent to the test person (no flight reaction when touched) were excluded when the average time was calculated. Throughout the visit, any occurrence of abnormal behaviour was recorded.

System and management: indicators concerning housing systems were collected from each farm, e.g. laying area/pig, number of pigs/water and feeding trough and outdoor area/pig. The farmer was interviewed regarding handling of sick animals, daily routines, feeding strategy and rotation interval, etc. Slaughter condemnation data from the farms were statistically analysed by generalized linear models (Olsson, 2002). The incidence of the different events was modelled using a Poisson distribution with a log link. The number of delivered pigs was used as an offset and the different years as repeated measurements. The Genmode software of the SAS (1999) system was used.

Results and brief discussion

The status of notified lesions at slaughter (Table 1) appeared similar to organic herds during 1997-1999 (Kugelberg *et al.* 2001) except for Pneumonia SEP and white spots. Analyses of slaughter condemnations (Table 1) revealed no significant differences between the mobile and the stationary system, years or year*system interactions. However, the two farms with farrow to finish production had a significantly ($p< 0.05$) lower number of Pneumonia SEP compared to the specialized fattening herds. These herds had an average level of Pneumonia SEP similar to the level for all pigs (mainly indoor pigs) that were slaughtered in the cooperative abattoirs, Swedish Meats (Table 1). Even so, one of the specialized herds with weaners bought from only one herd and batch rearing and the two herds with farrow to finish production had respiratory disorders that were less than 50 % compared to all Swedish Meats pigs. During the last five years it has become more common for Swedish organic pig farmers to specialize in one phase of the production and buy or sell young pigs. The reason for this is the same as in conventional pig farming. It takes more skill and interest to take care of both the breeding of piglets and the growing-finishing phase. In herds where piglets are transferred from several producers to fattening units, there is a rapid spread of infection among the animals (Wallgren *et al.* 1994). Signs of reduced immune functions are seen 1 week after allocation (Wallgren *et al.* 1993), possibly caused by stress, when the animals are transported, mixed and establishing new ranking orders. If this immunosupression occurs simultaneously with exposure to new microorganisms it would be expected to increase the pigs susceptibility to infections (Wallgren *et al.* 1994). Age segregated production (Holmgren & Lundeheim, 2002) and networking operations (Leeb & Baumgartner, 2000; Holmgren & Lundeheim, 2002) is recommended in specialized fattening pig production. None of the four specialized farms had separated sections between older and younger pigs. One however had batch rearing. Specialized farms in Sweden often had a stationary system, but one specialized farm in the study had a mobile system, where it was possible to empty and clean the whole stable during the summer. During the period when the pigs were kept in huts on pasture, the distance between groups could be increased and the risk of contamination between older and new pigs was low.

Table 1. Mean proportion of pigs with slaughter condemnations for the farms in the study and corresponding proportions for all pigs slaughtered at the cooperative abattoirs in Sweden (Swedish Meats).

	Year	Farms	Pigs (n)	Abscess	Joint lesions	Tail bites	Pneumonia SEP	Pneumonia *App.*	Pleurity	White spots
Mobile system	2002	M1- M3	1566	0.5	3.8	0.4	0.7	0.0	2.8	17.5
	2003	M1- M3	1677	0.4	3.3	0.2	1.5	0.1	2.8	22.9
	2004	M1 -M3	2208	0.3	6.2	0.5	1.0	0.0	2.6	18.1
Station. system	2002	S1- S3	1537	0.8	2.9	0.3	1.0	0.4	2.5	5.3
	2003	S1- S3	1561	0.8	5.3	0.1	4.8	1.1	8.9	15.4
	2004	S1- S3	1621	0.9	4.6	0.3	9.3	0.2	3.0	9.5
Farrow to finish prod.	2002	M1,M2	1246	0.3	3.3	0.6	0.1	0.0	1.4	17.0
	2003	M1,M2	1295	0.4	3.5	0.3	1.5	0.2	2.3	22.2
	2004	M1,M2	1694	0.3	6.9	0.6	0.9	0.1	2.8	13.8
Special. prod.	2002	M3, S1-S3	1857	1.0	3.4	0.3	1.3	0.3	3.4	7.7
	2003	M3, S1-S3	1943	0.8	4.7	0.1	4.1	0.9	8.0	17.4
	2004	M3, S1-S3	2135	0.8	4.4	0.3	7.4	0.2	2.8	15.0
Swedish Meats	2002		2203568	1.4	1.2	-	2.8	0.2	4.6	3.4
	2003		2001562	1.4	1.2	-	3.6	0.4	5.5	4.0
	2004		1901323	1.6	1.3	1.2	3.6	0.4	6.0	3.5

App = Actinobacillus pleuropneumoniae and similar.

Joint condemnations at slaughter, were three to four times higher in the herds studied compared to all Swedish Meats pigs. Vaccination against erysipelas is recommended when raising pigs outdoors (Kugelberg *et al.* 2001).

A total number of 1556 pigs were examined for health parameters e.g. skin lesions. Two herds had a higher proportion of skin lesions compared to the others. In one herd with increased skin lesions, weaners from different herds probably had been establishing ranking orders after being mixed at the arrival a week before the examination. Higher frequencies of pigs with skin lesions in the other herd was probably caused by insufficient space at the feeding troughs when the feed was restricted. In the mobile system, water and feeding places were too few in some groups, as compared to Swedish regulations, and simultaneous feeding during the restricted period was not possible. In the animal-approach test, the pigs quickly made contact with the test person in both the stationary and the mobile system (0.98 and 1.5 minutes respectively). The pigs who contacted the test person were probably the most curious and the test does not measure the reaction among the more nervous pigs. Wallowing facilities were usually well managed and grass and roots in the pasture provided oral activity to the pigs. No abnormal behaviours were recorded during the visits. The number of slaughter condemnations due to tail biting was generally low except for one farm that had a higher rate of tail biting. On that farm, most grass cover in the pig pasture had been destroyed. This, together with restricted feeding, could have been the cause of condemnations due to tail biting. Roughage can contribute to reduce pen mate-directed oral activities (Olsen, 2001) and to lower the level of aggression (Persson *et al.* 2004).

Pigs had access to an outdoor area with a pasture from May until autumn. In the mobile system the rotation interval for pasture was 3-6 years and in the stationary system 1–2 years. The stationary system also had permanent areas just outside the stables with no rotation at all and usually two groups, one after the other, on the same pasture during one summer. In the mobile system usually a new enclosed pasture area was used for each group. According to actual recommendations, a pasture rotation scheme should include all areas, including housing (Roepstorff *et al.* 2001) and the rotation interval should be 3 years or more (Kugelberg, 1999). The stocking rate should be as low as possible, pasture rotation should be strictly maintained and permanent pastures as well as stables with low hygiene should be avoided (Carstensen *et al.* 2002).

Conclusions

Both systems provided good opportunities for natural behaviour. In the mobile system, conditions were favourable to control transmission of infections and helminths and we estimate that water and feeding facilities can be improved by technical development. Farms specialized in fattening pig production and without age segregation had problems with controlling transmission of infections. In the stationary system, it was difficult to follow actual recommendations of rotation interval and to avoid permanent pastures in order to prevent accumulation of contamination from intestinal helminths.

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MINERAL LOAD ON THE PADDOCK OF ORGANIC SOWS IN THE NETHERLANDS

Sonya Ivanova-Peneva (1,2), Andrè Aarnink (2), Martin Verstegen (3)

(1) Agricultural institut, 3 Simeon Veliki blvd., 9700, Shumen, Bulgaria, Tel. +359 (0) 54 83 04 48, sonia.ivanova@wur.nl, http://www.minedu.government.bg/NSFB/rtd/eng/index.htm
(2) Wageningen UR, Agrotechnology and Food Innovations, Bornsesteeg 59, 6708 PD, Wageningen, The Netherlands, Tel. +31 (0) 317 47 65 54, andre.aarnink@wur.nl, http://www.agrotechnologyandfood.wur.nl
(3) Wageningen University, Animal Nutrition Group, Marijkeweg 40, 6700 AH, Wageningen, The Netherlands, Tel. +31 (0) 317 48 29 82, martin.verstegen@wur.nl, http://www.zod.wau.nl/vv/index.html

Key Words: organic farming, sows, nutrient load, paddock, nitrogen, phosphorous, potassium

Abstract

The main aim of this study was to quantify nutrient deposition on the paddock in Dutch organic pig farms. Observations of excreting behaviour of grazing sows were carried out at three farms in each of two measuring seasons (spring/summer and autumn). The nutrient loads of N, P and K were calculated according to their content in urine and faeces, average weight of urine and faeces per excretion, and number of urinations and defecations done in the paddock. The N and P loads on the paddock varied greatly between the organic pig farms ($P<0.01$ for N, not significant for P and $P<0.05$ for K). The total amount of nutrients on two of the farms far exceeded the permitted levels (170 $kg.ha^{-1}year^{-1}$ for N and 44 $kg.ha^{-1}year^{-1}$ for P). On all three farms, faeces were unevenly distributed in the paddock. Regular rotation of paddocks resulted in a more uniform distribution.

Introduction/Problem

According to EC regulation No 2092/1991 (Council Regulation 2092/91) and supplementing No 1804/1999 (CEC, 1999), in organic pig production pregnant sows must have access to pasture, which allows the sows to express their natural rooting and grazing behaviour. However, this practice brings animal welfare into conflict with environmental issues, as the animals deposit a high nutrient load on the paddock from their excretions. As the manure deposited by grazing sows is difficult to utilise, the potential for nutrient loss is considerable (Eriksen and Kristensen, 2001). Overstocking with pigs for long periods on the same area may cause nitrate leaching (Worthington and Danks, 1992) and phosphorus accumulation in soils (Jongbloed, 1998). Moreover, soil nitrate leaching results in enhanced nitrate levels in groundwater and surface water.

Methodology

General description of the farms

The study was conducted on three organic pig farms in The Netherlands in three different provinces. On farms 1 and 2 the soil was sandy; on farm 3 clay soil was dominant. All three farms were organic farms with sows and fatteners. Pregnant sows were housed in closed buildings with access to an outside yard and a paddock used in the time of the year when the vegetation (clover grass) was present.

Management of the paddock

On farm 1 the sows had access to the paddock continuously from approximately mid-May until October-November, when almost all the vegetation of the paddock was gone. The practice on this farm at the beginning of the grazing period was to expand the paddock by 3 m every two or three weeks, until the sows had access to an area of 4,270 m^2 in total. On farm 2 the sows had access to the paddock from end of May - beginning of June onwards until November-December. They had access to an area of approximately 1 ha (10,200 m^2). There were three equal-sized paddocks available on this farm for rotation every year. On farm 3 there were three almost equal-sized paddocks, with a total area of approximately 25,00 m^2. Sows had daily access to one of these paddocks from 15.30-16.00 h until sunset; except when the meadow was too wet. This prevented the structure of the clay soil from being destroyed by poaching. Every two weeks the paddock was rotated.

Observations and measurements

The sows' behaviour on the paddock was observed by direct observations during one day in each of two seasons (in spring and in autumn) . From the observations on excreting behaviour recorded on paper, the number of urinations and defecations and the place they were made were determined and analysed.

On the day after the behavioural observations, representative samples of urine and faeces were taken. The samples were analysed for total-N, total-P, total-K, NH_4^+-N, pH, dry matter and ash. Nutrient load of N, P and K was calculated according to their content in urine and faeces, average volume of urine and average weight of faeces, and number of urinations and defecations done in the paddock. The data on nutrient output were analysed by ANOVA using the Genstat program 7.1, including farm and period (spring-summer and autumn) as factors in the model without interaction effect.

The distribution of the faeces on the paddock was recorded once on farms 1 and 2 and twice on farm 3, simultaneously with direct behavioural observations. The location of visually fresh faeces was mapped on a plan of the paddock on millimetre paper. The spread of faeces on every farm was estimated according to the distance from the entrance and was calculated in number of droppings per square metre.

Results and brief discussion

EU regulations for organic farming (Council Regulation No 2092/91) stipulate that the amount of manure applied to a farmer's arable land may not exceed the equivalent of 170 kg N ha^{-1} yr^{-1}. The European Commission has not specified exactly how this application rate (including N excreted during grazing) should be converted into an acceptable excretion rate (Schröder et al., 2004). The Dutch authorities have reasoned that an effective application rate (i.e. *onto* the soil) of 170 kg N ha^{-1} is equal to an excretion rate of circa 200 kg N ha^{-1} (Oenema et al., 2000).

In our study there was great between-farm variation in the N, P, and K loads on the paddock: the effect of farm was statistically significant for N ($P<0.05$), but not significant for P and K. The effect of period (spring-summer, or autumn) was not significant. On farms 1 and 2 with paddock areas of 89 m^2 per sow, the nutrient output of nitrogen on the paddock was much higher than permissible standards (420 kg N ha^{-1} yr^{-1} for farm 1 and 2, respectively). On these farms, the big excess of nutrients means there is a real risk of environmental pollution. On farm 2, where the paddock area per sow was bigger (289 m^2 per sow) compared with the other two farms, nutrient output of nitrogen was below maximum permissible levels. Furthermore, the whole system was different: the sows had access to a sandy yard and a long sandy path to the paddock. This explains why faeces and urine were more evenly spread through the whole system. Although the urine of sows on this farm contained larger amounts of N, P, K compared with the other two farms, relatively little of the nutrients were deposited on the paddock. On farm 3 the N output was 523 kg ha^{-1} yr^{-1}, which is more than treble the permitted standard. On this farm the sows' access to the paddock was limited: from 15.00-15.30 h in the afternoon until sunset. The soil on this farm was clay and the meadow was generally too wet in the morning, or when it was raining. But on this farm the sows had a preference to urinate (45.8% of total urinations) and defecate (59.5% of total defecations) on the paddock in the afternoon hours, when they were released. This pattern of excretion behaviour contributed greatly to the higher nutrient load on the paddock.

With respect to phosphorus output on the paddock, on two of the farms the permissible level of 100 kg P_2O_5, which is equivalent to 44 kg P per ha per year, was exceeded (2.5 times on farm 1 and approx. 4 times on farm 3). On farm 2 the estimated value of 20 kg P $ha^{-1}year^{-1}$ was much less than the permissible level. There is no standard for comparing the load of K.

The main reason for the higher nutrient load on farms 3 and 1 is the higher number of animals per hectare. As reported by Eriksen and Kristensen (2001), increases in both soil nitrates and phosphorus were related to increased stocking rates. In most of the available literature the appropriate stocking density mentioned in relation to minimising environmental problems assumes outdoor pig production, where all the excretions are done on the paddock. We cannot simply compare our data with such a system, because of the different distribution of urinations and defecations between the different farm compartments in our study. But it is clear that the stocking rate on the paddock on two of the farms (128 animals per ha on farm 1 and as many as 172 animals per ha on farm 3) is too high. In order to prevent environmental pollution, either the size of the paddock should be increased or the number of sows should be diminished. Further research on different management practices in organic pig farms in The Netherlands must be done to determine the optimum number of sows per ha grazing area.

The current practice in organic pig farms in terms of diet and stocking density results in substantial nutrient deposition in the paddock (Watson and Edwards, 1997), which is in agreement with our results. However, even with moderate stocking densities the excretory behaviour of pigs may create nutrient 'hot spots' in the paddock (Zihlmann et al., 1997). We observed differences in the number of droppings per surface area on the three farms. The sows on farm 3 had the smallest area available (65 m^2 per sow), and on this farm the number of visible droppings was the highest (respectively 0.222 and 0.224 droppings m^{-2} in the first and second observations). The difference compared with the other two farms was highly significant ($P<0.001$). On farm 2, the number of visible droppings was the smallest: 0.012 droppings per m^{-2} on farm 1 the average number was 0.072 m^{-2}.

In all three farms the faeces were not spread evenly over the paddock, especially on farm 2. On that farm the sows had a large area available for grazing. The skewness in distribution on that farm was very big - about 5 times higher per m^2 in the first quarter of the area than the average for the paddock. On farm 1 the first quarter of the paddock (where it was bare) was favoured for defecation (41.6 \%). In the second and third quarters the excretions were almost equally spread, but in the last quarter only a small number of excretions were observed (10.2%). On farm 3, during the first observation the faeces were better distributed than during the second observation and in comparison with the other two farms. The second observation was characterised by a more uneven distribution of faeces. The favoured area for excretion was between 12 and 16 m from the entrance, where the average load of faeces was more than double the average for the whole paddock.

As a result of this uneven distribution of excretion, in certain areas the deposition of nutrients may be much higher than the average for the whole paddock. In accordance with other authors (Sommer et al., 2001; Eriksen and Kristensen, 2001), we would argue that a surplus of N could be source of emissions to the air and nitrate leaching. The distribution of N surplus between plant uptake, losses, and soil organic matter depends on soil type and climatic conditions. However, in temperate regions the combination of sandy soils and high rainfall may lead to a relatively large proportion being lost through leaching. This is very likely in The Netherlands, where most organic pig farms are on sandy soils. Furthermore, on most Dutch farms, clover/grass is the dominant pasture. Generally, clover grass ley elements are the most susceptible to nitrate leaching (Stolze et al., 2000) and that increases the risk of environmental pollution on organic pig farms in The Netherlands.

In addition to the type of soil and the distribution of nutrients, the vegetation cover of the pasture is important in terms of risk of environmental pollution of pasturages. In a study by Williams et al. (2000), the nitrate concentrations increased towards the end of the grazing season as the grass cover became more damaged, and the lack of vegetative cover during the second winter of the study had a large influence on leaching losses. We may expect leaching losses to be higher on farm 1 than on the other two farms because during the second observations (in autumn), the grass cover had disappeared as a result of the sows' grazing, trampling, and rooting. Bearing in mind that this farm had a high load of nutrients, was on sandy soil, and had a skewed distribution of excretions, we can expect a considerable amount of nitrogen to be leached to the groundwater and a considerable amount of phosphorus to accumulate in the soil, which will ultimately become saturated.

The distribution of nutrients was more even on farm 3, where sows had access to three small paddocks and paddocks were rotated very three weeks. But from the direct observations of the behaviour we found that when sows had limited access to the paddock, they excreted frequently in the first hour of grazing. Other authors (Eriksen and Kristensen, 2001) have argued that a uniform distribution of nutrients should be obtained by keeping sows in smaller groups instead of in a large communal paddock, and also by manipulating the excretory behaviour of sows. Our findings support this conclusion. We suggest that the excretory behaviour be manipulated by offering sows first a small paved yard for urination and defecation for one hour and then giving them access to the paddock. In this way most urine and faeces should be produced on the paved yard, where it could be easily collected and distributed evenly on the field in the right amount.

Conclusions

Nutrient load of N and P on the paddock of sows is varies a lot among organic farms. In two of the three studied farms, standards were considerably exceeded. Unequal distribution of excretions was found in all the studied farms. Rotation of paddocks resulted in a more uniform distribution on the paddock.

In order to prevent environmental pollution, the area of the paddock should be matched to the number of sows. Manipulating the excretory behaviour of sows also may decrease nutrient load on the paddock.

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SUSTAINABILITY ASPECTS OF AUTOMATIC MILKING SYSTEMS (AMS) IN ORGANIC DAIRY PRODUCTION IN DENMARK AND THE NETHERLANDS

Frank W. Oudshoorn (1), Imke, J.M. de Boer (2), Reint Jan Renes (3)

(1) Danish Institute of Agricultural Sciences,8700 Horsens, Denmark, tel. 76296106,E-Mail: FrankW.Oudshoorn@agrsci.dk

(2) Wageningen University and Research, 6700 AM, Wageningen, The Netherlands, tel. 0317484589, E-mail: Imke.deBoer@wur.nl

(3) Wageningen University and Research, 6700 AM, Wageningen, tel. 0317486146, E-mail: Reint-jan.Renes@wur.nl

Key Words: Automatic Milking System, sustainability, grazing, stakeholder perception.

Abstract

Use of new technology can contribute to sustainable development, but a careful assessment should be made. Using a theoretical framework, the economical, ecological and societal consequences for sustainability are assessed and translated. Selected sustainability indicators are validated though literature and evaluated by a participatory method; the focus group interview. There are no reports or references to research on organic dairy farms with AMS. By cross examining references on AMS use with organic principles and sustainability aspects, it can be foreseen that economy, eutrophication of grassland, and milk quality can be threats to sustainability. Advisors and farmers represent the stakeholders in production. There were differences in perceptions among Dutch and Danish advisors, as well as between advisors and farmers. Economy is more often mentioned among Dutch advisors, but grazing and milk quality clearly concerned all participants in the focus groups. Participants often referred to consumers and animal welfare.

Introduction/Problem

Organic dairy farming has been rapidly developing in Denmark as well as the Netherlands, but is presently having problems maintaining its market share. In both countries, automatic milking systems (AMS) are being implemented by organic farms. Use of new technology such as AMS can contribute to sustainable development, but a careful assessment will have to be made. The applicability of new technologies on organic farms is not self-evident, just because it functions on conventional farms. In addition, delicate marketing mechanisms and farmers' attitudes may cause serious problems with respect to implementation of techniques that are in conflict with organic principles, measures or standards. The objective of this study is to assess the sustainability of AMS on organic farms as an example of implementing new technology. A short summary is presented of a literature survey on sustainability aspects and measurable indicators (Oudshoorn & de Boer 2005) and the preliminary results of selected stakeholders' perceptions on the use of AMS in organic dairy production.

Methodology

The Animal Production Systems Group at Wageningen university has presented a standardized framework for making sustainability assessments (Zijpp 2001). It is based on the following steps:

1.Identification of stakeholders and description of the research case and problem areas.

2.Determination of the relevant economic, ecological and societal (EES) issues and the definition of goals.

3.Translation of the selected issues into quantifiable indicators for sustainability (SI).

4.Analysis of the contribution of the indicators to sustainable development and monitoring of the indicators.

5.Communication of the results to the stakeholders, review of the process and evaluation of the results on basis of the original problem definition.

The first three steps are presented in this paper. Often different stakeholders validate the research problem and the conclusions differently. To assess sustainability issues and indicators, stakeholders' perceptions are included in the problem formulation, the further research, and the validation.

Issues, translated into quantifiable indicators, are determined by reviewing literature. An international symposium aimed at developing a better understanding of robotic milking compiled the available knowledge

(Meijering A. et al. 2004), showing there was no specific knowledge on AMS use in organic herds. In the review, we focussed on sustainability and organic principles in two countries: in Denmark, with more than 8% of the 600 organic dairy farmers using AMS, where a rapid structural development is taking place; and in the Netherlands, where the AMS-concept is developed and where grazing has always been connected with dairy farming, but where AMS has not been implemented in organic dairy in the same way (1.7%).

For the evaluation of the selected sustainability issues by relevant stakeholders, the focus group interview technique (Halkier 2002) was used. The literature survey pointed out that the perceived threats to sustainability include economic factors and aspects involving grazing and consumer behaviour. Consumers behaviour concerning organic products is known quite well (Torjusen *et al.* 2004). The other aspects of concern have to do with production, inspiring the inclusion of advisors and farmers as relevant stakeholders.

Unlike normal interview techniques where information only flows one way, a focus group interview generates interaction between the participants in the group. It is an effective way to observe the participants perceptions and arguments. The topics introduced and the moderator were the same for the sessions in Denmark and in the Netherlands. The topics were based on the outcome of the literature survey. Organic dairy farm advisors in Denmark and the Netherlands were asked to participate in focus group interviews. In Denmark, 6 advisors and in the Netherlands, 8, were exposed to parallel questions and statements during approximately two hours. The advisors represented the core of organic advisors specialized in organic dairy production. Also, one focus group session with organic dairy farmers (three with AMS, three without) in Denmark is comprised. The condensation/indexation technique was used to analyze the sessions (Halkier 2002).

Results and some discussion

Literature survey

An economic study made in Denmark among conventional dairy farms shows that from a total of 41 registered farms with AMS, only 17 have managed to achieve a positive net income (Nielsen & Vestergaard 2003). Economic models indicate that both milk yield increases and labor savings, together with the fixed and variable costs, are important factors as regards the net-income (Koning de & Rodenburg 2004). There is no reason why organic farms introducing this technique should have better economic results. Organic feed prices might even decrease financial results.

Ecological studies point out only small environmental changes when converting from bulk milking to automatic milking. Nitrogen leaching losses are dependant on the stocking rate (Kristensen et al. 2003) and farmers' capability to spread the grazing over a sufficient area. Conversion to AMS can have an increasing affect on nitrogen leaching because of difficulties grazing larger areas, even though the standards in both Denmark and the Netherlands prescribe grazing (150 days in DK, 120 days in NL.). AMS use has little effect on the contribution to emissions of greenhouse gases, like nitrous oxides and methane because they are mainly dependant on the amount of cows (Boer 2003) which will not change significantly. The expected milk yield increase per cow, has not been found in practice, and is not expected in organic AMS herds either. 78-97% of acidification is caused by ammonia volatilization. In dairy systems, only 20% of the nitrogen input in the system is returned in the products produced. Of the nitrogen ingested, 75-95% is excreted, and 80% of this return is in urine. Here, as much as 20% can be lost through volatilization (Jarvis et al. 1988).

Until now, all studies show that introduction of AMS causes many farmers to stop grazing and others to strongly decrease the amount of grazing (Meijering A. et al. 2004). Grazing is obligatory on organic farms and also believed to be essential in sustainable organic agriculture. Many practical problems will have to be solved, and further research and development are starting.

The quantifiable societal aspects, animal health and welfare, did not give reason for concern, only indirectly when grazing is minimized. Physical product quality analysis concerning AMS show that the free fatty acid content of the milk in particular is higher, which is considered to be a negative aspect. Indirectly, many positive quality aspects of milk are connected to the period of grazing, both physical (Koning de et al. 2004) as well as metaphysical.

Consumer attitudes in general (Mathijs 2004), and within the organic network specifically (Torjusen *et al.* 2004), are very important. Communication to consumers and retailers regarding the different aspects of innovative technology is crucial (Mathijs 2004). This also relates to product quality, institutional constraints and the general opinion of organic agriculture. In societal studies on motivation of farmers to invest in AMS, it showed that arguments like "more freedom in work" in general were more important than economical gain (Meskens & Mathijs 2002).

Focus Group Interviews

Advisors' reactions to AMS on organic farms were mainly positive; however, more negative (critical) remarks were expressed among the Dutch. They recognized the necessity for organic dairy farming to anticipate use of modern technology. There were clear differences between the Dutch and the Danish perceptions. The Dutch emphasis on economy has been evidenced by research on conventional AMS farmers' perceptions (Meijering *et al.* 2004).

Table 1: Systemized reactions on AMS implementation on organic dairy farms in focus group meetings in NL and DK with organic dairy farm advisors:

	DK	NL	pos/neg
Statement			
It works fine	x	x	pos
No problems with the organic standards	x	x	pos
No problems with the consumers.		x	pos
Good for welfare	x		pos
Let technology help us	x	x	pos
Is forced on the farmers to survive		x	neg
Milk quality is questionable	x	x	neg
Grazing problems	x	x	neg
Prices are falling, it is necessary to rationalize		x	neg
Economy questionable		x	neg
Requires flair for computer		x	neg
We have to watch out for the wrong image		x	neg
It doesn't add marketing quality to the milk		x	neg
Decreases difference organic and conventional		x	?
It should be publicly disseminated		x	?
Only for the larger farms		x	?
Impossible for very big farms	x		?

The focus groups were asked to prioritize potential threats of introducing AMS on organic dairy farms with respect to selected sustainability issues. The following aspects were presented: poor economy, increased use of concentrates, problems with milk quality, technical dependancy, less grazing, animal welfare problems, animal health problems, consumer scepticism, and mineral deletion due to too many animals outside on a small field. The aspects were briefly explained to the group. All focus groups placed poor economy as the main concern, followed by animal welfare, milk quality and grazing, while technical dependancy, health and mineral loss were valued as less important.

Grazing was valued as one of the ecological indicators under pressure when assessing sustainability in the literature. The problem of minimal time for cows on grass pasture is not restricted to organic AMS herds, but also seen in very large bulk milked herds. Therefore the question was raised whether the grazing principle should be made more precise. Focus groups (two advisor groups and one farmer group) were confronted with a new rule: minimum 6 hours of grazing per day, and minimum 0.2 ha accessible grassland per milking cow in the grazing season.

Table 2: Systemized reactions from two focus groups consisting of advisors (adv) and one consisting farmers

Statement	NL	DK	DK
	adv	adv	farm
0.2 ha is too much	x	x	
Not for all countries	x		
Hard to regulate, control	x	x	
6 hours is not enough	x		
6 hours is ok, the 0.2 ha is too much	x	x	x
0.2 ha is necessary	x		x
Too radical, this was not what the farmer accepted when they converted	x		
People deciding this don't know anything about practical farming.	x	x	
Fine	x	x	x
would destroy the rotation	x	x	
would ruin the economy		x	
Make welfare score, grazing gives points, can be substituted by other measures		x	x

Conclusion

From these preliminary results, it can be seen that several sustainability issues derived from analyzing the literature on conventional AMS implementation, are recognized in organic agricultural practice. The poor economy of AMS farmers, although not registered for organic dairy farmers, concerns the Dutch farmers in particular, while milk quality and grazing problems are mentioned and discussed by advisors in both countries and farmers in DK. The reactions to the suggested extra regulations, setting limits to accessible area for grazing and grazing time, were quite different for the Netherlands and Denmark. In Denmark, advisors did not want such regulations, and suggested a welfare scale on which also other parameters could give the necessary score. In the Netherlands, some of the advisors found the 6 hours and 0.2 ha of accessible grassland acceptable, some even too little. Surprisingly, the Danish farmers could better accept this clarification of the rules, although the discussion in the group, where some of the farmers could not satisfy the requirements, offered inspiring solutions.

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ORGANIC EGG PRODUCTION IN FINLAND – DESCRIPTIVE FARM AND HEALTH CHARACTERISTICS

Anna-Maija Virtala (1), Ulla Holma (2), Marja-Liisa Hänninen (3), Tuula Hyyrynen (4), Malla Hovi (5), Helena Kahiluoto (6), Laila Rossow (7), Anna Valros (8)

(1) University of Helsinki, Faculty of Veterinary Medicine, Department of Basic Veterinary Sciences, P.O. Box 66, 00014 University of Helsinki, Finland, +358 9 19157065, anna-maija.virtala@helsinki.fi, www.vetmed.fi

(2) University of Helsinki, Institute for Rural Research and Training Mikkeli Unit, Lönnrotinkatu 3-5, 50100 Mikkeli, Finland, +358 15 202 3356, ulla.holma@helsinki.fi, www.mtkk.helsinki.fi

(3) University of Helsinki, Faculty of Veterinary Medicine, Department of Food and Environmental Hygiene, P.O. Box 66, 00014 University of Helsinki, Finland, +358 9 19157113, marja-liisa.hanninen@helsinki.fi, www.helsinki.fi

(4) University of Helsinki, Faculty of Veterinary Medicine, Department of Basic Veterinary Sciences, P.O. Box 66, 00014 University of Helsinki, Finland, +358 45 6356844, tuula.hyyrynen@helsinki.fi, www.vetmed.helsinki.fi

(5) University of Reading, Veterinary Epidemiology and Economics Research, United Kingdom, m.hovi@reading.ac.uk, www.reading.uk

(6) MTT Agrifood Research Finland, Ecological Production, Partala, Huttulantie 1, 51900 Juva, Finland, +358 40 5118335, helena.kahiluoto@mtt.fi, www.mtt.fi

(7) National Veterinary and Food Research Institute, P.O. Box 45, 00581 Helsinki, Finland, +358 9 3931877, laila-rossow@eela.fi, www.eela.fi

(8) University of Helsinki, Institute for Rural Research and Training Mikkeli Unit and Research Centre of Animal Welfare, P.O. Box 57, 00014 University of Helsinki, Finland, +358 44 3010563, anna.valros@helsinki.fi, www.vetmed.helsinki.fi

Key Words: Organic egg production, laying hens, poultry, Campylobacter, endoparasites, ectoparaistes, Finland

Abstract

A total of 20 organic layer flocks (in excess of 80 % of all Finnish organic egg producers that sell eggs to consumers through egg packaging companies or food shops) were visited in 2003 and 2004. Information about the farms was collected through faecal samples, mite traps and by interviewing the producer, using a semi-structured interview guide. Additionally, 38 dead hens from 12 farms were examined pathologically and for parasites through *post mortem*. The descriptive results are presented.

Introduction/Problem

Maintaining high welfare status and allowing birds access to natural behaviour and outdoors are particular challenges in organic egg production. Feather pecking, foot problems, external parasites and poor utilisation of outdoor areas have been recognised as problems in organic layer systems (Lampkin 1997, Berg 2001, Kjilstra *et al.* 2003). Lack of experience may cause imbalances in feed rationing due to the absence of synthetic amino acids and use of home-grown feed in organic rations (Gordon and Clarke 2002, Zollitsch and Baumung 2004). Birds in free range systems have potentially greater exposure to bird or human pathogens than birds in systems with no outdoor access. Good stockmanship and experience in free range systems have been identified as keys to high welfare status in organic poultry systems (Bestman and Wagenaar, 2001). Thus, organic egg production poses major challenges for producers in countries like Finland, where free range egg production is not common; where climatic conditions limit both outdoor access and building design, and where biosecurity and exclusion of zoonotic pathogens from the food chain has been one of the main aims of conventional egg production.

One of the main objectives of this work was to identify risk factors for potential problems in animal welfare and food safety on organic layer flocks in Finland. In addition, the aim was to establish potential solutions, suitable for Finnish conditions, to identified risks. A specific aim was also to describe the Finnish organic egg producing farms, as this has not been done previously.

Methodology

A total of 20 organic layer flocks were visited twice in the autumn of 2003 and in the spring of 2004. Risk factor data were collected through observation and by interviewing the producer, using a semi-structured interview guide. Fresh faecal samples were collected from the floor for analysis of campylobacter and salmonella bacteria (5-50 samples per farm) and for internal parasite identification (4-10 pooled samples per farm). Samples were cultured for *Campylobacter* spp. using both direct culturing on selective blood-free medium (modified charcoal cefoperazone deoxycholate agar) and by enrichment in Bolton broth. The egg samples were enriched in Bolton broth and after incubation in microaerophilic atmosphere on mCCDA plates. Gastrointestinal parasite eggs and oocysts were studied by flotation using a concentration McMaster technique according to Permin and Hansen (1998). For the prevalence study of poultry red mites *(Dermanyssys gallinae)*, six cardboard traps per henhouse were placed into the walls of a henhouse for 2-3 days as described by Höglund *et al.* (1995). After freezing, the mites were identified and counted under a stereomicroscope. Altogether, 38 dead hens from 12 farms were examined *post mortem* pathologically and for parasites.

Results

The Finnish organic egg producing farms had been on organic production for 4 years, on median (Table 1). About half of the organic hen houses had less than 1,000 hens; none of them had over 3,000 hens. Nearly a quarter of the farms had an outdoor area that was below the size required by the EU Regulation, a large proportion of the farms allowed access to outdoors for less than 120 days per year, and many farmers estimated low levels of usage of the outdoor areas by the birds.

Table 1. General information and management practices in 80 % of all Finnish organic egg producing farms that sell eggs to consumers through egg packaging companies or food shops in 2003 and 2004

Variable	N[1]	Median	Min – Max	% of farms	95 % CI[2] for the %
Number of hens in the henhouse *Henhouses with 1000-2666 hens* *Henhouses with 92 – 999 hens*	20	1066 NA	92 – 2666 NA	NA[3] 45 55	NA 35 – 50 50 – 65
Using at least some used hens for food	19	NA	NA	11	5 – 16
Years in poultry farming	19	5	1 – 34	NA	NA
Years producing organic eggs	20	4	1 – 14	NA	NA
Size of outdoor area/hen < 2 (1.3-1.8) m^2	20	NA	NA	20	15 – 25
2-2.999 m^2 3-3.999 m^2 4-4.999 m^2 > 5 m^2				50 20 5 5	40 – 60 15 – 25 0 – 5 0 – 5
Hens at least partly outside	20	NA	NA	75	70 – 80
Roughly estimated proportion of birds using the outdoor area (estimated by the farmer) %	18	35	7 - 95	NA	NA
7-25 % *26-50 %* *51-75 %* *76-95 %*		NA	NA	33 28 28 11	22 – 44 17 – 33 17 – 33 6 – 17
Time when access to the outdoor area is offered (farmer report)	19	132	0 - 240	NA	NA
< 120 days/year		NA	NA	37	26 – 42
120 – 149 days/year				37	26 – 42
150 – 180 days/year				21	16 – 26
> 180 days/year				5	0 – 5
Outdoor area rotated during the outdoor period	20	NA	NA	10	5 – 10
Outdoor area rotated annually between all flocks	19	NA	NA	5	0 – 5

[1] N=Number of farms with data, [2] Hypergeometric 95 % confidence interval for the percentage, taking account that in Finland there were altogether 23 organic egg producing farms that sell eggs to consumers through egg packaging companies or food shops in 2003-2004, [3] Not applicable

Only few of the farmers had recognized endoparasites or ectoparasites in their flocks (Table 2). However, a large proportion of the flocks had *Nematoda* spp. or red mites (caught with traps). The *post mortem* results are biased, as only 60 % (12 farms) sent dead hens for examination, and 42 % of the dead hens came from one particular farmer. However, red mites were detected in the *post mortem* examination on a corresponding number of farms as with the traps from all farms. Hens that showed signs of having died as a result of cannibalism were diagnosed on a number of the 12 farms.

Table 2. Health related information in 80 % of all Finnish organic egg producing farms that sell eggs to consumers through egg packaging companies or food shops in 2003 and 2004

Variable		N[1]	% of farms	95 % CI[2] for the %
A. Laboratory results				
Red mites	*In fall 2003*	17	59	48 – 71
In spring 2004		10	70	50 – 90
Endoparasites		19		
Nematoda in fall 2003			53	42 – 63
Nematoda in spring 2004			65	53 – 77
Campylobacter spp.	In fall 2003	19	84	79 – 90
	In spring 2004	17	77	71 – 88
Salmonella spp.	Both in fall 2003 and spring 2004	20	0	0 – 0
B. Medication (farmer's reports)				
Use of preventive medication		20	0	0 – 0
Use of curative medication		20	10	5 – 10
C. Main *post mortem* results[3]		12		
Cannibalism changes			50	33 – 67
Escherichia coli -infection			42	25 – 67
Parasite –infestations:				
Ascaridia galli			17	0 – 33
Heterakis gallinarum			17	0 – 33
Feather mite (sucking loose)			17	0 – 33
Red mite (*Dermanyssus gallinae*)			58	33 – 75

[1] N=Number of farms with data
[2] Hypergeometric 95 % confidence interval for the percentage, taking account that in Finland there were altogether 23 organic egg producing farms that sell eggs to consumers through egg packaging companies or food shops in 2003-2004
[3] Based on 38 hens from 12 of all 23 Finnish organic egg producing farms that sell eggs to consumers through egg packaging companies or food shops farms in 2003 and 2004

Of the flocks, 71 – 90 % were *Campylobacter* spp. positive, the fall and spring results did not differ significantly between the seasons. The most common species detected was *C. jejuni*. Two of the farms were campylobacter-negative both in autumn and spring. Campylobacter positive egg shell sample was detected once. Salmonellas were not detected either from fecal samples or eggs.

Discussion

The parasitic and cannibalism results compare well with results found in free range/organic poultry in Denmark (Permin *et al*. 1999), back yard flocks or alternative systems in Sweden (Höglund *et al*., 1995), hens in alternative systems in UK (Green *et al*., 2000) and organic laying hens in the Netherlands (Bestman and Wagenaar 2003). There is clear need in transferring this information to the farmers, as parasite levels can be reduced and welfare of hens increased through management practices.

C. jejuni colonizes commonly the intestines of wild birds and poultry. The results of this study suggest that organic laying hens are more often colonized by campylobacters than conventionally reared chickens in Finland, as some Finnish studies estimate approximately 4 % contamination levels in flocks when sampled at the point of slaughter. Campylobacter colonization did not appear to lead to contamination of egg shells, as only one sample was positive of a total of 36 samples studied. Campylobacters on egg shell surface are not likely to survive, as they are sensitive to dryness. These facts together indicate that the risk of transmission of campylobacters on eggs to consumers is small. Intestinal colonization by campylobacters may lead to contamination of meat at slaughter as seen commonly in chickens. Meat of used organic hens is not commonly used as food decreasing the possibility of meat to transmit campylobacter infection to humans.

It was apparent in this study that outdoor access for laying hens is problematic under the Finnish climatic conditions. The current EU Regulation requires outdoor access for one fifth of the bird's life, including the rearing period, which is often spent entirely without outdoor access. It will be difficult for the Finnish layer producers to fulfill this requirement, particularly for birds that come into lay during the autumn months. The EU Regulation does, however, allow reduced outdoor access due to climatic conditions, mainly as a temporary measure. The Finnish climatic conditions limit the outdoor access on a more permanent basis. Therefore, other solutions that allow access to natural behavior need to be sought, for instance, in the form of winter gardens and verandahs.

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POSTERS
ECONOMICS AND MARKET

THE ADVENT OF ORGANIC FARMING MODELS: ANALYSIS OF THE CURRENT SITUATION AND PERSPECTIVES IN BRAZIL

Lucimar Santiago de Abreu (1), Stéphane Bellon (2) Francisco M. Corrales (1)

(1) EMBRAPA Meio Ambiente, Rodovia SP 340 Km 127,5; CP 69 13820-000 Jaguariúna (SP, Brazil), lucimar@cnpma.embrapa.br; http://www.cnpma.embrapa.br;
(2) INRA-SAD, Unité Ecodéveloppement, Domaine Saint Paul, Site Agroparc, 84914 Avignon Cedex 9, France

Key Words: small organic producers, ecologisation of agriculture, farming models

Abstract

This text analyses the development of organic farming in Brazil. It shows the great variability of social models of organic production recognised by Brazilian Law: organic, agroecological, ecological or biodynamic agriculture, permaculture etc.. It depicts how the political and social concerns in the spheres of family farming and environment caused the reorganisation of production systems, in the agricultural practices and in the new relationships with the market and with natural resources. Based on interviews with farmers and stakeholders involved in the development of various organic systems, we qualified the related models of production as well as the related social and cultural values. We also present some aspects of the historical roots of this agroecological movement and the way family farmers adapt to the new challenges of ecological production.

Introduction

Organic farming (OF) exemplifies the on-going ecologisation process of agriculture. Studying this process means exploring the procedures contemporary societies adopt to respond to the environmental problematic of development dynamics. Such procedures are not only related to production and consumers' social practices but also to the choices of different economic and social stakeholders involved in ecological networks. They also result from the increased public awareness of environmental problems and of the hazards of artificially produced food (Abreu, 2002). In Brazil, the debate on agriculture and environment began in the 70s, following the publication of "Silent Spring" (Carson, 1968). This work affected public opinion and helped expand the environmentalist movements. It also contributed to knocking down a prevailing cultural vision of unlimited growth and to generating conditions that would make the establishment of new relationships between environment and agriculture possible.

In Brazil, the development of OF, especially in the last three decades, entailed the growth of organic production in both internal and external markets. With a cultivated area of 842,000 ha, this sector represents a market that almost reached USD 1 billion, in 2003. 19,000 certified organic properties and 174 certified organic farms plants are scattered throughout the country. Brazilian OF, which grows at an annual rate of 20%, has already a significant presence in the domestic market and is clearly expected to expand its international market share. OF concerns not only family agriculture but also large companies. The growing demand for organic products is related to the fact that domestic and foreign consumers are increasingly concerned about the quality of foods and the impacts of agriculture on the environment. This expansion can also be attributed to the development of a market that is fairer to both producers and consumers, in addition to creating jobs.

There is an important diversity of types of OF in Brazil today. Beyond the mere obligation to substitute chemicals by other inputs respecting certain specifications, multiple interpretations of OF (collective values, fair trade, territorial entities) and of signs (labels, logos, certification systems) have appeared, ratified by Federal Law 10.831 of Dec. 2003. Certification is also diverse and contributes to new values and production models (Ruhlmann, 2003; Seppänen and Helenius, 2004). It can be individual, collective (allowing to reduce the certification costs by 10) or even "participative" with the "Ecovida" network (Oliveira and Santos, 2004). Is this diversity of expressions related to the dynamics of development of OF in Brazil? Or does it result from the translation of foreign fundamentals and references in terms of certification (IFOAM or ISO65)? This raises the problem of the meaning this range of agricultural models can take: survival condition for some small producers, abandonment of "poisons or biocides" in production and/or ecologization of agriculture; social aspects and emergence of new systems of values; new relations to oneself (food, family health) and consumers; professional legitimisation and reduction of the inequalities. We intend to explore briefly such models and try to interpret their meaning.

Methodology

The approach taken was twofold. On the one hand, it was based on literature reviews, direct interviews with research workers whose PhD thesis was dedicated to organic farming in Brazil and with agents involved in the development of permaculture or biodynamic agriculture (namely in experiments and training sessions for farmers), information collected through participation in organic networks and subsequent visits to organic farms and market places in the States of Santa Catarina and Paraná. Concerning certification, we visited the IBD Center (Biodynamic Institute for Rural Development, Botucatu, operating on the international level) and interviewed two former chairperson from AAO (Association of Organic Agriculture, São Paulo, operating on the federal and state levels) as well as managers from Ecocert (Florianopolis, SC), ACOPA (Association of Organic Consumers in Parana) and AOPA (Association of Organic Producers in Parana, Curitiba). On the other hand, we carried out research and field work in a rural area of the São Paulo State, with case studies in different organic farms and organisations. In this new organic green belt (Ibiúna), we gradually identified and conducted interviews with key persons and active OF organisations: technical and political officers, organic inspectors, group leaders and farmers. A total of 25 people were interviewed and 20 of them were affiliated with social organisations (Bellon and Abreu, 2005). The questions differed according to the people being interviewed. As for technical officers, we focussed on their activities and relationships with organic farmers, as well as on their description of the OF universe. The certifying inspectors we encountered worked either for the IBD or for the AAO. We analysed group dynamics and operation, marketing channels and certification processes.

Results and discussion

Models of organic farming

An ecologization process of agriculture in Brazil emerged in the mid-90s as a social movement in search of a new ecological model of production where OF and its potentials were felt as the “ideal type” or prototype of agriculture (Sylvander & Bellon, 2003). Despite controversies and the different trends of the models of ecological production, we adopted those proposed by the Organic Law (Brazil, 2003), which joins different alternative models of agricultural production under the name of Organic Agriculture. From an empirical viewpoint, we noticed that the production systems are being rethought and that farmers are organising themselves or are already organised to convert their production systems and to search for innovative markets (Bellon & Abreu, 2005). These models of OF can be described in a comprehensive way (Table 1).

Table 1: Characterisation of organic farming models

Organic Farming Model	Relation to the market	Production and certification	Social and cultural values
Agro-ecological	Solidarity (fair prices); Direct sale; Interactions among farmers and with consumers	Confidence and validation for the communities. Organisation in core groups and networks of farmers	Autonomy and Diversity; Fraternity; Cooperation; Socio-technical interaction.
Organic	Experience and Interaction; Emphasis on visual quality for supermarkets.	Crop planning; Technical assistance and third party certification, Collective or individual	Economic Reality Technology: Human health Soil and plant care
Biodynamic	Specific stores; Anthroposophy network.	Brazilian Institute of Biodynamics (IBD); Demeter label.	Holism; Spiritual dimension; Cooperation; Fraternity;
Permaculture	Direct selling; Exchange;	Land care and land use planning; Crop-animal interactions Recognition by Ecovida	Respect; Justice; Long term projects; Living and habitat; Cooperation and interactions.

In Brazil, the logic of the strictly speaking organic model is based on the economical calculation (or accumulation), the use of technology and entrepreneurial management, although the latter is usually executed by members of the family. Nevertheless, the reference to the organic model does not mean that all organic farmers prefer the same system of values (relationships to the land and heritage, to the techniques, to the market and the global society) or have the same expectations as for their future. Their distinctiveness should be taken into consideration, that is, the deadlock or rupture situations that do or do not allow them to put their strategies into practice. Temporal and socio-cultural heritage analyses should also be included. Differently from that of the organic farmers, the behaviour and systems of value of farmers involved in the agroecological, biodynamic and permaculture models are underpinned by humanistic, truly ecological ethics, although they really differ among them.

Organic horticulture in small farms from São Paulo Metropolitan Area

The organic model of production is well represented in the State of São Paulo. The Ibiúna region, the green belt of the great São Paulo Metropolitan Area, for instance, reveals a certain originality and represents a significant contribution the Brazilian horticultural production, estimated in 3,000 ha (Ishimura, 2003). Its OF(s) are dynamic and new markets are exploited (supermarkets in medium cities), whereas a first driving initiative consisted in conquering the metropolis supermarkets by privileging the visual quality of their products. Other forms of organisation were identified (Bellon & Abreu, 2005). For instance, APPRI (Association of Small Rural Producers from Ibiúna) is close to OF but targets other consumers, in a relation between the countryside and the city. The countryside-city relation is redefined in Ibiúna, which, strictly speaking, is not a periurban area (between 50 and 100 km from the metropolis). This results from a double movement: the delocalization of the green belts and the creation of new proximity or territorial entities. Hints for processing and interpreting the data collected were also proposed during this research on the technical level; questions of horticultural production planning and its environmental assessment with tools developed for modes of production other than OF were also discussed. Actually, these tools underestimate the facts that crop diversification and the consumption of environment are present in certain models of OF. One challenge consists in testing the congruence of the various forms of organisation of OF as compared to the producers' trajectories and practices. Field visits allowed us to understand how difficult it is for the organic farmers (in particular, in the region of Ibiúna, São Paulo) to enforce the requirements of the IBD norms (based on European norms). Another obstacle is the cost of certification for the farmers and the appropriation of the organic product added value by the large-scale distributors. This resulted in the search of alternative forms of certification and distribution (direct sale to consumers).

Heritage and innovation in OF

The diversity of the social production forms can be interpreted as part of the heritage of European models, adapted to the Brazilian conditions. They co-exist with other original forms settled under the specific conditions of the local context. OF is also promoted by political organisations committed with the construction of a new model of society, claiming equity and justice and thus involved in social transformation. Thus, organic agriculture does not have the same meaning as in some regions in a few other countries, where organic agriculture emerged from the counterculture and movements against the consumption society (Brandenburg, 2002). We also rescue and revitalise the cultural heritage of the local communities that direct their production to multiple markets including innovative forms of relationship between producers and consumers (Karan, 2001).

To better explore these agricultural alternatives, we should identify and characterise the devices in which such agricultures are expressed and network them. This prospect was evoked in several opportunities during work meetings with Embrapa colleagues. A network of organic farms was recently built up in the State of Sao Paulo, animated by Embrapa Meio Ambiente (MCT/ MDA/ Embrapa, 2004). A methodological deepening is necessary to apprehend these various practices. Since they raise new theoretical and methodological issues and challenges that are already contributing to redefine the discipline contents of agriculture professionals, these activities introduce innovation in and enhance the Embrapa's process of scientific knowledge generation.

Discussion and conclusions

We suggest that the agroecological model is more frequently found in Southern Brazil because of the strong dynamics of the social movement of agriculture ecologization. This was based on solid community roots with a strong political dimension, supported by the implementation of environmental measures (landcare, forest conservation and development…) and consolidated by the emergence of local agroecological networks. It is probably a result not only of the cultural heritage of the European alternative models but also of a huge work of environmental preservation backed by public policies (soil and biodiversity preservation, this base has probably constituted the seeds to build agricultural alternatives). We can question to what extent this model, so present in Southern Brazil, may be concretely considered as relevant for the development of Brazilian family farming? It expresses itself in all the alternative movements aimed at combining food autonomy, better income and respect of the natural or ecological environment limits. The organic model of production is also well represented in the State of São Paulo, where it shares its territorial space with the other models mentioned.

In Brazil, most organic producers (organic, agroecological, permaculture) have settled in small land structures and the production strategies are oriented towards family subsistence and to the sale on multiple markets. These include their socio-economical reproduction and the need to respect the limits of the environment. Such issues thus led us to think of and define new, innovative forms of market and of relating to the environment and society. Transition to a new model of development goes through the adoption of measures and policies to strengthen OF. In Brazil, the ecological crisis in agriculture can be explained by the debate incited between environmentalists and advocates of a technical and productivist agriculture, settled through an ambiguous game of immediate and circumstantial interests. As for the future of organic agriculture in Brazil, various programs aim at strengthening the initiatives to support the transition from traditional agriculture to sustainable models. A credit line that stimulates projects of agroecological production which favours the proper handling of the natural resources, resulting in better income and quality of life to small farmers should be enhanced. In fact, the last events seem to indicate that the Brazilian government intends to promote a change to support the development of agroecological and organic production as a way of stimulating family farming. The results here presented are the fruits of the first step of a research that must necessarily be more comprehensive when it comes to development of OF. The scientific cooperation with INRA/France will allow us to perform a comparative analysis and deeper study, articulating case studies with global analyses.

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METHODOLOGY FOR SUSTAINABILITY EVALUATION IN ORGANIC FARMING UNDER COLUMBIAN CONDITIONS: A PROPOSAL

C.A. Escobar[1]; A. Espinosa[1]; R. Malagon[2] and A. Zuluaga[3].

1. Sustenta Group, Cl 5 # 45ª - 125, Cali. Tel. +57-310-4276085, Email: sustenta@terra.com.co
2. National University of Colombia. Cra. 32 Chapinero, Palmira. Tel. +57-2-271700, Email: rmalagon@palmira.unal.edu.co
3. Independent Consultant., Email: azuluagah@yahoo.com

Key words: Environmental quality, Sustainability, Organic Agriculture

Abstract

The lack of specific methodologies to evaluate and monitor the impact of agricultural activities on the-biotic, abiotic and socio-economic environment constitutes a technical - scientific barrier for the development and improvement of Organic Agriculture in Colombia.

The proposed methodology consists of:

Step 1: Gathering of information on the organic production system by means of surveys and interviews with farmers.

Step 2: Characterisation and description of the production system.

Step 3: Qualification and quantification of the production system.

Step 4: Identification and evaluation of environmental quality indicators and creation of diagrams

Step 5: Interpretation of results.

This proposal is a first approach for a complete evaluation of any organic production system by means of using indicators that define environmental quality. The proposal is flexible to modification according to the specific conditions of each system, region or country.

Introduction

The interest in Organic Agriculture has increased in many countries, including Colombia, because this production system offers interesting possibilities in socio-economic, environmental and productive terms.

In Colombia, there are currently appr. 36.000 hectares under organic production (Espinosa 2004). Yet, in spite of practical experience in Organic Farming, research on organic production systems is still lacking, mainly, concerning the relationship between Organic Agriculture and sustainability, in particular when considering that sustainability includes social, economic and ecological dimensions (Carls & Reiche, 1996; Malagon, 1999).

The present investigation denominated “Methodology of Evaluation of Sustainability of Organic Systems” (Spanish acronym: MESSO) is a contribution to the development of Organic Agriculture because it proposes tools, instruments and indicators for easy evaluation of the interaction between socio–economic, environmental and productive factors of organic systems under Colombian conditions. Nevertheless, MESSO is permanently under revision and it can be improved or adapted to conform to specific conditions.

The methodology is based on theoretical knowledge from the General Systems Theory (Bertalanffy, 1980), the methodology Marco for Evaluation of Systems using Sustainability Indicators (Spanish acronym: MESMIS) (Masera, 2001), the methodology of Leopold (Conesa, 1995) and methods of the Institute Batelle - Columbus (Conesa 1995). It is also enriched by authors and collaborators from different international research institutions.

Methodology

The concept of MESSO includes the following phases:

Bibliographical survey on organic production, sustainability and environmental conditions to identify the past, present and future of these topics.

Visit of organic farms to understand and identify typical components, actions and their interactions with the system. Surveys were made three times and consisted of a visit to an organic farm of a small farmer and his family. With their help, using theoretical models and a model survey, we characterised organic farming practices. It permitted us to create a model survey for MESSO as a first tool for the evaluation system.

The characterisation of a specific organic production system is based on Bertalanffy's Theory enriched with bibliographical information. This information permitted us to identify main activities and components for typical organic farming in Colombia. The characterisation of the systems according to Bertalanffy (1980) is a second tool for MESSO.

The possible activities and components were included in a matrix of impacts; usually, this matrix is used in environmental impacts studies. Then, this draft matrix was revised by national and foreign professionals with the goal to build an "ideal matrix" with "typical components and activities" of a Colombian organic production system. The procedure used consisted of eliminating activities and components that are not important or representative for typical Organic Farming in Colombia using a simple qualitative classification. This "ideal matrix" and its glossary are a third tool for MESSO.

Then, we organised a system of indicators considering bibliographical information and real situations. This system was formed with simple indicators that facilitate the understanding of relations between activities and components easily. These indicators could be used on the field, and needed no supervision by an expert. These systems of indicators are the fourth tool for MESSO.

Finally, we used mathematical models for the construction of environmental quality diagrams and coefficients of transformation that allow to eliminate units like kilo, pounds, and percentage, allowing an expression of the results in terms of environmental quality. This is the fifth tool for MESSO.

Results and brief discussion

In conclusion, the MESSO comprises the following steps:

Selection and gathering of information on organic production systems using a model survey as well as other techniques such as visual assessments on organic farms and their surroundings. This model survey can be improved according to specific conditions. The minimal questions have to cover information on social, economic, productive and ecological aspects as well as basic information e.g. maps or climate.

Description and characterisation of organic production systems are based on the field survey. It consists of identifying activities (e.g. the application of organic fertiliser), components (e.g. soils, rivers, animal species, crop species, forest), limits (borders), external inputs (e.g. seeds, bio-pesticides, medicine), outputs (e.g. beans, coffee, milk) and internal and external interactions. Extensive and reliable information is very important for the next step.

Identification, qualification and quantification of organic production systems start from the "ideal matrix" and move down to the "local matrix". Based on the "ideal matrix" and information derived from the characterisation (see above), it is possible to build a "local matrix" with specific components and activities. In this case, the user has to review whether the glossary sufficiently explains all specific local activities and components. If this is not the case, concepts for each new activity and component need to be added or modified.

Then, the "local matrix" has to be qualified as follows:

Actions or activities that impact positively (+) or negatively (-) on components, i.e. a qualitative value.

Quantitative values using a scale 1 to 10 according to the following categories:

Impact very low (IVL), 0 – 1

Impact Low (IL), 2 – 3

Impact Medium (IM), 4 – 6

Impact High (IH), 7 – 8

Impact very High (IVH), 9 – 10

These valorisations determine a corresponding degree of impact. Subsequently, vertical and horizontal additions have to be carried out. Adding vertically reflects the level of impact of all agricultural activities on one impact factor, while adding horizontally determines the level of impact of one activity on all components (i.e. the productive system).

By this method it is possible to obtain first results about environmental impacts of organic production systems. Then, after analysing the results, it is possible to start to improve the management of the organic system, if considered necessary.

The Methodology MESSO developed 37 indicators for social, ecological and productive components. The indicators permit to assess the condition of any component to provide an early warning signal of changes in any component or to diagnose the cause of any problem in the system. Moreover, the list of indicators has to reflect key information about structure, function and composition of the organic system.

Each indicator has a unit (e.g. pounds, kilo, percentage) but they can not be aggregated and analysed together (holistic). For that reason, MESSO proposes the use of indexes of environmental quality based on the use of transformation functions, resulting in unitless indicators.

After the use of indicators versus transformations functions, a diagram on environmental quality assessments can be established making results visible. These generated graphics are the basis of the evaluation.

Finally data needs to be analysed and decisions on improving a specific organic production system need to be taken, if deemed necessary to comply with the dimensions of sustainability.

The proposed methodology is in process of validation because it might have inconsistencies or difficulties, while the organic system is dynamic. Nevertheless, it is clear that MESSO can be modified or adapted according to local conditions.

Conclusions

The advantages of MESSO are:

- it has a holistic vision
- it requires interdisciplinary work
- it can measure the environmental quality of organic farms
- it is susceptible to changes and adaptations according to site specific conditions
- it has its own methodical tools such as surveys, indicators, etc.

Although MESSO is based on real information starting from one typical organic farm, it is a mixture of routine and theoretical aspects. Therefore it has to be validated in different regions and types of organic farms (e.g., small farmers, big farmers, indigenous communities). For that reason, since 2004 MESSO is being used and validated in indigenous farms

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LIVELIHOOD STRATEGIES AND HUMAN RESOURCE USE ON DANISH ORGANIC FARMS

Pia Frederiksen, Vibeke Langer (2)

(1) Department of Policy Analysis, National Environmental Research Institute, P.O. Box 358, DK- 4000 Roskilde, Denmark. pfr@dmu.dk

(2) Department of Agricultural Science, the Royal Veterinary and Agricultural University, Agrovej 10, DK-2630 Taastrup, Denmark. vl@kvl.dk

Keywords: diversity, pluriactivity, organic farming, Denmark, livelihood, resource allocation, heterogeneity

Abstract

The diversity in the Danish organic farming sector is quantitatively described in terms of the use of resources for off-farm activity (pluriactivity), farm production, and other farm-based activities. Based on interviews with 10 % of the organic farmers representing the national distribution of organic farm types as well as major landscape systems, household livelihood strategies are identified based on combinations of off-farm income levels, time used for farming, and farm size. Implications for agricultural and rural development policies are shortly discussed.

Introduction

Agricultural restructuring takes place all over Europe. Economies of scale still force a change towards larger farms, but the Common Agricultural Policy of the European Union changes subsidy structures from production support to area support and increases the share of the budget allocated to Rural Area development support schemes partly in favour of on-farm diversification. Within this political economic context various farm development pathways exist for the family farm (Bowler *et al.* 1996; Ilbery *et al.*1998). Van der Ploeg *et al.*(2004) describe farm based rural development in terms of three processes: *deepening* of activities (more value added pr unit of product) encompassing on-farm processing and high quality production; *broadening* of activities (structural diversification) including new farm-based activities such as agri-tourism, nature- and landscape management. The third is *regrounding* – mobilizing resources through e.g. farming economically or off-farm incomes. A large number of studies has provided evidence of the diversity of farms and in livelihood- and production strategies in Europe (e.g de Vries 1993, Jervell 1999, Eikeland 1999, McNally 2001, Djurfeldt *et al.* 2002, Walford 2003, Meert 2005), demonstrating that diversifying traditional farm production is common.

The choice of conversion to organic production has been viewed as one development pathway – a recombination of farm resources for value added agricultural products. This paper explores the diversity among organic farming households in terms of human resource use for farm production, off-farm work and other farm-based activities (OFA). The aim is to demonstrate that organic farming is in itself composed of a variety of livelihood strategies, which must be addressed when discussing development strategies for organic farming in general, and especially the role of organic farming in relation to societal objectives of rural development.

Data and Methods

Data on farming households, background and history on farm, and resource use for farming, off-farm activities and other farm-based activities were collected through quantitative interviews. These were carried out in 2002 in 11 case-areas, within which all organic farmers were approached (response rate: 75%). A total of 347 farmers were interviewed and 341 subsequently included in the analyses. These farms covered approximately 10% of all organic farmers in Denmark and represented the national distribution of farm types. The case areas represented major landscape types of Denmark and areas with a relatively high density of organic farms.

Farms were grouped according to time used for farming based on the respondent's estimation of work load. The workload of all participants was estimated in 4 classes, as shown in table 1.

Table 1: Time used for farming

Agricultural type:		Workload:
Hobby farms		Less than 10 hours pr week and person
Part time farms		Between 10 and 37 hours pr week and person
Full time farms	Single full time farms	37 hours or more pr week – one person
	Double full time farms	37 hours or more pr week - 2 or more persons

Farms were subsequently grouped into 6 levels of off-farm work based on combinations of the farmer's and the spouse's off-farm activity. The off-farm income level of the farmer was defined at three levels: main income, minor income or no income. These three groups were again subdivided according to the spouse's off-farm workload divided into high (full or part time off-farm job), and low (minor or no off-farm work). See table 2:

Table 2: Off-farm categories

Off farm level:	Farmer's income from off-farm work	Spouse level of off-farm work
Farmer major/spouse major: FmajSmaj	main part of income	full or part time
Farmer major/spouse minor: FmajSmin	main part of income	minor or none
Farmer minor/spouse major: FminSmaj	minor share of income	full or part time
Farmer minor/spouse minor: FminSmin	minor share of income	minor or none
Farmer no/spouse major: FnoSmaj	no off-farm income	full or part time
Farmer no/spouse minor: FnoSmin	no off-farm income	minor or none

Other Farm-based activities (OFAs) were categorised into four groups:

1) The farming related: farm shops, processing of farm produce, direct sale or having a machine pool

2) The land related: farm tourism, leasing of hunting rights, riding schools and horse pensions

3) The profession related: crafts, business on farm, paid childcare,

4) Other: sale of energy (windmills), let out of buildings

The respondent also estimated the time used for these activities.

A common classification based on agricultural type and farmer's off-farm level was used as an approach to identify livelihood strategies. The size of the managed area (field area) was used as an indicator of the "similarity" of farms for testing the classifications' ability to distinguish farms of different character using Wilcoxons rank size test.

Results and discussion

39% of the farms were full-time farms, while part-time farms and hobby farms made up 31% each. The full time farms consisted of two groups: the double full time farms (15%), and the single full time farms (24%). The time allocation to farm work by spouses was generally low – less than 10 hours pr week, except for the few (6%) traditional family farms with farmer and spouse both worked full time on the farm. The farm size was significantly different between the four groups ($p<0.0001$).

On 44% of the farms both the farmer and the wife draw the main income from off-farm work. On additional 10% of the farms, off-farm income was the farmers' main income source, while the spouses had no or little off-farm activity. 45% of the farms were managed by the remaining four groups of farms on which farmers had no or minor off-farm incomes and spouses varied (see fig.1).

The size of farms was tested against the 6 off-farm levels. A significant difference ($p<0.01$) was only found between the two groups, where the farmer draws the main income from outside the farm, and the four groups where the farmer had no or minor off-farm incomes. Based on these analyses, the 6 off-farm levels were reduced to two: the farmer having main income from off-farm work and the farmer having no or minor income from off-farm work.

Fig 1: 341 farms categorised according to off-farm. level of farmer and spouse in 2001 (legend, see farms in 2001 table 1)

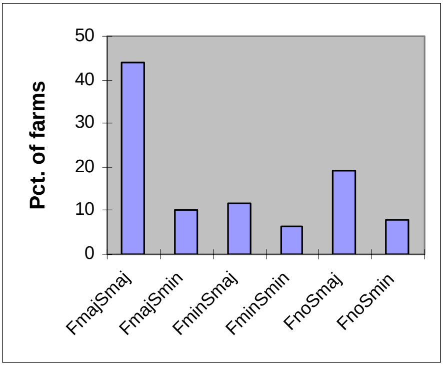
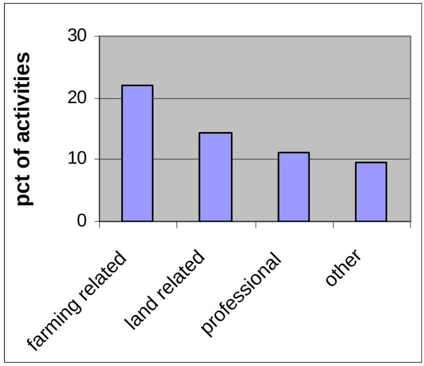


Fig 2: Other farm-based activities on 169 farms in 2001



Half of the farms did not have any OFAs on the farm, 34% had one activity and 15% had 2 or more. The distribution of the four main types of OFAs is shown in figure 2. Direct sale, letting out of hunting rights and buildings were the most frequent activities. The time use for OFAs was, however, generally low and 75% of farms with OFAs used only little time for these purposes.

A classification of livelihood strategies based on agricultural type, off-farm level and farm size was produced as shown in table 3. Those of the resulting groups that represented less than 2% of the total sample were not identified as separate strategies, as they covered special situations such as pensioners, a few farms run by a manager, etc.

Table 3: Combination of off-farm income levels and time used for farming on 341 farms in 2001. Groups which are not further described are in Italics.

	Agricultural type				
Farmer's off-farm level		**hobby farms**	**part time farms**	**single full time farms**	**double full time farms**
main income	Pct of farms	28	24	*2*	*0,3*
	mean farm size, ha	17	30	*68*	*88*
no/minor income	Pct of farms	*2*	6	22	15
	mean farm size, ha	*13*	47	71	129

The farm dwellers were identified as the households running hobby farms on which the farmer draws the main income from off-farm work. They used little time on farm work, and the farms were smaller, primarily arable farms, with 43% of the farms that had OFAs dominated by profession related activities. They make up 28% of the sample. Two groups of part time farmers were present: the first one consisted of the 24% busy part time farmers, who managed smaller farms and still drew their main income from off-farm work. 57% of these had OFAs on the farm. The other group consisted of the 6% part time farmers who used less than full time on an on average medium sized farm, having no or little off-farm incomes. 48% of these farms had OFAs and on these farms as well as on the farms of the busy part time farmers, the farming related activities were most frequent. Farm dwellers and the two groups of part time farmers held mainly arable and mixed farms and 30% of these had an urban background. In the other end the full time farmers with no or minor off-farm incomes were found. The two groups managed average farms of 71 ha and 129 ha respectively and the farmers had no or minor off-farm incomes. 20% and 12% of these had an urban background. While the single full time farms consisted of all farm types, the double full time farmers were predominantly dairy farms. Half of the double full time farms were so-called family farms, run by farmer and spouse, both using full time on the farm. These make up 7% of the total sample.

5 different livelihood strategies were thus identified based on combinations of agricultural type and off-farm levels. Three of these, the farm dwellers, the busy part time farmers and the part time farmers followed

strategies of structural diversification. They constituted more than half of the total number of organic farms in Denmark, and it may be asked if these groups receive sufficient attention in agricultural and other policies. A lack of attention is understandable in terms of their generally small contribution to total production, but other aspects suggest that policies should also consider the needs and wants of these groups of farmers. One is the rural development aspect, where it is important that rural areas do not depopulate along with to the structural development. Other aspects relate to the ability of farms to contribute to nature conservation policies. Small farms, which have not followed the scale-enlargement strategies and which are often run in a less intensive manner than the larger farms, may contain potentials for nature management and conservation which should be considered (Frederiksen *et al.* 2004).

Conclusion

The organic farming sector in Denmark consisted in 2002 of a variety of livelihood strategies, and a quantification of different types has been attempted. The study showed that more than half of the organic farms draw their main income form off-farm activities. The majority of these consisted of household with two major off-farm incomes. Moreover it showed that full time farms made up only 39% of the farms, covering two groups with different farm size and input of labour. The households' engagement in other farm-based activities was large in terms of numbers and types of activities, but were mostly not consuming much time. The role of the spouse in terms of farming was small and often confined to do the accounting, and consequently a dual lifestyle was to a large extent a reality. The traditional family farm, often perceived as the role model of organic farms by consumers, was thus not in line with reality.

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MONOTORING THE CONVERSION TO ORGANIC FARMING

Bernhard Freyer, Andreas Surböck, Jürgen K. Friedel, Markus Heinzinger, Manfred Gollner (1)

(1) University of Natural Resources and Applied Life Sciences, Department of Sustainable Agricultural Systems, Division of Organic Farming, Gregor Mendel Straße 33, A-1180, Vienna, Austria, Tel. +43-1-47654-3750, Bernhard.Freyer@boku.ac.at, http://www.boku.ac.at/oekoland

Key Words: organic farming systems monitoring, conversion to organic farming, stockless organic farming, landscape, biodiversity

Abstract

A long term field monitoring concerning the development of Organic Farming is performed at the bio-farm "Rutzendorf " of the BVW GmbH in the Marchfeld region east of Vienna. It is an interdisciplinary project of eleven research institutes, which started in 2003. The aims of the project are: examination of changes concerning soil and plant parameters accompanying the conversion to organic farming; investigation of the effects of different organic fertilisation systems (green manure, communal green forage compost, farmyard manure) on soil properties and on crop performances; analysis of existing biotopes (hedges and field stripes) on the farm, and planning and selective realization of new biotopes with the aim of enhancing the biodiversity of the area, offering habitats for beneficials and reducing wind erosion potential.

Introduction/Problem

In Eastern European Regions, organic arable stockless farming gains more and more significance as also bigger farms convert to organic farming. In those dry regions, with high wind erosion and high risk of heightened nitrogen concentration in the groundwater, low landscape element area and low plant, macro- and microorganism biodiversity, conversion to organic farming is a high challenge for every farmer. Referring to nutrient cycles and soil fertility, the stockless system operates without any compost input, but with green manure. To understand organic farming, its productivity and its impact on environment and economy, a long term farm trial, including landscape elements, was established in 2003. In field trials estimating the effect of different organic manure systems, transect trials for the analysis of erosion, water management, pests and beneficials, and monitoring of the whole farming system including landscape elements, 11 institutes cooperate in research and in monitoring the development of the farm.

Methodology

The long term field monitoring is performed at the biofarm "Rutzendorf", which is managed by the Landwirtschaftliche Bundesversuchswirtschaften GmbH. The farm is located in the Marchfeld region east of Vienna, Austria. The climate is warm and dry (average annual temperature: 9,8°C, average annual rainfall: 546 mm). The soil is a Calcaric Phaeozem, the soil texture is loamy silt to loam. The plough-land of the farm is 143,20 hectares, contiguous holding, and is equipped with different biotope structures. In eight fields, the following crop rotation is realized: 1st year: lucerne, 2nd year: lucerne, 3rd year: winter wheat + catch crop, 4th year: potatoes, 5th year: cereals + catch crop, 6th year: grain legume + catch crop, 7th year: winter wheat + catch crop, 8th year: cereals + underseed lucerne.

Eleven scientific divisions work at different investigation levels on the farm, depending on their research topic (Surböck *et al*. 2005). The data and results of the project are administrated in a common data base, improved soil maps are created. The Division of Organic Farming is responsible for the coordination of the overall project. The trial is carried out on three experimental levels, (i) on field plots, (ii) on transects in the fields, and (iii) on the farm and landscape level. On these levels, effects of (i) fertilisation systems, (ii) biotope elements, and (iii) the whole farm management are investigated (table 1).

Table 1: Research questions of the project partners depending on the investigation level.

Investigation level/ division	*Field plot trials* Influence of the fertilisation systems ...	Transect trials Influence of the biotope structures ...	Farm/landscape Influence of the farm management ...
IfOEL[1]	... on plant parameters, soil microbiology, soil structure and nitrogen cycle	... on crop yield, soil microbiology and soil structure	... on crop yield, plant health and weeds
IBF[2]	... on soil chemical parameters (nutrients)	... on soil chemical parameters (nutrients)	-
IHLW[3]	... on soil physical parameters	... on soil water	-
MET[4]	-	... on microclimate parameters	-
Zoology[5]	... on diversity of soil fauna	... as source respectively predator reservoir for soil fauna	... on resettlement of the fields with soil fauna
Zoology[5]	-	-	... on avifauna
Botany[6]	... on weeds and soil seed bank	-	-
LBI[7]	-	... on biodiversity and density of selected arthropod groups	
ILEN[8], ZUN[9]	-	Developing a concept of maintenance on the basis of a structural and vegetation mapping of existing biotope structures and interdisciplinary planning and planting of new biotope structures.	
ZUN[9]	-	... on biodiversity of wild bees	
Economic[10]	... on variable margin	-	... on variable margin
NUWI[11]	... on feed value of cereals	-	-
ILEN[8]	Creating and supervising of a data- and information platform for the whole project. Creating improved soil maps for the whole area of the farm based on point data from the Austrian soil taxation, relief parameters and crop data.		

- IfOEL[1] ... Division of Organic Farming, Department of Sustainable Agricultural Systems, University of Natural Resources and Applied Life Sciences (BOKU)
- IBF[2] ... Institute of Soil Science, Department of Forest- and Soil Sciences, BOKU
- IHLW[3] ... Institute of Hydraulics and Rural Water Management, Department of Water - Atmosphere – Environment, BOKU
- MET[4] ... Institute of Meteorology, Department of Water - Atmosphere – Environment, BOKU
- Zoology[5] ... Institute of Zoology, Department of Integrative Biology, BOKU
- Botany[6] ... Institute of Botany, Department of Integrative Biology, BOKU
- LBI[7] ... Ludwig Boltzmann-Institute for Biological Agriculture and Applied Ecology, Vienna
- ILEN[8] ... Institute of Landscape Development, Recreation and Conservation Planning, Department of Landscape, Spatial and Infrastructure Sciences, BOKU
- ZUN[9] ... Center for Environmental Studies and Nature Conservation, Department of Integrative Biology, BOKU
- Economic[10] ... Institute of Agricultural and Forestry Economics, Department of Economics and Social Sciences, BOKU
- NUWI[11] ... Division of Livestock Sciences, Department of Sustainable Agricultural Systems, BOKU

(i) Field trials (1 factor block design with four replications) were implemented on homogeneous soil of intermediate quality in each of the eight fields of the organic farm. Additionally, two reference plots were established, one plot on a soil of low quality in one of the organic fields, and the other plot on an adjacent conventionally farmed field. The field trials were installed to investigate the effects of three different organic fertilisation systems on the development of crops and on soil properties over time. The three tested organic fertilisation systems are: System 1: Only green manure by cultivation of lucerne and catch crops. System 2: Additionally to green manure, communal green forage compost is applied to balance the export of phosphor and potassium within the eight year crop rotation. System 3: the lucerne crop and cereal straw according to the demand of a suckler cow herd of 0.5 livestock units per hectar is harvested, the farmyard manure of the herd is then returned to the plots.

The examined parameters on the field trials and reference plots are: soil water and other soil physical parameters, soil nutrient concentration, content and subsequent supply of nitrogen, nitrogen leaching, microbial and fungal biomass, soil structure, various soil animals affecting the soil fertility, crop yield and crop quality characteristics, plant health, field nutrient balance, above-ground vegetation and soil seedbank, economic performance.

(ii) Transect trials were established in organic fields in several, exactly determined distances to existing hedges and new fields stripes. At these sites, the influence of hedges as wind protection barriers on soil quality (soil water, soil nutrient concentration, microbial and fungal biomass, soil structure) and crop yield are examined. Specific microclimate investigations of the impact of the hedges on neighbouring fields are conducted, especially wind profiles and profiles of percipitation, global radiation, dew occurrence and evapotranspiration. Additionally, at these and further monitoring plots on the farm, selected groups of arthropods (beneficial insects and pests) and wild bees were monitored.

(iii) Thirdly, a monitoring at farm level is established. On the fields crop yield, weeds and plant health are examined. In the whole area of the farm, the territories of breeding birds (avifauna) are censused. In existing biotopes, the diversity of plants is analysed and will be, if necessary, improved. Newly established biotopes, particularly field stripes, with the aim of enhancing the biodiversity of the area will be applied. These ecological measures, such as maintaining of hedges and field stripes, integrate the results from different disciplines and the management of the farm.

Results and brief discussion

The first year of the project 2003 was used to establish the long-term monitoring areas at the organic farm and to determine the present state of the different examined parameters at the beginning of the conversion to organic farming and before the first organic fertilizer input. Concerning the data (soil parameters: content and subsequent supply of nitrogen, microbial and fungal biomass; crop yield) examined by the Division of Organic Farming, no significant differences were evident after the statistical analyses. Therefore, the selected plots are suitable for the investigation of effects on soil fertility and plant development caused by different organic fertilizers.

The first experimental plots were fertilized with farmyard manure and compost in autumn 2003, before cultivating winter cereals (winter wheat and winter barley). The inquiry of yields of the harvest 2004 showed small advantages for the variants with an additional organic fertilizer (system 2 and 3). However, these differencies were not significant in the statistical analyses. Concerning the grain quality in dependance of the different fertilisation systems, only crude protein content in winter wheat was significantly higher in the systems 2 and 3 than in system 1 with only green manure. All other quality parameters of winter wheat and winter barley were not significantly different. The average dry matter grain yield of the trial with winter wheat was 5.735 kg ha^{-1} and that of the trial with winter barley was 4.812 kg ha^{-1} (Freyer *et al.* 2005).

A significant regression regarding the influence of a hedge on the lucerne yield in the adjacent field was detected only at the third cut of the lucerne in August 2004. This could be explained by very dry conditions in summer and still higher availability of soil water closer to the hedge. Additionally, various soil parameters were measured in spring 2003 in several distances to a hedge. Soil microbiological values remained on the same level at the different examined distances. Therefore no significant relation between soil microbiology and hedge distance could be proved. For reliable conclusions on this topic however, investigations conducted over a longer period of time are necessary.

Conclusions

Details of monitoring of organic farms, and especially data on the environmental effects of organic farming including landscape elements from the beginning of the conversion to organic farming, are scarce. The implications of such monitoring systems are far reaching. Effects of the changed farm management are expected no sooner than three to five years after starting with the conversion process. Nevertheless, there are several lessons to be learned on how to manage, monitor and to archive such a system.

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THE ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACTS OF ORGANIC FARMING IN WALES

David Frost (1), Danny Ardeshir (2) and Owen Davies (3)

(1) ADAS Pwllpeiran, Cwmystwyth, Aberystwyth, Wales, UK, 00441974 282229, david.frost@adas.co.uk
(2) ADAS Pwllpeiran, Cwmystwyth, Aberystwyth, Wales, UK, 00441974 282229, danny.ardeshir@adas.co.uk
(3) ADAS Pwllpeiran, Cwmystwyth, Aberystwyth, Wales, UK, 00441974 282229 owen.davies@adas.co.uk

Key Words: Organic Farming, Wales, environmental, socio-economic, monitoring

Abstract

The scientific basis of organic agriculture's role in benefiting health, the environment and agricultural communities has been the subject of considerable debate. In Wales, a three-year monitoring study found evidence of the compatibility of organic farming with environmental conservation. The study also found a positive attitude towards production issues among organic farmers, but increasing concerns about marketing and profitability.

Introduction

In 2001, the National Assembly for Wales endorsed the promotion of organic farming as a means of making Welsh agriculture more viable and environmentally sustainable (NAW, 2001). Three programmes have been funded to achieve this aim: the Organic Conversion Information Service (OCIS), a Centre of Excellence for organic farming - Organic Centre Wales, and the Organic Farming Scheme (OFS). These measures have contributed to the share of agricultural land area managed organically in Wales increasing from 0.3% in 1998 to 4% by the end of 2004. The number of organic farms has increased from 120 to 610 over the same period (Welsh Agri-Food Partnership Organic Strategy Group, 2004). With increasing uptake of Agri-environment schemes, a series of studies has been initiated to monitor the associated changes. A three-year project undertaken by ADAS and funded by the Welsh Assembly Government started in 2002 to investigate the environmental and socio-economic effects of organic farming.

Methodology

Desk study and environmental monitoring

In 2002, a desk study of the environmental and biodiversity effects of organic farming was undertaken to examine its potential impact on United Kingdom Biodiversity Action Plan (UKBAP) habitats and species in Wales. Also in the first year, a baseline environmental survey of a sample of 30 farms entering the Organic Farming Scheme (OFS) was undertaken. Environmental monitoring comprised field visits, including a habitat survey, botanical quadrate survey and boundary assessment. The habitat survey was based on Phase 1 Habitat Survey methodology (JNCC, 1990). Botanical species information was collected from 1 metre quadrates using an adapted ADAS methodology (ADAS, 1995). Plants were identified to species (Stace, 1997) where practical. The 30 farms were re-surveyed in 2004 to monitor changes associated with organic conversion. In 2003, a survey of 10 case study farms that had been fully organic for at least ten years was also undertaken. For comparative analysis, established organic farms were paired with farms in the OFS in terms of enterprise type, geographical proximity and Agri-environment scheme participation. Habitat diversity on these case study pairs was measured using the Shannon-Wiener diversity index (Zar, 1996).

Socio-economic monitoring

The main socio-economic monitoring method was a postal survey of 471 farmers participating in the Organic Farming Scheme Wales (OFS). At the time of the survey in 2004, the sample population represented approximately 80% of all certified organic farms in Wales. There was a 35% response rate. Respondents who indicated on the schedules that they could be contacted for further information were identified, and a structured sample of 20 farms was constructed that represented each of the main farm enterprise types. Using an open-ended schedule of questions, further in-depth telephone interviews were carried out.

Results

The literature review and desk study revealed considerable evidence of the general biodiversity benefit from organic farming, but found very few studies on the biodiversity of all-grass and upland farms. Environmental monitoring highlighted the value of combining organic farming with habitat-based support schemes. The socio-economic survey found a range of motives for converting to organic farming and an overall positive attitude towards dealing with technical issues, but an increasing concern about profitability and marketing. There was also uncertainty arising from changes to CAP and the end of the EU Livestock Feed Derogation in 2005. Hill sheep farmers were the group most likely to consider giving up organic farming.

Environmental impacts

In the desk study, a comparison of the actions proposed for Biodiversity Action Plans in Wales and the effects of the wider adoption of organic farming found that overall, organic farming methods are broadly compatible with actions for BAP species and habitats. It suggested that a number of bird and plant BAP species and certain BAP habitats would benefit from the wider uptake of organic farming in Wales.

The literature review confirmed the value of hedgerows for organic farming, and environmental monitoring found that where the OFS Scheme is combined with another Agri-environment scheme[1], relatively high levels of hedge maintenance and restoration work had been carried out. Levels were lower for farms not in Agri-environment schemes (Frost & Ardeshir, 2004). The condition of hedges on OFS farms improved between 2002 and 2004 but only on those farms in an Agri-environment agreement scheme. Generally, hedges on established organic farms were found to be in a much better condition than on converting OFS farms, but although more hedge *maintenance* work was undertaken on established organic farms, more hedge *planting* was carried out on OFS farms.

While arable cropping is common in those areas of Wales with appropriate soils and climate, farming in the hills and uplands is predominantly pastoral. In such grass-dominanted landscapes the introduction of pesticide-free arable cultivation would increase biodiversity providing, *inter alia*, habitat for arable weed plants and seed eating birds. Crop rotation and mixed farming are two of the key methods for delivering potential benefits for wildlife (Soil Asociation, 2004), particularly in upland areas such as those of Wales. However the environmental monitoring found little evidence that mixed farming is being widely adopted by OFS farms in Wales. By 2004, only 31% of farms surveyed had an arable enterprise, and this proportion had changed little since 2002. Overall, established organic farms had a much greater uptake of mixed farming, with 80% having an arable enterprise. There were signs that even on these farms arable cropping was being reduced. Market forces were cited as the principle reason.

Where arable cropping was introduced, the results were positive for biodiversity. One dairy and sheep farm surveyed introduced both barley and oat crops, and these cropped fields were found to have a diverse flora. In a species survey undertaken on the oat field, a one metre quadrat was found to contain 25 species including corn spurrey (*Spergula arvensis*), sun spurge (*Euphorbia helioscopia*), charlock (*Sinapis arvensis*), scentless mayweed (*Tripleurospermum inodorum*), field woundwort (*Stachys arvensis*) and prickly sowthistle (*Sonchus asper*).

Established organic farms were found to be more diverse than converting OFS farms. Established organic farms tended to have a greater percentage of the farm under arable crops and a lower proportion of improved grassland. Established organic farmers were more likely to use composting systems and to have horticultural enterprises than converting farmers.

All the OFS farms in the environmental monitoring survey contained at least one BAP habitat. Farms with another Agri-environment agreement tended to have more BAP habitats than those without. In total, 93 BAP habitats were identified on the 30 OFS farms. On average, established organic farms were found to have a greater diversity of habitats than converting farms, and this was reflected in higher average Shannon-Wiener diversity indices. Between 2002 and 2004, the most common habitat change found on converting farms was from arable to improved grassland and *vice versa,* which reflected the introduction of rotational

[1] Although the OFS is an Agri-environment scheme, for the purposes of this paper, this term is limited to habitat based schemes, and refers in Wales mainly to the Tir Gofal and the Environmentally Sensitive Areas schemes.

farming practices. All of the BAP habitats identified in 2002 were still intact in 2004. Three habitat types were assessed for changes in species richness: improved grassland, semi-improved grassland, and arable. In 2004, species richness was higher for improved grassland, marginally higher for semi-improved grassland, and lower for arable. T-test analysis found that the mean difference in species richness in arable land was statistically significant ($P<0.05$). This finding is at variance to the literature, which suggests that organic arable fields tend to have high species diversity (Stolze *et al*, 2000). This project only covered a two-year period, however, and this finding may be linked to higher than average rainfall in 2004.

Socio-economic impacts

In the socio-economic survey, the majority of organic farmers surveyed were beef and sheep farmers. Hill cattle and sheep was the largest main farm type (27%), followed by upland cattle and sheep (18%) and lowland dairy (17%). This distribution is broadly representative of agricultural holdings in Wales.

The average size of holding in the survey was 92 ha, which is larger than the average in Wales (40 ha). The higher proportion of large organic farms in Wales is consistent with an EU trend identified by Padel (2001), who found that across the EU the average size of organic holdings has been larger than for conventional farms since the late 1980s. Larger farms tend to be more extensive units and benefit from the area-based OFS payments. In the postal survey it was found that the largest organic farms were hill sheep (mean 179 ha) and hill cattle and sheep (mean 148 ha) enterprises, followed by lowland dairy (mean 109 ha) and arable enterprises (mean 102 ha).

Where farms enter into an agri-environment scheme that restricts fertiliser and pesticide use and requires stock reduction, there is also an incentive to maximise grant income by combining two schemes. The financial appeal of combining, for example, Tir Gofal with the Organic Farming Scheme, is also increased if there are possibilities for enhanced prices through organic premiums. In the socio-economic survey, a majority of organic farms (69%) were participating in the Organic Farming Scheme and another Agri-environment scheme, most often Tir Gofal. Of these farms, 47% were upland and hill farms: 29% were hill cattle and sheep enterprises and 18% were upland cattle and sheep enterprises. Over a quarter of organic lowland farms also combined OFS with another agri-environment scheme; 17% of the total were lowland cattle and sheep farms and a further 10% were lowland dairy enterprises.

A majority of farms (71%) covered by the survey had embarked on the two-year period of organic conversion in the peak period 1999-2000. In those years, interest in organic conversion was encouraged both by the introduction of the new grants in 1999 and by the availability of high premiums for organic produce in the marketplace. In the livestock sector, organic premiums were particularly attractive compared to the very low prices on the conventional market, which were depressed *inter alia* by the BSE crisis and the loss of European export markets (Colyer, *et al*, 2002). Since 2000, there has been a noticeable reduction in the number of Welsh holdings entering organic conversion; this trend was reflected in the survey population.

Socio-economic monitoring found a wide variety of reasons for farmers converting to organic methods, including environmental, financial, and social motives. More than three-quarters of organic farmers surveyed said that the OFS had been essential or useful, or had contributed to a positive attitude toward organic farming. A majority of farmers indicated that conversion had improved their financial situation, but there was an increasing concern about markets and profits, and some had to sell their produce on the conventional market. Although most farmers in the survey had no regrets about converting to organic farming, just under a quarter said they had regrets and more than a third said they had seriously considered returning to conventional farming. Additional ongoing financial support and improved marketing possibilities were cited as factors most likely to persuade those thinking of leaving to stay in organic farming. Simplification of the procedures, less bureaucracy and concern about the ending of the permitted EU non-organic feed derogation also figured high for many respondents. In the case studies, four main themes emerged. These were: concern over the implications of the reform of the EU's Common Agricultural Policy; concern over the implications of the end of the EU's permitted non-organic feed derogation; the onerous level of paperwork involved in farming organically; and the physical and financial performance of farms under organic management.

Conclusions

Organic farming methods are broadly compatible with actions for BAP habitats and species. This project demonstrates that organic farming delivers greater environmental benefits where land is also subject to habitat-based Agri-environment schemes. The short period of study could detect major impact changes such as those derived from ploughing and re-seeding, but was too short to detect more subtle changes. Positive changes for species composition within plant communities, for example, tend to be gradual, ocurring over a relatively long time. Follow-up surveys in five to ten years could begin to detect these, and provide more robust data sets. The potential wildlife benefits for bird and mammal species and soil invertebrates, and the effects of organic farming on soil, air, and water need also to be included in monitoring programmes.

Socio-economic monitoring indicated a generally positive attitude among organic farmers toward production issues but an increasing concern about marketing and profitability. There is, however, a degree of uncertainty as farmers are confronted by changes to the EU's Common Agricultural Policy and the introduction of the Single Payment Scheme, *etc*. Further studies following implementation of CAP reform, including comparative studies of non-organic farmers, could provide further valuable information on the role of organic farming in rural development.

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THE ORGANIC OLIVE OIL SUPPLY CHAIN IN ITALY AND SPAIN: A SOCIAL NETWORK STUDY

Bernardo De Gennaro and Umberto Medicamento[(*)]

[(*)]Università. degli Studi di Bari, Facoltà di Agraria, via Amendola 165/A, 70126Bari, Italy
mailto:bernardo.degennaro@agr.uniba.it, www.uniba.it

Key Words: organic olive oil supply chain, network, relationships.

Abstract

In recent years, due to the growing supply of organic production, the economic performance and the competitive advantages of the farms have become more dependent on network organizations in the supply chains. This evolution requires methodological approaches able to capture all the variables involved in the value-generating processes. The network dimension of the supply chain has become a key element, and enables us to understand better the competitive performances of firms. The relationships of firms, among intangible assets, are recently considered one of the main sources of profit. The relational capital forms the essence of the value of the firm and it is advantageous on the whole, achieved by occupying a specific position (role) in the network of social relationships, the social network (Costabile, 2001). The goods present in a context are not enough to explain the wealth of a firm or a supply chain or sector, so it is necessary to understand the nature of exchanges and how they work through the network. For these reasons our study compares supply chains of organic olive oil in Italy and in Spain using Social Network Analysis. The data was collected by surveys in two areas: the Sierra de Segura (Andalucia, Spain) and the province of Bari (Puglia, Italy). From the results of our study we can assert that the Sierra de Segura shows a simple network that allows, through a cooperative organization, value to be generated for the farms. On the other hand, in the province of Bari the network organization is quite disperse, denoting a luck of organization that leads to a low level in competitiveness of the whole supply chain. At the same time, firms with a good economic results also have a central position in the network.

Introduction/Problem

The area of olive trees cultivated organically in Italy amounts to 94,425 ha (Biobank, 2004), while in Spain it is not very dififerent at 91,000 ha (MAPYA, 2003). The potential production of Italian organic olive oil is more than 56,000 tons, while for Spain it is about 40,000 tons (Degennaro, 2004). The choice of Spain as a comparison has to do above all with the rapid development experienced in this sector in recent years (Cavazzani *et al*, 2001). The Italian organic olive oil sector is decreasing (from 106,754 ha in 2001 to 94,000 ha now), while in Spain this sector is growing (about 1,800 ha in 1993 and 91,208 in 2003). From the above-mentioned analysis it emerges that the two supply chains examined are very different in their organization. The Sierra de Segura (SdS) is characterized by a deep co-operation spirit, with a simple and not very articulated structure, which makes it possible for the product to reach the consumer after a few steps. Farmers are associated in a few processing co-operatives, which in turn depend on a single co-operative which is concerned with the commercialization of products. Only a small percentage of this production is sold on the Spanish market because of the low domestic demand; most is sold on foreign markets. On these markets it is sold either bottled with its own brand or in bulk, above all for the cosmetics industry. The premium price for Sierra organic olive oil ranges from 30-35% for loose oil to 100% for bottled oil; exports are growing and last year, 63% of organic olive oil from Andalucia exported to Japan came from this region.

The supply chain network of the S.d.S. is compact and rich in relationships. Institutional stakeholders, with some exceptions, effectively spread know-how and competence and interface with the sector. There is good participation, the choices are discussed and the ‘organic feeling’ is shared and felt by almost all the stakeholders. The few co-operatives and, in particular, the only one dealing with commercialization, in fact represent a strong hierarchical element. However, no lobbies can be found that exert a resource-centralizing coercive power, although such a compact network can represent an obstacle to the constitution of different organizational dynamics in the supply. The conformation of the network of the Sierra makes it possible to have a contractual power. Years ago, this was probably unexpected. It reduces the added value of external commercialization firms and guarantees high efficiency of co-operatives, which manage to sell the whole of their production at a remunerative price. Sierra de Segura is compensating, in a few years, for a past as an underdeveloped region, through commercial development running parallel to the social one.

The Province of Bari (P.o.B.) has a fragmented productive sector, as in the agricultural, industrial and commercial phase. Brands are numerous, the product is subdivided into many small units and a few large ones. The most important stakeholders are above all traders, commercial macro-organizations and some co-operative oil mills, which concentrate the supply and large industrial groups and large-scale organized distribution, both of which are extra-regional. Apart from these, there are also firms that have their own brand that have managed to place themselves on the market in a competitive way. The incursion of of bulk oil on bottled is high, the experience of co-operatives is not as dominant as the individual ones and, in the case of associations, does not exclude the simultaneous management of private interests. There is more than one association, of various kinds; the relationships are not always linear, the hierarchies present may not be apparent to all the stakeholders in the supply chain. Among other things, they do not always share experiences and information with each other, or are functional to the growth of the sector, since they sometimes do not favor communication and sharing of interests.

The farmers are more subject to the market. They do not all have a high contractual power. Some deal with organic and conventional production at the same time and do not have a unique business strategy; some count on the brand, on market niches and on high quality (choice that leads to good results in many cases), while others rely on quantity, still others on both. Competition is very high. There are cliques and lobbies, sometimes extensions of lobbies of the conventional sector. The firms reach the market in different ways, and the same thing happens with single producers. The general profit margin is lowered by the greater quantities of organic olive oil sold in bulk, and collected then by a few, often extra-regional, stakeholders dealing with packaging, sale and/or distribution, or further selling of bulk olive oil. Organically cultivated area and the number of operators in this field have decreased in the last three years and many of them, when interviewed, report decreasing profits and lack of trust in the sector, with the exception of some more competitive farmers. The relationship with institutions (although there are some exceptions), associations of farmers and certification institutions is not as intense as in the Sierra de Segura. Vertical – especially downward – distribution of information is difficul,t whereas participation in the decisions and choices is rare– when it iexists at all– and in some cases completely absent. In this scenario, the farms' efficiency in managing their own relational capital is not the same for everyone, and this leads, in the case of low effectiveness, to a marginal position in the network and not always satisfactory economic results.

Methodology

The approach chosen for this study is that of Social Network Analysis (SNA). This method allows a deeper analysis of the supply chain, since it gives the opportunity to understand stakeholders and sizes that are not normally analyzed in this kind of investigation. Actually, in this case it would be more correct to speak about network analysis than of supply chain analysis. What is especially emphasized therefore, are the ties between the stakeholders, personal as well as commercial ties: in a word, relational. Indeed, what becomes more and more relevant in defining value is the role of intangible assets and of a category of resources that underlies them: enterprise relationships, to the extent that relational resources have been recently regarded as one of the major sources of wealth, especially relationships with supply. Therefore, relational capital constitutes the essence of enterprise value. Economic performances of individuals and of businesses are remarkably influenced by their social performances and by the context in which their economic activity is 'immersed'. The concept of social capital has been defined as the whole of advantages deriving from holding a specific position in a network of social relationships; from the business point of view, it represents the current and potential status of the relationships with external stakeholders, expressing its value in aiming at competition (Costabile, 2001). Material goods present in a context are not enough, therefore, to explain the richness of a business (or of a sector, or a supply chain); it is necessary also to understand the nature and functioning of exchanges that take place in the network of relationships.

Before passing to the results of the study, it will be appropriate to describe the tool used for investigation. SNA consists of an analysis of the relationships existing between elements of a whole, called nodes or stakeholders. The choice of the nature of the relationship is fundamental, since it is the critical element that, *a priori*, determines the exclusion or inclusion of certain stakeholders. Furthermore, this method is interesting for the capacity of being known by intuition: the structure of ties indeed helps in explaining and foreseeing the behaviour of the stakeholders (Piselli, 2001). Moreover, network analysis embodies two relevant features of social action: every stakeholder is part of a ‘system’ that influences its actions and decisions, and within the ‘system’ there are different roles and positions as regards power, influence, information transmission, etc. Substantially, the method is based on the representation of the network in two different modes: matrix and graphic. In the former, relations are outlined using binary values – that is, 1 if the relationship exists, and 0 if not. This mode is functional for quantitative and qualitative determinations in the shape of sociometric and descriptive indexes and sizes (Guidicini, 1998). These data, obtained through matrix calculations, provide information about the density of the relationship, their distribution, the presence of under-networks, of groups (*cliques*), and isolated individuals.

It also is possible to study how the stakeholders are connected with the resources, thereby understanding in what ways and to what extent they control them, in what ways and to what extent they take advantage of them, and how effective the network is in allocating resources and exploiting them. The graphic elaboration of the network, which is developed as a consequence of that of the matrix, results in the so-called sociograms, in which the stakeholders are represented as dots and the relationships are lines – or arrows if the relationship is directional. The study of sociograms is called ‘theory of graphs’ and provides an immediate representation of the network and a direct understanding of its structure and organization (Salvini, 2003). For the construction of the network it is necessary to make a list, as complete as possible, of the nodes, and detect the presence of relationships among them. In this phase of the project a twofold approach to the choice of stakeholders has been chosen: reputational as well as positional (Scott, 1991). Thus, ‘informed people’ have been interviewed – that is, a group of individuals who know the network very well. The list obtained has been used for preparing a questionnaire, which then is presented to the stakeholders. In the questionnaire, for each single node the presence or absence of a relationship with other stakeholders is reported. For both options, it also was possible to qualify the relationship as commercial, communicative, mediation, or patrimonial. The data obtained in this way have been reported in two spreadsheets, one for each supply chain, and ordered, for each one, in a square matrix, called adjacency matrix, having the stakeholders as indexes. As for the mathematical elaboration of data, Ucinet V.6 was used, while NetDraw was used for the graphic representation.

Results and brief discussion

The mean (effective ties divided by potential ties) of the two networks is respectively 0.735 for the Sierra and 0.03 for the Province of Bari; the standard deviation is 0.44 in the first case, 0.16 in the second. The mean highlights a high difference in relational effectiveness in favour of the Sierra, while the standard deviation indicates the variability of distribution of ties, and, therefore, a higher uniformity for the Sierra and a higher variability for the province of Bari. The difference observed between the values of these indexes is largely attributable to the different numerousness and extent of the two networks; this is why, for the following comparisons, reference is made to absolute (or ‘normalized’ values) such as Network Centralization Index (NCI). The investigation of centrality (Freeman’s degree centrality measure) provides, first of all, the NCI, which measures in % the similarity with a highly centralized star-shaped network. For the province of Bari this value is 61.64%, while it amounts to 3.71% in the Sierra. The same index, expressed as in and out degree, measures 28.9% and 19.08% in one case and 37.1% and 35% in the other, confirming the data, though highlighting a more marked tendency of the Sierra network towards a ‘sink’ behaviour of its stakeholders rather than ‘source’ in the management of the information flows. Compared to the values of the Freeman’s betweenness centrality, in the Sierra de Segura almost half the stakeholders exceed the average value (which, normalized for the network, amounts to 2.652). In the Province of Bari, slightly more than 10% of the stakeholders exceeds the mean value of this index (which, normalized, amounts to 0.636). It is important, at this point, to highlight how in this small group, besides large-scale traders, industrial groups, commercial macro-organizations, also the stakeholders who have a more important ‘political’ value – firms have managed to go on the market on their own and have obtained very good commercial results.

Besides the number of farms involved and their diversification degree (from a legal point of view), the two networks differ in the quantity and quality of actors involved, pertaining to spheres other than the entrepreneurial one. In this case also, the network of the Sierra is much simpler. Few institutional actors can be identified, among them some with a very active role in local development; three certification institutions, one of which is at the margins of the network and another is a central actor of the Sierra; some associations of various kinds; and two associations, one of which (ASAJA – Associaciòn Agraria Jòvenes Agricultores) is against the organic sector but is very active and has an ambiguous position. The network can, therefore, be divided into two political factions: one depending on the network of the most important certification institution and the other on the ASAJA. Some stakeholders have, then, an intermediate role, in a different way.

The network of the Province of Bari is much more complex. Some big stakeholders can be identified that mainly deal with conventional production and are in close contact with great industrial and distribution groups and associations, which then interface, directly or indirectly, with the world of organic or with the Denomination of Origin. These stakeholders thus play a role that goes beyond the centralization of supply and seems to have much influence on the local market. The important certification institutions are substantially three, two in the territory, and only one of these with a network including most of the productive context and large-scale distribution actors. The institutional stakeholders are definitely less relevant than the equivalent ones in the Sierra. Lastly, there are traders, who are much less numerous than firms, and whose behaviour has been already described. Thanks to the cluster analysis, the network can be divided into four factions, including four different under-networks, depending above all on the relations between the commercial macro-organizations and the traders. One in particular involves most co-operative oil mills, in which a large quantity of product is concentrated. The four factions are not completely independent from each other, but they partly overlap. In this context, the farms that have their own brand work in a different way and, relying on quality and on the differentiation of the product and on the quality of their relational capital, keep on increasing the income deriving from organic olive oil sales and invest more and more in the sector. These farms indeed have a very high degree of centrality and their networks include stakeholders in the production sphere as well as the commercial sphere, included in more than two factions at the same time.

Conclusions

The results, in terms of network extent, centrality analysis and cluster analysis, suggest two levels of conclusions. The first is a systemic conclusion, which highlights how a more equal distribution of informative fluxes between actors such as in Sierra de Segura's network (Andalucia, Spain), favours the establishment of social mechanisms that, through the creation of a territorial identity, assisted by the action of local authorities, lead to the aggregation of stakeholders of the phase of production, who can thus elaborate common commercial strategies that increase their contractual power and the profitability of their work and make them the promoters of sector policies, also in agreement with central institutions and the sector's lobbies. In contrast, more dispersed networks with a higher rate of 'inequality' in the distribution of ties, like Province of Bari's network (Puglia, Italy) do not help such aggregation processes, but favour the establishment of lobbies and speculations, which decrease the level of economic efficiency of the system and of the single firms.

The second kind of considerations is more particularistic, and highlights how in a network such as the one of the Province of Bari, the management of relationships takes on a much more decisive role in terms of competition than happens in the Sierra, where, in contrast, the structure of the network itself hinders the interruption of informative fluxes and thwarts the competitive efforts aimed at establishing power groups, non-transparent commercial agreements and lobbies. This phenomenon is so apparent that firms with growing economic results are those that have a higher degree of centrality. The SNA, therefore, allows the description and schematic representation of the relationships among the actors of supply chains, systems and networks. The different conformations that the relationship structure can give to these production organizations influences the efficiency of the system but also that of the firm, in a reciprocal relationship. The firm's relationship management capacity is thus decisive for obtaining satisfactory short-term economic results, but above all, satisfactory long-term ones.

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ASSESSING PRICE FORECASTING MODELS FOR ORGANIC COMMODITIES

Timothy Park[1], Tatiana Gubanova, Luanne Lohr, Cesar Escalante

(1) Department of Agricultural and Applied Economics, University of Georgia, Athens, GA 30602-7509, U.S.A., e-mail: TPark@agecon.uga.edu, Tel: +1-706-542-0731

Key words: organic price forecasts, seasonal auto-regression, price risk, assessing forecast performance

Abstract

This project develops price forecasting models to guide organic commodity marketing decisions. Forecasting models for organic commodity prices at the farm level are specified and tested using a comprehensive national farm price series data set collected for organic commodities in the United States. A framework for testing the predictive ability of competing models using conditional predictive ability is developed. Forecast performance is evaluated using the root mean squared error (RMSE) and mean absolute error (MAE) for point forecast comparison along with tests for market timing ability of the forecasting model.

Introduction/Problem

Retail sales in the U.S. organic industry have grown on average 20 percent annually for the last twelve years. According to the Economic Research Service (ERS) at the U.S. Department of Agriculture (USDA), the amount of organic cropland increased by 53% to exceed 1.3 million acres in 2001, and the number of organic farmers increased by 38%, reaching 6,949 operations. In national survey data collected by the Organic Farming Research Foundation (OFRF), the inability to find the best price was identified as the third most significant marketing barrier inhibiting adoption of organic agriculture. Nearly 22% of OFRF survey respondents cited prices, market quotes, or determining a fair price as their top marketing information priority. Price forecasting and historical trend analysis are needed to provide a basis for risk-minimizing investment decisions.

Research on information needs for the organic sector suggests unmet demand for price information. In a national survey of organic farmers, 69% identified “inability to find best price” as a moderate to serious constraint. In 2002, 12% of organic farmers selected “organic price reporting services” from a list of 18 factors as having the greatest positive effect on economic sustainability, ranking it 3.51 on a scale where 4 was “most useful.” Pricing rated as a major concern among a national sample of retailers, manufacturers, and distributors surveyed in 1998, with 49% of respondents citing the need to follow current price trends as the top reason for using price information.

Price information and analysis for the organic sector remain sparse. Lack of price information and planning tools based on price information are serious impediments to industry development and effective government regulation and research according to representatives of both the Agricultural Marketing Service (AMS) and the Economic Research Service. Currently, there is no effort being made to analyze price risk for organic commodities. Developing accessible resource materials for farmers and agribusiness professionals to systematically compare the price risk of crop planning and marketing options will greatly improve the chance of successful marketing.

Methodology

The organic price series used in this report are the only time series of farm and wholesale organic price information available in the United States. A private company, Hotline, offers a weekly organic price information service, the OBN Fax Commodity Service, with national average high and low prices for more than 100 horticultural and grain commodities at the wholesale and farm levels. Data are gathered by phone from brokers and farmers throughout the United States. Weekly prices are averaged for all locations from which data are collected to generate national high and low prices. Conventional data are not assessed in the report, but the percentage change in organic prices from the previous weeks is calculated and included. The historical organic price series allow for a consistent analysis of market price trends and marketing margins and has been used by government agencies such as the USDA-AMS and the commercial sector. Farmgate prices for nine organic produce commodities were selected and used in the forecasting model including apples (red delicious), avocados, green cabbage, ruby grapefruit, lemons, romaine lettuce, yellow onions, red potatoes, and tomatoes. Weekly price observations were reformatted into ten-day groups in order to allow for monthly seasonality adjustment.

We select two forecasting methods and evaluate the performance of these models for the set of organic commodities. The first method is the Winters-Holt (WH) exponential smoothing method using updating equations to fit parameters for the model, while a second method fits a seasonal autoregressive (AR) model using appropriate choices of lagged values of the price series. For these methods, missing data are replaced based on a linear spline approximation and sample averages. We analyze weekly observations of farmgate prices for a set of organic produce items to obtain forecasting errors for the case of 1, 3, 6, and 12-month leads. The same commodity-specific information value matrix is applied for all methods and forecasting horizons. All methods are evaluated using the out-of-sample testing principle in both rolling and expanding data windows.

Our framework for testing the predictive ability of the competing models is based on tests for conditional expectations of forecasts and forecast errors rather than the unconditional expectations that are the focus of existing literature. Giacomini and White (2003) suggest that conditional predictive ability testing offers a number of key advantages, and outline the statistical foundations of the method. The approach focuses on inference about conditional expectations of forecasts as opposed to using unconditional expectations. The conditional testing framework features a comprehensive treatment of forecasts as it considers the complete forecasting method, not simply the forecasting model as the object to compare while explicitly accounting for the effects of estimation uncertainty, the estimation procedure, and the choice of estimation window.

The framework for testing the predictive ability of the competing models utilizes conditional expectations of forecasts and forecast errors rather than the unconditional expectations that are the focus of existing literature. We compare the forecasting performance of two models ft(1) and gt(2) for the conditional mean of the organic price series Yt+1 using a squared error loss function. A statistical test of equal forecasting ability is conditioned on the information set available at time t

Results and Brief Discussion

Following procedures defined by Fildes and Ord (2002) for developing valid forecasting competitions between alternative models, the price series were each split into a training subset, that is, the data available for the estimation of model parameters, and a holdout subset for which out-of-sample forecasting was performed. The size of the holdout subset was one complete year of observations (36) for each commodity, while the sizes of training datasets varied depending on the starting date. Missing data were interpolated with linear splines, using the neighboring observed points.

The conditional predictive ability tests were applied to evaluate the accuracy of the exponential smoothing and the seasonal autoregressive model based on a squared error loss function. A Wald test statistic rejects the null hypothesis of equal conditional predictive ability for a one-step predictive horizon when comparing the seasonal autoregressive and exponential smoothing models. The conditional predictive ability of the seasonal autoregressive model dominates the exponential smoothing model for short time horizons. However, for longer forecast horizons (including 3 and 6 month leads) the exponential smoothing model appears to achieve better performance. Initial results presented by Giacomini and White suggest that tests for conditional predictive ability are less powerful in predicting price variables and perform better for economic variables such as industrial production, personal income and employment figures. The results presented for forecasts of organic prices tends to reinforce this finding.

Forecast quality was also evaluated using the root mean squared error (RMSE) and mean absolute error (MAE) measures for point forecast comparison along with the Henriksson-Merton (HM) test for direction-of-change comparison. Lopez (2001) commented that statistical loss functions such as the mean squared error criterion are commonly used since specific economic loss functions are rarely observable. A primary shortcoming to the RMSE measure that should be recognized is that the symmetric nature of the loss function puts equal penalty weights on forecast deviations above and below the true value, but the RMSE forecast evaluation criterion is standard in evaluating forecasts and is used here as a benchmark. The results are presented in Table 1. The precision of the seasonal autoregressive forecasting model is notably better in delivering both smaller magnitudes of forecast errors and more accurate predictors for change in the direction of price movements. RMSE and MAE measures of the seasonal autoregressive forecasts are smaller for all commodities than those based on the exponential smoothing model, sometimes by a factor of two or three.

Table 1. Forecast Quality Assessment.

	Exponential Smoothing			Seasonal Autoregressio		
Commodity	**RMSE**	**MAE**	**HM**	**RMSE**	**MAE**	
Apples	0.19	0.15	**1.23	0.11	0.09	
Avocados	0.55	0.49	0.78	0.38	0.28	
Cabbage	0.17	0.15	0.96	0.08	0.07	*
Grapefruit	0.08	0.06	0.98	0.06	0.04	**
Lemons	0.49	0.39	1.00	0.19	0.12	*
Lettuce	0.62	0.57	1.07	0.16	0.12	*
Onions	0.42	0.37	0.89	0.14	0.13	
Potatoes	0.09	0.07	***1.22	0.07	0.06	*
Tomatoes	0.50	0.46	**1.17	0.12	0.09	

*** — 99% significance level,
** — 95% significance level,
* — 90% significance level.

The Henriksson-Merton test for market timing ability is based on the conditional probabilities of making correct forecasts. A nonparametric test that a market timing forecast has economic value can be developed and the HM test is readily computed in a regression framework. In the context of decision-based forecasting, the test is useful in determining whether the price forecast has value as a predictor for the sign of the actual price change in the next period. The null hypothesis of the Henriksson-Merton test is that the value of the criterion is 1 and the forecast is of no value. The alternative hypothesis is that the criterion is greater than 1. Values of the HM criterion were found to be significantly greater than 1 for most commodities based on forecast values from the seasonal autoregressive model. This indicates that price forecast contains information that farmers and organic marketing agents can use in assessing whether the actual price will be higher or lower in the next period. This information can be useful in adjusting short-term sales or marketing allocations across the supply chain to wholesalers or retailers. In contrast, values of the HM criterion from the exponential smoothing model were often found insignificant. The reason for mostly poor fits with the exponential smoothing model is apparently driven by the presence of an autoregressive rather than a moving-average component in the data-generating processes and problems with the automatic choice of smoothing weights.

Price forecasts can be used to assess the risk-reducing revenue potential for adding a new crop to an operation. When compared across several crops, price trends, statistical returns, and price forecasts enable the farmer to choose an optimal portfolio of crops. The farmer's goals will determine whether to maximize minimum expected returns by planting crops whose prices move in opposite directions over time, or to maximize the chance of large returns with a greater risk of losses by selecting a crop mix that has high upside price variance.

Conclusions

The efficiency of production decisions by farmers, along with marketing initiative by wholesalers and retailers that specialize in organic products or introduce organic items to their product lines, depends critically on their expectation of accurate projections of price trends for organic commodities. For the emerging organic produce market, accurate price forecasts are not broadly available. This leads to a high degree of uncertainty about future revenues and increases the occurrences of sub-optimal output/pricing decisions by all parties involved. The study proposes a forecasting model and set of evaluation tools for organic industry marketing professionals in assessing forecast performance.

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Measuring Agriculture Sustainability: An Essay for a more Suitable Index

Emile N. Houngbo
Research and Action Group for Rural Self-Help (GRAAP-Benin), 05 BP 774 Cotonou (Republic of Benin), Tel. (229) 943976, E-Mail: enomh2@yahoo.fr

Key words: Sustainable agriculture, Function differentiation, Global factor efficiency.

Abstract

Sustainability of agriculture has been of growing concern during recent years, because of the increasing awareness of the ecological effects of agricultural activity. In fact, while agriculture constitutes a necessity for life, it is at the same time the main activity that implies human interference with nature, especially with land. Because of the past environmental impact of this activity, worldwide action is to preach another form of agriculture that could satisfy the increasing human needs of the present generations without compromising the satisfaction of that of the future generations. It follows that sustainability is a new and complex notion. So, there is limited and debatable guidance in literature on what suitable index can help to measure it. That is why this paper is proposing to the scientific community appreciation of an index called "Global factor efficiency'' (G) which takes into account some of the weak points that characterized some earlier indexes.

Introduction

This paper presents consecutively the actual main indexes available and introduces the Global factor efficiency (G) proposed here. With a concrete example, G is compared to TFP (Total Factor Productivity), which has been the most common index up until now.

1- Main indexes currently used for quantitative measurement of sustainability

Although current debates focus on finding a simple and universally accepted index, we can, for the moment, only rely on some indexes which can be used to obtain approximate measures of sustainability, always bearing in mind that they are prone to number of weaknesses. The main indexes in use are: the Total Factor Productivity (TFP) of Lynam & Herdt (1989), the Total Factor Productivity revisited (TFPR) of Samuelson and Nordhaus (1985), the Trends in *per capita* production of Monteith (n.a.) and the Intertemporal Total Factor Productivity of Denny and Fuss (1983).

a) The Total Factor Productivity (TFP)

Lynam and Herdt (1989) suggest that sustainability can be measured in terms of trends in Total Factor Productivity (TFP). Thus: **TFP = O/I**, where,

O = total value of all outputs

I = total value of all inputs

A differentiation with respect to time gives the following:

(dTFP/dt)/TFP = (dO/dt)/O – (dI/dt)/I, where (dTFP/dt)/TFP is the percentage change in TFP with a small increment in time. Then, the conditions for a farming system sustainability is:

TFP = O/I > 1

(dTFP/dt)/TFP = (dO/dt)/O – (dI/dt)/I = 0 ⇔ (dO/dt)/O = (dI/dt)/I

As one could imagine, a major shortcoming identified by critics of the index is its failure to take into account changes in the quality of the agricultural resource base such as organic matter and nutrients accumulated in the soil.

b) The TFP Revisited

According to Samuelson and Nordhaus, the TFP approach could be made more useful by linking it to a production function. To correct these imperfections, they suggest another formula for TFP, which is: **TFP = Q – SL(L) – SK(K),** where,

Q = Output growth rate (in percentage per year)

L = Labor input growth rate (in percentage per year)

K = Capital input growth rate (in percentage per year)

SL = (Constant) Labor factor share, and

SK = (Constant) Capital factor share.

As defined, TFP is a residue after accounting for the separate effects of increased input levels on output. Hence, the sustainability of a farming system would be effective when the TFP is always positive. Except for the fact that this index does not consider changes in the quality of the agricultural resource base, one wonders whether the relationship between the TFP and the production is always linear.

c) The trends in per capita production

Monteith (n.a.) considers that to be sustainable, a farming system should maintain *per capita* benefit levels from year to year (and in principle from generation to generation) and should not deteriorate as a consequence of being used. A system is sustainable over a defined period if outputs do not decrease when inputs are not increased. Monteith assumes that with input levels held constant, per capita production (C) is a function of yield (Y), harvested area (A) and population density (P). Thus: $\mathbf{C = Y(A/P)}$.

By differentiation with respect to time, percentage changes become additive in the following manner: $\mathbf{(dC/dt)/C = (dY/dt)/Y + (dA/dt)/A - (dP/dt)/P}$, where (dC/dt)/C is the percentage change in *per capita* production with a small increment in time.

In other words, the percentage increase in *per capita* production is the sum of the percentage increase in harvested area and the percentage increase in population density. (dC/dt)/C positive over time indicates the sustainability of the system. This other index is also criticized as it provides little information on changes in the agricultural resource base, the root cause of non-sustainability.

d) The Intertemporal TFP

Based on the Intertemporal TFP measure of Denny and Fuss (1983), Ehui and Spencer (1994) proposed a generalized model measurement of TFP. This model includes the unpriced contributions from natural resources and their unpriced production flows.

It is assumed that the agricultural production process of cropping system in period t can be represented by the dual variable cost function: $\mathbf{G_{\mathit{it}} = G(Y_{\mathit{it}}, Z_{\mathit{it}}, W_{\mathit{it}}, B_{\mathit{it}}, T_{\mathit{t}}, D_{\mathit{i}})}$,

where G_{it} is the cost of production; W_{it}, a vector of input prices; $Y_{it,}$ crop output; Z_{it}, the change in resource stock levels; B_{it}, the resource stock abundance level; and T_t and D_i are indicators of intertemporal and interspatial efficiency difference. Derivation of those two TFP indices depends critically on the proper specification of the total cost function C_{it}, which in turn depends on the nature of Z_{it}, i.e., whether the change in resource stock is positive or negative.

Even though this model of Ehui and Spencer takes into account the changes in resource stock level in the soil, it remains necessary that the income generated by the production activity is able to cover the social needs of the producer. If not, the latter will be obliged to depend on other sources of revenue, with the risk that he finally moves from agriculture to another activity. Moreover, the model is rather difficult and hence not user-friendly.

2 -A new index for sustainability measurement: The Global Factor Efficiency (G)

The index proposed here is an improvement of the original one suggested by Lynam and Herdt (1989), the TFP. It takes into account not only the main objections raised regarding the above indexes, but it also considers the social needs of the producer (farmer) to survive. Likewise, changes in the quality of the agricultural resource base are included. Obviously, soil organic matter and nutrients are sustainability factors; for they can, through their level and its variation, indicate whether the farming system practiced by the farmer is degrading or not.

Over time, from one harvest to another, the sustainability would be ensured first by the increase or at least the constancy in soil organic matter and nutrient level, and secondly by the soil capacity to transfer these nutrients to the crops. In fact, the yields indirectly reflect the quantity of nutrients made available by the soil for the crops. The Global Factor Efficiency (G) is thus a ratio between the generalized farming income and the global poverty threshold. It constitutes an integration of the changes in nutrients and organic matter/carbon into Lyman and Herdt’s TFP. Moreover, the agricultural income efficiency is supposedly linked to its capacity to cover at least the poverty threshold. Thus:

(1) $\mathbf{G = [(0 + f) - (I + i)]/\alpha.P}$ ⇔ Generalized farming income/Global poverty threshold;

where,

O = Total value of all outputs

I = Total value of all inputs external to the considered farming system

f = Total value of the main nutrients and organic matter contained in the soil after harvest

α = Mean poverty threshold (at household, village, region or nation level). This parameter includes all the social needs (health, food, education, clothes, …)

P = Number of persons contributing to the production process.

i = Total value of the main nutrients and organic matter contained in the soil at the beginning of a season; $i_n = f_{n-1}$.

These fertilizing elements (nutrients and organic matter) generally consist of nitrogen fixation by the legumes, residues of the chemical fertilizers formerly used, leaves and stems rotting, animal breeding refuse and extraction of mineral nutrients from soil depth by trees roots. The main nutrients to be considered in this formula are Nitrogen (NH_4^+ and NO_3^-), Potassium (K^+) and Phosphorus (HPO_4^{2-} and $H_2PO_4^-$). Both the main nutrients and the organic matter/carbon contained in the soil can be quantified by specific techniques described for example in Pauwels *et al*. (1992). Thus, the mineral nutrients value could be obtained from the local price of the chemical fertilizers and that of organic matter/carbon from its approximate local price to be determined, objectively.

Assuming that α and P are constant for a short period, a differentiation of the equation (1) above with respect to time gives the following: $\mathbf{dG/dt = (dO/dt + df/dt)/\alpha P - (dI/dt + di/dt)/\alpha P}$.

In order for the system to be sustainable, the factor time needs consideration:

$\mathbf{G>1 \Leftrightarrow G - 1 > 0}$ and

$$\mathbf{(dG/dt)/G = 0 \Leftrightarrow [(dO/dt + df/dt) - (dI/dt + di/dt)]/[(O + f) - (I + i)] = 0}$$

$$\mathbf{\Leftrightarrow (dO/dt + df/dt) - (dI/dt + di/dt) = 0 \Leftrightarrow (dO/dt + df/dt) = (dI/dt + di/dt)}$$

Then, a farming system can be qualified as sustainable if these conditions are satisfied during a period of several years; and at least three years in our case. The quantities of available soil N, P and K per hectare must be computed, using a standard bulk density level of 1.21 $g.cm^{-3}$ proposed by Lal and Ghuman (1989). In fact, if G is higher than one, we can be sure that the production process does not involve social charges (health, education, food…) that could not be covered by the generated income. The farming system adopted does not cause an (financially) insupportable damage on the farmer's health. G also indicates whether there is an approximate social equity which will allow the farmer to support himself. In comparison to the TFP of Lynam and Herdt, the G proposed here is quite different. Its usefulness is highlighted by the example contained in the table below where the values are in thousands of dollars (see Table 1). .

However, a clear difference between TFP and G can be observed. A system which is sustainable when considering the TFP index may become unsustainable when considering the G index. In this case, the productivity is obtained at the expense of the soil quality degradation ($f < i$) or is insufficient to cover the minimum social needs of the farmers [$(O + f - I - i) < \alpha P$].

Conclusion

The index G represents, according to our view, a consistent index to measure sustainability. It can help to estimate both economic efficiency and the capacity for productive resources conservation of a given farming system over time. It may lastly help to evaluate separately the impact of agricultural activities on the soil structure through organic matter and nutrient quantification.

We expect the proposed index to be tested, criticized or improved by the scientific community, consequently resulting in its improvement.

Table 1: Comparison of different indices

Indexes	Year 1						Year 2						Year 3						Deduction
	O	f	I	i	α	P	O	f	I	i	α	P	O	f	I	i	α	P	
	5.4	0.12	3	0.24	1.2	3	6.36	0.048	3.06	0.12	1.2	3	6.8	0.012	3.24	0.048	1.2	3	
TFP	5.4/3 = 1.80 > 1						6.36/3.06 = 2.08> 1						6.8/3.24 = 2.10 > 1						The system is sustainable because TFP > 1 and (dTFP/dt)/TFP > 0
(dTFP/dt)/TFP	-						(2.08 – 1.80)/1.80 = 15.5% > 0						(2.10 – 2.08)/2.08 = 1.0% > 0						
G	(5.52 – 3.24)/3.6 = 0.63 < 1						(6.648 – 3.18)/3.6 = 0.96 < 1						(6.812 – 3.288)/3.6 = 0.98 < 1						The system is not sustainable because G < 1
(dG/dt)/G	-						(0.96 – 0.63)/0.63 = 52.4% > 0						(0.98 – 0.96)/0.96 = 2.1% > 0						

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NUTRIENT REQUIREMENTS, FERTILIZING PRACTICES USED AND NUTRITIONAL STATUS OF ORGANIC AND CONVENTIONAL OLIVE ORCHARDS IN THE AREA OF CRETE

Loupassaki M.H., Digalaki N.B., Psarras G. and Androulakis I.I.

N.AG.RE.F., Institute for Olive Tree and Subtropical Plants, Chania Crete Greece

Key Words: Leaf analysis, Soil pH, Soil Acidification, Nutritional Survey

Abstract

The nutritional requirements of the olive were investigated in a long term fertiliser experiment using 'Mastoides' olive oil cv. in the area of Chania, Crete. On the other hand, a Nutritional Survey (NS) on both organically and conventionally fertilised olive orchards was carried out. Leaf samples were analysed for N, P, K, Ca, Mg, B, Fe, Zn and Mn content. Soil samples were analyzed for essential soil properties.

Optimum leaf nutrient levels were determined using the results of the fertiliser experiment. Alternatively, similar values for leaf nutrients were calculated based on the results of the NS carried out.

As seen from the fertiliser experiment the yearly requirements of the cultivar approximate 1 kg of N, and 0,6 kg K_2O per tree, while there was no response to P fertilisers. The addition of manure had only a small effect on the yield or the content of NPK in the leaves and caused a small but consistent increase of micronutrients in the leaves. Optimum content of NPK in the leaves was determined. Significant soil acidification occurred in the treatments comprising the higher rates of ammonium sulphate.

In the organic olive groves studied, the nutrition for all but N nutrients was optimum while there were no side effects on soil properties.

Introduction / Problem

In the recent decades the need for more food production has led to the increased use of chemical fertilizers in many crops and olive has been no exception. However, the extended use of fertilizers endangers not only environment at large and soil fertility in particular, but food safety as well. In the literature, reports on soil acidification or contamination with undesirable elements (e.g. Cd), nutrient antagonisms and / or imbalances etc. are available. Therefore, environmental friendly and safe fertilization techniques have to be planned and implemented. Crop requirements need to be determined as accurately as possible and the effect of the materials used to meet these requirements on the crop and soil fertility carefully monitored. In Greece, nutrient requirements for olive trees have appeared sporadically (Androulakis et al., 1976; Stathakopoulos, 1976; Gavalas, 1978; Pontikis, 1981; Sfakiotakis, 1993). In general, olive tree has been shown to respond to N-fertilizing by increasing yield, K deficiency has been reported in several olive growing areas in Greece while, under Greek conditions, response to P application is rather rare depending on soil characteristics. For the implementation of the "best agricultural practices" however, the type and the application rate of the fertilizing materials used should be adjusted to crop requirements and soil characteristics.

In the present work, the results of a fertilizer experiment with and without farmyard manure as well as of a nutritional survey on organic and traditional olive orchards are described.

Methodology

All factorial combinations of three levels of N as ammonium sulphate, two levels of phosphorus and two levels of potassium with and without farmyard manure were used in a long term fertilizer experiment established on an 80 years old olive orchard, cv. 'Mastoides', in the area of Chania, Crete. All fertilizer treatments were applied during mid-January, after harvest. The effect of the 24 different treatments on the nutritional status of the trees and yields were recorded.

On the other hand, in order to compare results and further define optimum fertilizing practices for individual orchards, a Nutritional Survey (NS) on both organic and conventionally fertilized olive orchards was carried out. Leaf samples were taken from selected orchards between October and November for a period of 2 years. The total number of sampled orchards was 136 (83 during 1997 and 53 during 1998). Leaf samples were analysed for N, P, K, Ca, Mg, B, Fe, Zn and Mn (Androulakis, 1987). Soil samples under the tree canopy and in-between tree rows were taken from all orchards and analysed in order to determine essential soil properties like pH, electrical conductivity (EC), soil texture and total $CaCO_3$. Apart from leaf and soil sampling, additional information was collected through farmer interviews and field inspection. Special information sheets were filled out, providing data on orchard layout, tree status (planting density, cultivar, age, canopy dimensions, visual deficiency symptoms, and fruit yield for the last two years) and the agricultural practices used (type, frequency and method of fertilizer application, irrigation method, etc.). The sampled orchards were categorised according to yield, soil properties, nutritional status and the fertilising practices used, and specific fertilizing guidelines were issued for each one of them.

Results and brief discussion

Nutrient requirements-long term experiment: The results of the long term experiment on 'Mastoides' olive cv. with a yield capacity of 60-80 Kg of fruit per year (see Table 1) showed the yearly requirements of the cultivar to approximate 1kg of N, 0,6 kg of K_2O, while trees did not respond to P fertilisers. The addition of manure had but a slight effect on yield or the content of NPK in the leaves, however it should be mentioned a small (data not shown) but consistent increase of micronutrients in the leaves of the trees treated with manure. These results are in line with previous findings in Greece and elsewhere. Optimum content of NPK in the leaves was found to be 1.9, 0.1 and 0.6% respectively. K contents appear to be somewhat lower than those usually reported but the corresponding yields are considered satisfactory. Significant soil acidification occurred in the treatments comprising the higher rates of ammonium sulphate.

Table 1. Average yield of fruit in Kg/year and the content of NPK in the leaves of the 'Mastoides' olive cv. found in a long term fertiliser experiment in the area of Crete

Level of Nutrient Factor	Yield/tree in Kg	Content of NPK (% d.w.) in the leaves		
		N	P	K
N_0	61.58	1.749	0.109	0.547
N_1	65.68	1.797	0.105	0.539
N_2	68.05	1.812	0.106	0.53
P_0	64.26		0.107	
P_1	65.9		0.106	
K_0	62.34			0.501
K_1	67.82			0.576
M_0	64.57	1.775	0.106	0.537
M_1	65.60	1.797	0.107	0.54

Table 2. Suggested concentration ranges for different nutrients, for the interpretation of leaf analysis data in olive orchards of Chania Crete (sampling date October-November).

Nutrient	RANGE				
	Deficiency	Low	Optimum	High	Surplus
% leaf dry weight					
N	<1.20	1.2-1.6	1.6-1.8	1.8-2.2	>2.2
P	<0.07	0.07-0.10	0.10-0.13	0.13-0.15	>0.15
K	<0.50	0.5-0.8	0.8-1.1	1.1-1.3	>1.3
Ca	<0.50	0.5-1.0	1.0-2.5	>2.5	
Mg	<0.07	0.07-0.10	0.10-0.30	>0.30	
ppm ,leaf dry weight					
B	<15	15-20	20-50	50-150	>150
Fe		20-50	50-150	150-500	
Zn		5-10	10-30	>30	
Mn	<10	10-20	20-60	60-150	>150

Nutritional Survey: Based on the results of leaf analysis and the interpretation of the yield data, the values for deficiency, optimum and excess range for the different nutrients were determined (Table 2).

Concerning the soil properties of the sampled orchards, the mean percentage of sand, clay and loam were 47.8, 22.7 and 29.8 % respectively. About 28 % of the soils were loams (L), 21 % sandy clay loams (SCL), 19 % sandy loams (SL) and 17 % clay loams (CL). Orchards on sandy (S) or clay (C) soils were less than 2% for each category. In general, soils were medium-textured and mostly loams. The concentration of $CaCO_3$ ranged between 0 and 75.6%, while soil pH ranged from 4.2 to 8.6. In about 20% of the orchards, pH was < 5.3 under the canopy, while in 10% of them it was >8.0. In other words, about 30% of the orchards were located in soils where plant nutrition could be problematic. The average soil pH was lower in samples taken under the canopy compared to samples taken within rows (6.7 and 7.1 respectively). This indicates an acidification effect due to fertilizer application, which was more important for soils with low $CaCO_3$ concentration (5.6 and 6.1 respectively).

According to the collected information, a significant percentage of farmers were using composite fertilizers. About 62% of them were using fertilizers like 11-15-15, 20-10-10 and 12-12-17, while 23.2% were using N-fertilizers in addition to the composite ones. Supplemental application of K was used by 10% of the farmers, while only 9.3% of them were adding B to the soil. Another 9.3% were using composite fertilizers containing micronutrients (Magnivor and Polybor) to cover the B needs. Although acidification was a common problem, as previously mentioned, only 2.3% of the farmers were adding lime. The average application rates in the sampled orchards were 0.90, 0.39 and 0.60 kg/tree of N, P and K respectively.

Table 3. Nutritional status of the sampled olive orchards (values are % of the total number of sampled orchards).

Nutrient	RANGE				
	Deficiency	Low	Optimum	High	Excess
N	0.7	29.9	30.9	37.8	0.7
P	2.2	7.7	13.3	44.2	32.6
K	2.3	15.7	27.1	35.4	19.5
Ca	0.8	15.7	71.5	12.0	
Mg	0.8	-	91.7	7.5	
B	0.7	58.9	40.4	-	
Fe	-	-	75.7	24.3	
Zn	-	2.3	93.2	4.5	
Mn	2.3	10.6	84.1	3.0	

In the organic olive orchards most commonly farmyard or poultry manures and to a lesser degree olive leaf or olive mill cake composts were being used.

The nutritional status of the sampled orchards is shown in Table 3. In about 30% of the orchards, N-fertilizing could be considered as inadequate, while in 38% of the cases N was applied at higher rates than needed. Over-fertilising was more intense for P and K, since these nutrients were applied through composite fertilizers. (Table 3). Concerning the micronutrients, the large majority of the orchards were having optimum concentrations of Fe, Zn and Mn. However, in about 60% of the orchards, B concentration was below the optimum range.

The leaf analysis results of the surveyed organic orchards (Table 4) showed that the nutrition, regarding all nutrients analysed but nitrogen, in all the cases was at satisfactory levels. This can be assigned

to the absence of the undesirable effects usually attributed to the excess of chemical N-fertilisers as well as to the more or less restricted growth of the trees observed in these orchards.

Conclusions

The results show that fertilizing practices of conventional farmers in the area of Chania Crete in several cases can not be considered as ideal. Cases of over-fertilising and unbalanced fertilizing were observed. Over-fertilising can increase the cost of olive culture with no apparent advantages in terms of yield or fruit quality, while at the same time, it may introduce environmental pollution problems. The use of composite fertilizers when not needed may contribute to the accumulation of K and P in the soil, and fertilizers covering only the existing needs of N could be preferable in most of the cases. According to the findings of the survey and the results of the long term fertiliser experiment, the recommended application rates for N, P and K should be about 0.8 and 0.5 Kg of N and K_2O /tree/year while P should be applied where leaf analysis shows it to be needed.

Table 4. Content of N P K Ca Mg (as % leaf dry weight) and B Zn Mn Fe (in ppm) in the leaves of several organic olive orchards in the area of Crete

Case	N	P	K	Ca	Mg	B	Zn	Mn	Fe
1	1.670	0,112	0,90	2,46	0,260	19,02	26,2	37,8	147
2	1.600	0,150	0,90	2,70	0,230	17,00	30,0	51,0	102
3	1.347	0,147	1,15	1,75	0,195	17,32	18,0	35,5	
4	1.980	0,150	1,10	2,40	0,190	19,00	25,0	53,0	147
5	1.857	0,163	0,95	2,10	0,230	16,20	18,2	41,1	
6	1.720	0,150	1,10	2,45	0,190	18,00	25,0	63,0	173
7	1.608	0,153	1,30	1,85	0,220	17,26	16,0	49,7	
8	1.770	0,175	1,10	2,04	0,210	21,89	28,8	34,7	168
9	1.585	0,157	1,20	1,90	0,220	16,55	18,8	75,3	
10	1.574	0,162	1,00	2,30	0,220	18,57	17,9	44,1	
11	1.520	0,150	0,90	3,00	0,210	19,00	28,0	47,0	126
12	1.920	0,150	0,90	2,75	0,200	17,00	25,0	40,0	97

The increase of fertilizer application rates in cases where soil pH is responsible for nutritional imbalances is a false strategy, and liming, or use of the appropriate type of fertilizers could be beneficial. The application rates of the major nutrients (N, P and K) were higher than needed in the majority of the traditional orchards, however, only few farmers where aware of the periodic need for B addition to the soil, since B deficiency is quite common in the area.

In organic orchards leaf nutrient content was within the optimum range for most nutrients, except nitrogen. Given that nitrogen is an essential element that can greatly affect yield and its addition is required on an annual basis, special attention should be given to nitrogen in organic olive orchards. Green manures and / or supplementary cultural practices such as for example appropriate pruning can help to increase nitrogen levels.

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CONVERSION TO ORGANIC FARMING AND SUSTAINABILITY: A SOCIO-ECOLOGICAL ANALYSIS

Maria Loreto (1), Glen Filson (2), Nora Cebotarev (2), Liliam Ferrao (3)

(1) University of Viçosa, Campus Universitário, 36571000, Viçosa, MG Brasil, Telephone: (31)3899-2432 dorinhasaraiva @hotmail.com

(2) University of Guelph, 50 Stone Road, N1G 2W1, Guelph, ON. Canada, 519-824-4120 E. 56231, gfilson@uoguelph.ca; E. 52504, ecebotar@uoguelph.ca

(3) INCAPER, Vitoria/Espirito Santo-Brasil, Telephone: (27)3137-9868, liliam@incaper.es.gov.br

Key Words: Organic Farming, Sustainability, Socio ecological Analysis

Abstract

This study aims to understand the process of conversion from conventional to organic farming in Canada. Specifically, it looks at what factors have affected this decision and if this production system improved the prospects for sustainability. In order to achieve these objectives this study uses a socio-ecological approach and focuses on organic farmers in Ontario. Besides including a bibliographic review, organic agricultural leaders were surveyed and life story interviews were conducted with producers. The results showed that the decision to become organic is influenced by the type of farmers, their context, and their rationale for conversion. The reasons for converting to organic depended not only on economic factors, but also socio-cultural and institutional parameters. The conversion was associated with a change of values towards protecting the environment and improving farmers' lifestyles. This model of development doesn't entirely attain sustainability. In order for that to occur, the harmonization of the Canadian organic farming system requires a political solution, which humanizes the complex system of interests for organic producers and shows the potential contribution of organic farming to the achievement of sustainability goals.

Introduction/Problem

The environmental and socio-economic problems related with conventional farming led many farmers to convert to organic farming. The conversion to organic farming has recently grown rapidly throughout the world and is expected to continue to expand between 20 and 30 percent annually (IFOAM apud RAYNOLDS, 2004).

According to Darnhofer et. al. (2005) and Darolt (2002), the success of organic production systems is associated with farmers´ rationale ("committed organic") and the relatively high consumer consciousness about the environmental costs of conventional agriculture. The growth of organic farming and markets has been accompanied by rapid growth in the number and complexity of the different systems of organic regulation- both private and government.

The increasing social distance from the organic global market, resulting from globalization, can reduce organic farming's ability to produce sustainability. Yet, organic agriculture is a way of obtaining a high quality of life, respecting the cultural characteristics and the ecological limits.

According to Alroe and Kristensen (2004) these perspectives may lead to the reflexive question of how organic farming can promote the sustainability of the global food system without letting go of its ecological principles. The role of organic farming from a global perspective and in relation to sustainable development was discussed by Sturms (2005) who emphasizes the neostructuralist theory for analyzing the perception of the role of the state and other groups within society in the process of sustainable development. In her opinion, the solution to problems is increasingly based on horizontal political coordination in pluralistic policy networks. In this sense development isn't a spontaneous process but is a planned and systematic action of the government and the civil society. This implies that the state has to mediate between conflicting agents and recognizes the importance of helping to "empower" weaker parties to negotiate their interests and proportionate to voice them through participation and representation. The small producers need to be "empowered" and given an opportunity to be heard.

Thus, the concept of sustainability is associated with the balance between the desire of the society and capacity of the local system, focusing on three aspects: <u>sustainable use</u> that allows the renewal or replacement of the systems; <u>sustainable growth</u>, where the important basic question is if the growth considers the limitation of the resources, not allowing environment degradation; and sustainable development that is not a formularization technique of an agronomic or strictly economic matrix, but is an eminently political task for searching for local, regional and national consensus (SILVA, 2002).

In this context, the research aimed to understand the reality of the conversion process to organic farming in Canada. Specifically it was reflected in the following questions: what is the reality of the Canadian organic farming's context and what kind of factors have affected the decisions about converting to organic farming? Has the conversion to organic production system contributed to social, economic, and, agro-ecological sustainability?

The hypothesis is that organic farming can promote sustainability, if it includes taking care of humans' needs and rights for all people involved at all levels within daily organic production system.

Methodology

To achieve the objectives of the research this study used a systemic and holistic socio-ecological approach as well as a network framework, because it presumes that farmers, researchers, certified bodies, firms, government authorities and non-government organizations (NGOs) are all involved in the complex web of material and non-material (culture and local values) relationships.

As specified in Figure 01, this methodology is based on a socio-ecological framework because it presumed that there is a social construction that allows farmers and decision-makers to understand problems, trade-offs, alternative actions and outcomes. It takes into consideration the agro-ecological, economic, socio-cultural, and institutional parameters within a wide context of objectives and perceived needs of the social actors (SCIALABBA, 2000).

Contextualization of the study's object was characterized by the environment lived in by the farmers and their families, as a whole. Based on Macey (2004) the population of the Certified Organic Producers in Canada is 3,134; and the Province of Ontario has the third position, with 478 producers (15.25% of the total). The questionnaire was sent to 400 producers, for whom we had complete addresses.

In the second stage of the research a sub-sample of this group of farmers was selected for a deep and evolutionary analysis, using a qualitative research method (life story), for analyzing the conditions and trade-off between the agro-ecological, economic, social, and institutional parameters.

Results and Brief Discussion

Empirical evidence, obtained by the bibliographic review, showed that life in this modern pluralistic society is characterized by inequalities and economic inequities. According to MacRae et. al. (2005) Canadian organic farming exists in a state of disequilibria and inefficiency that can be reduced by policy interventions for supporting the conversion to an empowering form of sustainable organic farming.

The results of the life story interview, with a sub-sample of Ontario's farmers, showed that the conversion to organic farming depends on the type of producers and the reality of their micro and macro environment. The implementation of organic farming is associated primarily with philosophical reasons, with a change of values and lifestyle. For "ecologically minded producers" the organic methods are better either for the health of themselves or their families. Organic farming is: the "right way to farm"; "the stewardship of land and growing clean environment and food". For another group the most common motivator is market opportunity, which compensates for the risks of organic production, such as: weed control and availability of labour. In this sense the main reasons for changing to organic farming aren't only economic, but are also concern about personal life and the environment.

Another positive attitude towards organic farming is associated with the political situation. Some organic farmers asked for a realistic environmental policy, with a financial compensation for take caring the natural resources; for a national standard certification; for public marketing, which shows the benefits of the organic farming for sustainability. In the other words, "the lack of co-operation and harmony has become a problem for the harmonization of organic systems (BOWEN, 2002).

The role of the Certified Bodies in this process of harmonization and also humanization of the organic system is very important because they have the function to verify "in locus" the different fulfilment of the conditions, which must be observed in organic production systems. The process of certification has added value to organic production and has constructed a relation of confidence between the farmers and the Certifying Body. However, the cost of certification is high and its social dimension remains fragile. The instruments that can be used by the certified organisms to verify the social sustainability of organic systems are timid; with special reference to family workloads and social relations of production (HOWARD, 2005).

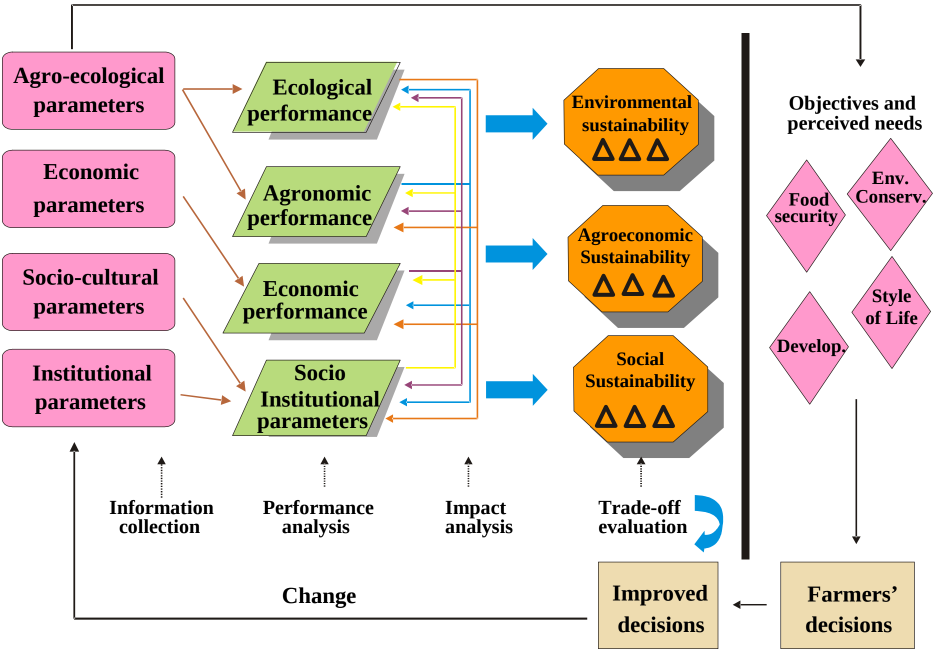

Figure 1. Components of the Socio-Ecological Approach

SOURCE :Scialabba (2000), with modification

Conclusions

Canadian Organic Farming is dynamic, with opportunities and challenges, because it demands balanced decisions about the capacity of the environment, the needs of the farmers and the priorities of the decision-makers, with all their value systems and interests The main reasons for converting to organic production are philosophical (beliefs and lifestyle) and economic. The organic system needs harmony and rationality not only between people and nature but also among humans. There is a state of some disequilibrium, which reflects on its capacity to promote sustainability, because the institutions have shifted away from consideration of equity to a market driven efficiency perspective, with a lack of national legislation and adequate policies to support organic agriculture.

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Does Organic Conversion Mean Food Chain Conversion?

Pierre Stassart (1), Daniel Jamar (2), Didier Stilmant (2)

(1) Univ. Liège (ULG), Av Longwy, 6700, Arlon, Belgium, 0032 63 230816, p.stassart@ulg.ac.be, www.ful.ac.be

(2) Walloon Agricultural Research Centre, Farming Systems section, 100 rue du Serpont, B-6800 Libramont

Key Words: Organic beef Chain, Referential, sustainable development, conventional, supermarket, consumer

Abstract

The conversion of food chains to organic production is problematic. In the future, however, the development of organic production will go through an increasing involvement of food chains. A four-year interdisciplinary research project has investigated the tension within an organic beef chain, trying to improve coordination between the demand of organic consumers, herd management, and the interactions between the different actors. Results show the necessity for a holistic approach to provide a new cognitive and normative framework shared by all stakeholders.

Introduction/Problem

During the last 15 years, organic farming has gained an institutional and commercial legitimacy on the European level. The recent progress is due to two factors: the triggering impact of agri-food crises and the commercial interests of supermarket retailers in the marketing of organic products, and the increasing social legitimacy through the expression of various dimensions of sustainable development (environmental impact, animal welfare and the multi-functionality of the landscape).

Organic farming sustainability could be argued from two points of view. (1) A normative point of view: Is this sector more sustainable than a conventional system of production and consumption? The organic system proceeds to evaluate its environmental and techno-economical externalities compared to those obtained in the conventional system. Such evaluation has to integrate the consequences of market growth, the lengthening of agro-food chains and the regional translations of the European Organic Frame of Reference. If these obstacles are overcome, a further issue is the importance to be given to the different criteria of sustainability evaluation. (2) On the other hand, the comprehensive point of view aims to explore the ability of the organic model to develop itself, in a sustainable way, aside from the conventional and dominant model. Indeed, instead of maintaining a large panel of technical alternatives to be able to extend future capacity, the dominant model create irreversibilities through some agreements benefiting its own supported options (Godard and Hubert, 2002). So, it is the viability of the system's biodiversity that is questioned, rather than its adaptation or its acceptability. The question of sustainability in the conversion to organic farming brings up other questions: (1) the capacity of the whole food chain to convert to organic production and (2) the ability of the organic food chain to contribute, within the food system, to the diversity of the agro-food chain's models (Thompson, 1997). The main hypothesis is that such capacity is amplified by the coexistence of a large panel of distinct and autonomous models. The adoption of such a point of view has led us to question the organic conversion at the organic food chain scale in comparison to the conventional agro-food chain scale (instead of the production system scale). This led us to shift from the system of production concept, with its technical frame of reference, to the concept of agro-food chain frame of reference, or referential (Jobert and Muller, 1989).

Methodology

Implicit characteristics of the food chain referential led us to develop 'intervention research' (Hubert, 2002) aiming to associate researchers to the different actors involved in this social field while making new hypotheses. Such type of research is based on the principle that relationship and knowledge are inseparable (Hatchuel, 2002). This approach requires us to accept the double condition of a learning process and interdisciplinary work. The efficiency of the transversal integration of agronomist, sociologist and economist competences depends on the researcher's ability to build and test shared hypotheses in different fields of social interactions within the studied referential: between the breeder, cattle and their parasites; between breeders and retailers within the same food chain; between organic and conventional beef breeders.

The social field we have chosen is the organic beef network of production, distribution and consumption, as it is characterised by its uncertainty (Stassart 2003). In the European context, the multiple food crises of the conventional sector induced a new situation: a large-scale implication of the industrials and supermarket retailers in the organic beef market. The specialised and closed network of organic beef distribution led to direct confrontation between the organic beef sector and the national, highly coherent conventional "referential of the Belgian Blue" beef referential. This conventional referential was coined as "lean and tender". The analysis of the tensions emerging from this confrontation has allowed us to understand how a strong conventional frame of reference can interact with the conversion to organic farming.

Results and brief discussion

The hypothesis of a lack of interpretative frame (Muller, 2000). for the whole beef chain has been assessed and confirmed. Gaps were identified at various levels, leading to partial conversion and reversibility to the conventional referential of "lean and tender" meat. Attempts to learn how to fill the gaps have been made at three levels: through the analysis of (1) breeders-retailer relation, (2) the interaction between the product and its consumers and (3) breeders – cattle relation.

Breeders – retailer relation

At the production level, the cooperation between the retailer, the slaughter house, the collecting firm and the breeders has allowed the transformation of two strong characteristics of the conventional frame of reference: the breed and the dissociation between the breeding and the fattening phases. Indeed, breed conversion allows the breeders to learn or to re-learn, from a more rustic breed - for example the limousine - all the things that traditional Belgian Blue breed and the strong characteristics, linked to the systematic occurrence of caesarean birth in this breed, have brought out of farmer know-how: maternal competence of the cow, rough forage valorisation abilities, etc. Moreover, and most important for the whole organic beef food chain, breed conversion, once affirmed, will allow the articulation of the consumer (pertinent signal), the retailer (clearer product differentiation) and the breeder (animal and herd competence).

To reconnect the breeding and the fattening phases within the same exploitations, this is, first of all, to question the farmer identity and the type of reciprocal involvements between farmers and retailers, this in the context of a limited cooperation. Such reconnection allows us, thereafter, to question the "conventional" conception of beef fattening that remains in organic systems even after their conversion. More particularly, it questions the conventional frame of reference on the superposition of the growing (skeleton development) and fattening phases and on the consequences of such practices on the animal health and welfare, on one hand, and on product quality, on the other hand. Such transformations were allowed because the retailer engaged himself, with the breeders, to communicate these transformations to the consumers : adaptation of the product label with the notification of the breeder-fattener's name, specific articles in its contact journal, etc. Since then the market of the organic beef has, for this retailer, shifted from a constant decrease to an increase that will need to be confirmed on the long run.

At the same time, the researchers have questioned the social actors on the limits of such approach based on a mean obligation (breeder-fattener, breed conversion). Indeed, even if in harmony with the organic frame of reference, such an approach does not allow the differentiation between the end product and the conventional frame of reference. There is no difference between a piece of meat coming from a Belgian Blue baby beef and the same piece of meat coming from a limousin baby beef! A differentiation process, initiated around the principle of an unforced breeding concept, has led to the questioning of the SEUROP's central norm (Official European carcass and fattening classification) on the conventional frame of reference. The experimentation, questioning the fattening concept and its consequences on the link between animal feeding and animal health, has been set up in this logic.

Organic Consumers?

From the consumer's part, the recent crisis and the development of large organic retail networks paradoxically introduced a new type of less exclusive consumers, whom we shall call "occasional consumers" (Lamine, 2003). We hypothesised that knowing/acknowledging the occasional consumer figure might help us to better define the organic frame of reference as it fits into the market that large retailers seek to develop. Let us consider the question of taste. For organic consumers, from a normative point of view, taste means breaking away from the industrial world and converting to the more nature-friendly rhythm of the organic frame of reference. Taste is thus a performance indicator for all organic consumers, whether they are exclusive or occasional. But such a normative choice remains controversial in practice: generally speaking, no taste-related conclusions are favourable to organic products (Bourn and Prescott, 2002) especially as far as beef is concerned (Stassart, 2003). Even though there may be a taste difference, it is small and requires not only chain-specific skills, but also skills that enable consumers to taste the difference. According to our first survey, exclusive and occasional consumers seem to diverge on the development of the taste issue. To cut short, we would say that exclusive consumers underestimate, or even neglect the difference's lack of significance owing to normative attitudes: good products have organic labels and certified products are tastier. Taste has become a keyword allowing consumers to define the organic concept. In return, taste is a debatable notion and remains under-defined. On the other hand, as occasional consumers risk the comparison between organic and non-organic products, they open the debate. Taste becomes a performance indicator, which they should learn to appreciate, negotiate and define, in cooperation with the production chain. Considering the irreversible alteration of taste/lack of taste resulting from the demand for tenderness, it has become necessary - in order to escape from the lean-and-tender standard - to work out a new category allowing consumers to assess quality, to decide that natural meat is not less tender, but just firmer... because by the yardstick of tenderness, no other reference can equal the lean-and-tender referential.

Consequently, a better knowledge of consumer figures can lead breeders to make distinct choices in terms of priorities and room for manoeuvre: if they opt for exclusive organic production, they shall favour 100% organic animal nutrition. But they may also believe in the potential dialogue with occasional consumers and in unforced production, which notably relies on the selection of "social" breeds such as Limousin cattle - which becomes a powerful coordination tool. A breed change is indeed a quality indicator that can include specific breeding qualities (animal well-being, etc.) and show some margin from Belgian Blue beef's de facto monopoly.

Breeders - cattle relation

Parallel to supermarkets, a regular intervention within the farm, on the field of parasitism and animal performance (weight) evaluation, is opening new perspectives of collective re-equipment of organic farming systems. In the lean and tender conventional referential, we can underline a chain of norms defining from the good animal to the 'good parasite', passing through the good grassland. Each of these choices is stabilized by an image and a representation allowing the farmers to stay in phase, to coordinate themselves with the other partners of the agro-food chain. To keep its cattle 'in shape', the breeder has developed, with the veterinarian and the zoo-technician, performance criteria (animal conformation and average daily gain) coherent with such representation. However, such criteria focus the attention on individuals instead of herd performances, whereas, in the sustainability frame of reference, more attention is paid to such herd dimension susceptible to question conventional livestock farming systems.

The organic referential, across its norms of grazing obligation, of forbidden preventive allopathic treatment and of choosing rustic breeds, proposes to pass from the lean and tender statement: "a healthy animal does not get thinner and does not cough"; to the organic referential question: "   Can you call a herd with some coughing animals or with animals getting thinner during a limited period of their life a healthy herd? ". This transition is only possible if some points are 'equipped'. To do so, it is necessary to produce an image that shows the relation between the parasite, its host and the grassland. Indeed, how can a breeder or a veterinarian learn to manage the parasite problem if his representation of the interaction is the one of an animal crawling with worms?

There needs to be a change of relation between the breeder, its herd, the veterinarian, its grassland and the knowledge shared between these actors, including the researcher, and this at different levels. (1) Timing: from the instantaneous moment of the coughing animal to the period during which it gets thinner, from the animal getting thinner for its breeding career, from its life to the type of meat it will produce and also the type of consumers who will appreciate it. (2) Space: from the parasite to the animal, from the animal to the grassland, from the grassland to the farm and territorial management. (3) Management: from the infected lung to the coughing animal, from the animal to the group of cattle sharing the same grassland and the same history, from the group to the farm herd, from the herd to farm management and from the farm management to the corresponding food chain management. From the collected data that is still to be closely analysed we can already draw the hypothesis that, aside from the techno-centered model, of value in the conventional frame of reference, there is a more eco-centered model, in harmony with the differentiation project of the organic frame of reference, where parasite, cattle and grassland can grow together in a sustainable equilibrium managed by the breeder.

How can we make a difference from the ‘lean and tender’ meat found in the conventional system? What are the constraints, resources and stakes of such differentiation? The organic normative frame is restricting in the context of the ‘lean and tender’ model but offers a new opportunity to be the starting point of product differentiation all along the agro-food chain from the producer (feeding scheme based on grazing) to the consumer (cooking habit) passing through the processor (maturation, processing habits) and the retailer (explanation of the differences). As we can see, a new organisation, based on a new frame of reference and a shared representation of the ‘occasional consumer’ of organic products, is possible between the actors of the food chain. Setting up, with all the actors of the food chain, an experimentation in a research station aiming to question the fattening scheme, what is a good carcass and a good meat completely changes the traditional role of a research station in term of knowledge production and relation modification.

Conclusions/Perspectives

The sustainability of the organic agriculture relies on two questions, one regarding the sustainability of the model of production and one concerning the ability of this model to grow on a permanent basis as a distinct model, autonomous and sufficiently equipped to maintain and develop the diversification of the technical path that it opens up. This forces us to take this into account on one hand the fact that the logic of a dominant system (in this case the conventional lean and tender) resists to the organic conversion because it is well equipped and on the other hand to accept that the normative-cognitive frame of the organic food chain is under-equipped and needs further social and technical research. Without such work of equipment, making organic production reversible to conventional production, or conventionalising the organic food chain, organic production will remain difficult.

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COMPARATIVE COSTS OF ORGANIC WHEAT PRODUCTION IN AUSTRALIA AND GERMANY

Els Wynen (1)

(1) Eco Landuse Systems, PO Box 1121, Belconnen 2616, Canberra , Australia,
Tel.: +61-2-62583561 , E-mail: els.wynen@elspl.com.au, Internet: www.elspl.com.au

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Abstract

Scarce resources can be saved if goods are produced in locations most suited to their production and transported to consumers across international borders. However, some national organic agencies favour consumption of locally-produced products. This can have unnecessary environmental costs. The issue is illustrated with an example of Australian and German organic wheat consumed in Europe.

Introduction/Problem

Although concerns about local production and consumption have been heard for many years in the organic movement, they have increased in intensity over the last few years. The idea behind it is that local consumption would cut down on transport costs, and therefore be better for the environment. While organic organisations may campaign for consumers choosing locally produced food (see, for example, Soil Association (2002)), the case for reduction in resource use through producing goods as efficiently as possible (through specialisation of production and international trade, see Vanzetti and Wynen (2002)) seems forgotten or misunderstood. Purchases of locally-produced products at higher prices than those which international trade allows, can accentuate non-optimal resource use to the detriment of producers and consumers — and environments — in all countries. The concept of the “whole life cycle” evaluation in terms of resource use is well established (Meier-Ploeger, Kjer and Simon, 1996), yet its importance is rarely mentioned when the issue of local food consumption comes up. Furthermore, exports of organic goods provide an important opportunity for many poor farmers in developing countries.

For international trade, transport is required, the price of which may not reflect the true costs to society. Most forms of transport cause some pollution that is not paid for by the users of the transport system. Noise, air pollution and road damage are some obvious examples. A further argument is that transport costs are wasteful, as transport is dependent on a non-renewable resource, oil. Implicit in this is the view that oil is underpriced.

Methodology

The cost of production reflects the resources used. Data from Germany and Australia are used to compare production costs of wheat in the two countries. Adjusting the production costs for transport, in which transport-related externalities are internalised, gives an estimate of the total use of resources to produce grain in the two countries. A sensitivity analysis indicates the order of magnitude of the externalities of transport that needs to be assumed to warrant a policy of local consumption.

Results and brief discussion

Production

Table 1 shows a breakdown of the costs of production of organic wheat in Germany and Australia. Actual costs per farm depend on many factors such as location (soil type and weather), policies (influencing, amongst others input prices) and exchange rates. The figures in the table show average figures from surveys. In Australia, the figures represent averages of 5 farms in Eastern Australia in 1998-99, and are similar to figures collected in 1985-86 (Wynen 2001), and in Germany the data was obtained from a survey carried out for 2002 by Bundesforschungsanstalt für Landwirtschaft (FAL), comprising x number of farms (to be confirmed). Comparing figures obtained by two different surveys is somewhat hazardous as, in addition to the usual problems with averages derived from surveys, there is the problem of use of different methodologies (e.g. for estimating the depreciation on machinery and equipment and imputed values such as for the cost of family labour), and use of regional figures (for example for arable area and organic payments). However, the figures are useful in illustrating the point on comparative resource use for growing wheat in two different countries.

Table 1: Comparative cost of organic wheat production in Australia and Germany

		Australia		Germany		Difference	
		€/ha	**€/tonne**	**€/ha**	**€/tonne**	**€/ha**	**€/tonne**
Variable costs	Seed	12	6	87	25	75	19
	Nutrients	28	14	244	70	216	56
	Pesticides	1	0	0	0	-1	0
	Fuel	31	16	0	0	-31	-16
	Repairs and maintenance	23	12	244	70	221	58
	Labour (casual)	37	19	50	14	13	-4
	Other (e.g. marketing, drying, administration)	28	14	73	21	45	7
	Total	161	80	698	199	537	119
Fixed costs	Labour (family)	63	31	6	2	-57	-30
	Machinery	65	33	290	83	225	50
	Buildings	2	1	20	6	18	5
	Land	105	52	220	63	115	10
	Total	235	117	536	153	301	36
TOTAL COSTS		395	198	1234	352	838	155
Yield (t/ha)		2		3.5		1.5	
Gross return		241	120	1085	310	844	190
Arable area payments		0	0	360	103	360	103
Organic payments		0	0	160	46	160	46
Total gross return		241	120	1605	459	1364	338

Sources: Australia: Wynen (2001); Germany: Frank Offermann, researcher Bundesforschungsanstalt für Landwirtschaft (FAL), personal communications, April 2005.

In the table, the costs per hectare of growing wheat in Germany are shown to be over three times higher than in Australia. Taking into account the higher yield per hectare in Germany compared with Australia, the costs (or use of resources) per tonne of wheat produced in Germany are nearly double of those in Australia.

The difference in cost of seed would reflect both the lower planting rate and price of the seed per unit. The comparatively high cost of nutrients in Germany is mainly due to the opportunity cost of manure, an input that is not used in Australia in the broad-acre cereal growing sector. But the largest difference in cost per hectare is in costs related to mechanisation, reflected in fuel, repair and maintenance, and depreciation. Wheat-growing in Germany generally occurs on smaller farms, and with climatic condition providing fewer suitable days to plant and harvest crops, machinery cost per hectare (€534) and per tonne (€153 per tonne) tend to be higher in Germany than in Australia (€120 and €60, respectively). Fuel costs per tonne are also higher, although partly as a result of higher taxes in Europe (still to be updated). However, one consequence of the use of large machinery for short periods is that the labour costs (casual and family) are lower, €16 per tonne in Germany compared with €50 per tonne in Australia on average. Higher costs for land in Germany are likely to be a function of higher output prices and availability of subsidies in Germany.

Though volatility in, for example, local conditions and exchange rates influence input costs and returns to wheat to vary from year to year, and changes in policy (for example the phasing out of area payments in the EU from 2005) will make final payments in the future somewhat different from what is shown in Table 1, the general picture of the differences between the two countries in returns to wheat is unlikely to change greatly. It is clear that resource use in Australia to produce one tonne of wheat can be considerably lower than in Germany.

International transport:

The cost of shipping a container of wheat from Australia to Europe is almost €80 per tonne (Mike Fisher, Megafreight, personal communications, May 2005). Fuel costs amount to about 20 per cent of the total shipping costs, that is, approximately €16 per tonne (Malaysia International Shipping, personal communications, May 2005). A doubling of fuel costs would increase freight costs by € 16 to € 96 per tonne. With the difference in costs of production between Australian and German wheat of over € 150 per tonne, it is clear that the efficiency of growing wheat in Australia, and probably other countries such as the USA, Canada and Argentina, outstrips the resources used by transporting the wheat to Europe.

Although the cost of transporting organic produce (in containers) may be higher at present than of conventional produce (in bulk), the environmental costs of the transport are similar. The extra expense is taken up in storage, handling, packaging, insurance and commission rather than fuel. If trade in organic wheat increased in importance such that wheat would be exported in bulk, the cost per tonne would drop considerably. In this example, based on estimated costs, a five-fold increase in fuel prices (at present € 16 per tonne) is needed to make organic wheat trade in containers between Australia and Germany unprofitable, a rise not likely to be needed to internalise all externalities of fuel costs, especially at present high prices of fuel.

Conclusions

In summary, transport costs for international trade provides little justification for promotion of the policy of local consumption of organic food on the basis of environmental grounds. As resource use, as measured by the price of producing wheat, is around €200 in Australia compared with €350 in Germany, adding transport costs of €80 per tonne doesn't reverse the conclusions. Even assuming that present transport costs do not reflect the true costs, total resource use for the production and transport of a good can be lower when transported internationally than produced and consumed locally. Substantial rises in fuel costs for transport, in the order of 5-fold, would be necessary to eliminate the potential gains from locating production more appropriately. Note that this analysis does not include tariffs (for example for imports in the EU) as these do not contribute in any way to efficiency in use of resources.

Rather than espouse purchases of locally-produced products, as so often heard in organic circles especially in the EU, a more fruitful approach may be to encourage governments to play a more active role by initiating polluter-pays policies. A tax on pesticide and fertiliser use is one such example in agriculture, as several countries in Europe have already implemented.

There may be sound social, political and environmental reasons to prefer locally-produced goods and there may also be economic reasons not discussed here. Underpriced transport costs appear not to be an adequate justification. Consumers should bear in mind that, where locally-produced goods use more resources to be produced, global environmental benefits may be foregone.

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> Soil communities
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> Land use, conversion and rural development
> Political instruments for organic farming
> Market analysis – Improving knowledge about markets and their actors
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