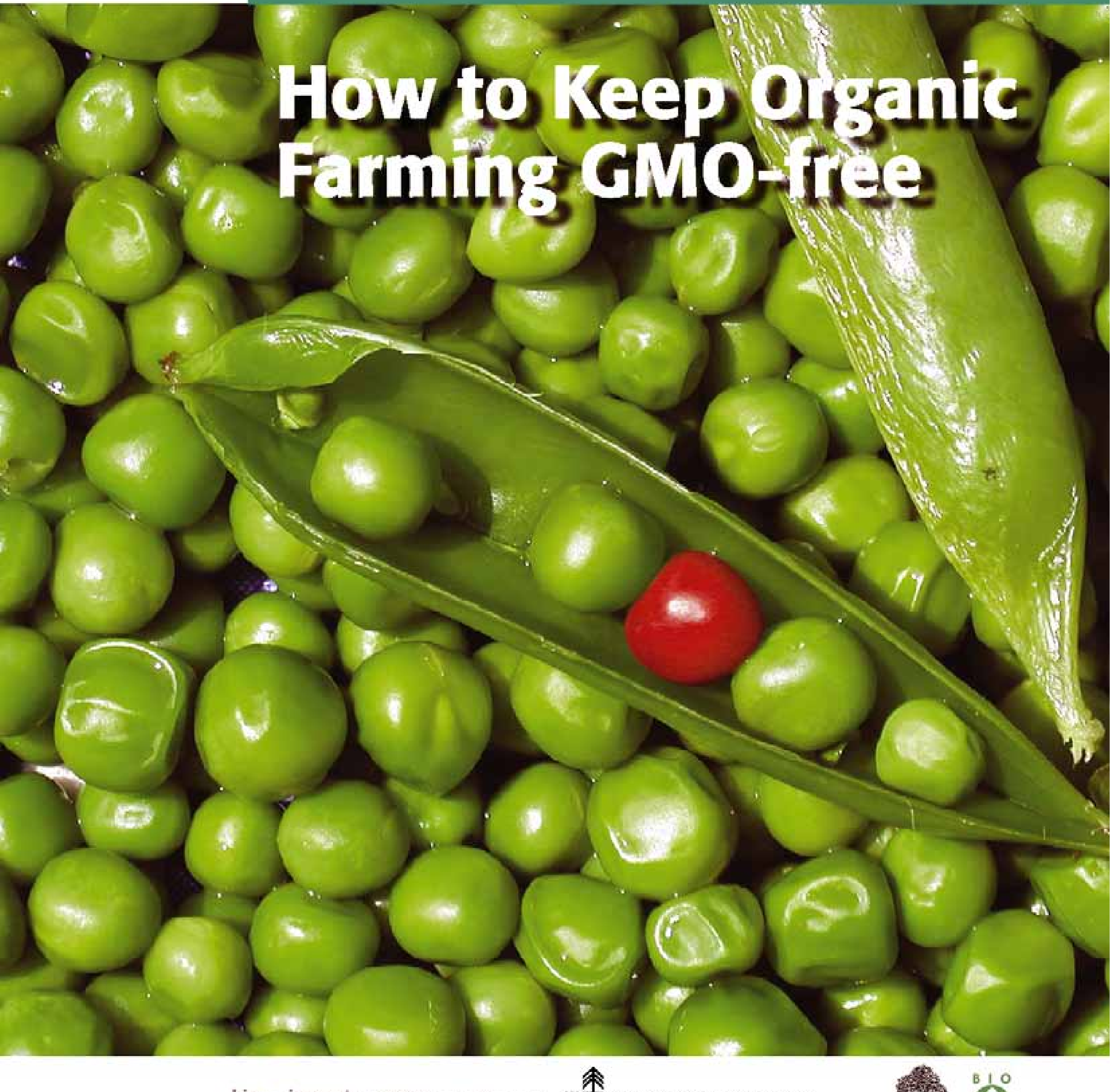
No. 3 February 2003
1st edition

FiBL DOSSIER

Organic Farming and Genetic Engineering



How to Keep Organic Farming GMO-free

In cooperation with: bio inspecta · Öko-Institut e.V. Institute for Applied Ecology Institut pour l'écologie appliquée · BUWAL Bundesamt für Umwelt, Wald und Landschaft · OFEFP Office fédéral de l'environnement, des forêts et du paysage · UFAFP Ufficio federale dell'ambiente, delle foreste e del paesaggio · SAEFL Swiss Agency for the Environment, Forests and Landscape · ELM FARM · BIO SUISSE Rely on it.

Table of contents

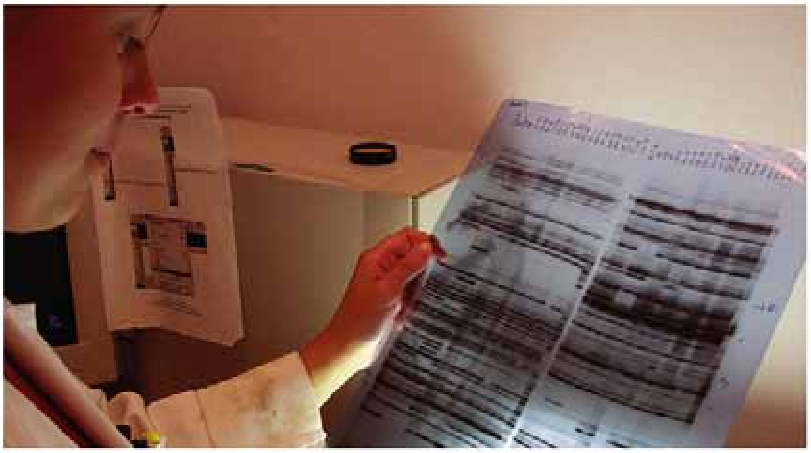
Organic farming worldwide uses neither genetically modified organisms (GMOs) nor their derivates. However, genetically modified plants are being cultivated increasingly by conventional farmers, mainly in the USA, Canada and Argentina and more and more derivates produced of genetically modified micro-organisms are used in food and feed processing. Therefore, there is an increasing risk of unintended GMO contamination by pollen drift, conventional auxiliary means or mixing during the flow of goods. This dossier aims to provide information on the state of the discussions and measures taken as regards the safeguarding of a GM-free organic farming.

Introduction

What is genetic engineering?

Genetic engineering can be used to isolate individual genes and to utilize these across the species barrier. A gene of a bacterium, for example, can be incorporated into the genome of a plant. However, what sounds easy is a complicated technical process. In the laboratory gene constructs (special plasmids or other vectors) are produced. These contain DNA-sequences that mediate the uptake and integration of the vector or part of the plasmid into the genome of the cell. Moreover, the gene construct has to possess promotor, termination and other regulation sequences so that the foreign genes can be recognized and the included information read.

Normally, a gene construct is built from DNA-sequences of four or five different organisms. The gene constructs are randomly spliced into a chromosome. In plant breeding, in a complex selection process those plants which contain the new gene construct and no other visible changes are picked out. These plants become part of the further breeding process. Thus, genetic engineering has many more and new options compared



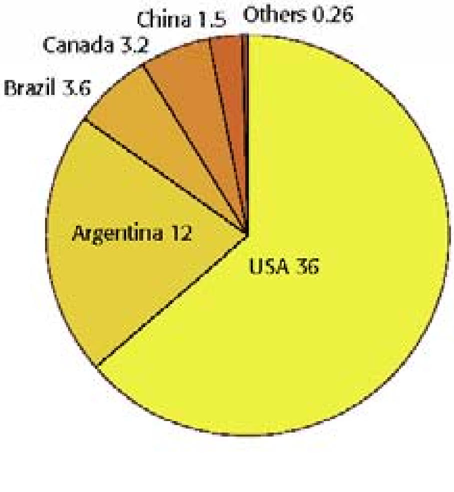
Evaluation of an autoradiogram of a gel with DNA markers in marker-assisted selection.

to conventional breeding possibilities (for more details to traditional breeding methods see FiBL Dossier No. 2 "Plant Breeding Techniques"). Genetic engineering can put genetic information together that never would come together without laboratory help.

These new options are taken as reason that such newly created organisms can be patented. Patent protection means that it must not be cultivated, propagated or used for breeding purposes without paying a licence fee (even for saved seeds).

Area under GM-crops, aims and application of GMOs

GMO area by country in million ha, 2001



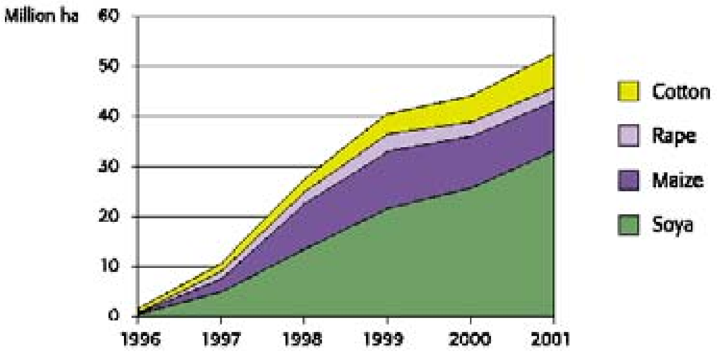
Area under GM-crops[1]

Ninety-nine percent of the areas planted with GM-crops are located in four countries: USA, Argentina, Canada and China. Other countries that produce GM crops are Brazil (illegaly), Australia, Indonesia, Japan, South Africa, Uruguay, Mexico, Spain, Rumania, Bulgaria, Ukraine.

Actual data on
www.transgen.de
www.agbios.com
www.infogm.org
www.admin.ch/buwal

The most important GM-crops

In the past six years, the area under GM-crops has increased from 2 to 53 million hectares.
In 2001, 46 % of the world production of soya was grown from genetically modified plants, the figure for cotton was 20 %, oilseed rape (Canola) 11 % and maize 7 %.



Commercially grown GM-crops

Worldwide, more than 100 crop plant species have been genetically modified and about 40 varieties of transgenic crop plants are commercially grown. This table shows the permitted GM plants (in certain countries) and examples of processed food products.

Crop	*Processed Products*
Soya	tofu, protein, lecithin, oil, vit. E; contained in 20.000 food products
Maize	corn flakes, oil, protein, flour, starch, glucose
Cotton	oil, protein isolate, methylcellulose (E 461)
Rape	oil
Potato	starch, glucose
Tomato	tomato ketchup
Rice	starch
Flax	oil, seed for bakery
Wheat	bread, flour, beer, starch, glucose

Further plants:
Tobacco, Radicchio/Chicory, Melon, Papaya, Zucchini, Sugar beet, Carnation

Aims and applications of GMOs

The aim of much of the genetic engineering approach is to obtain higher yields or to simplify production techniques.
The bulk of genetic modifications of crop plants concern herbicide (77 %) and insect resistance (15 %) or a combination of both (8 %). Transgenic plants that have been engineered for resistances to viral and fungal infections adaptions to environmental conditions, changes in food quality and processing quality are also currently being tested in field trials and hence released into the environment. Several enzymes produced by genetically modified micro-organsims are used in food and feed processing.

Genetically modified animals are not yet on the market although there have been a number of high profile cases covered by the media such as Dolly the sheep and the recent example of the piglets engineered for human organ transplantation. The licensing of genetically modified salmon is currently being discussed in the USA. In October 2001, there had been the first experimental release of genetically modified moths in a cotton field in Arizona.

GM-Enzymes

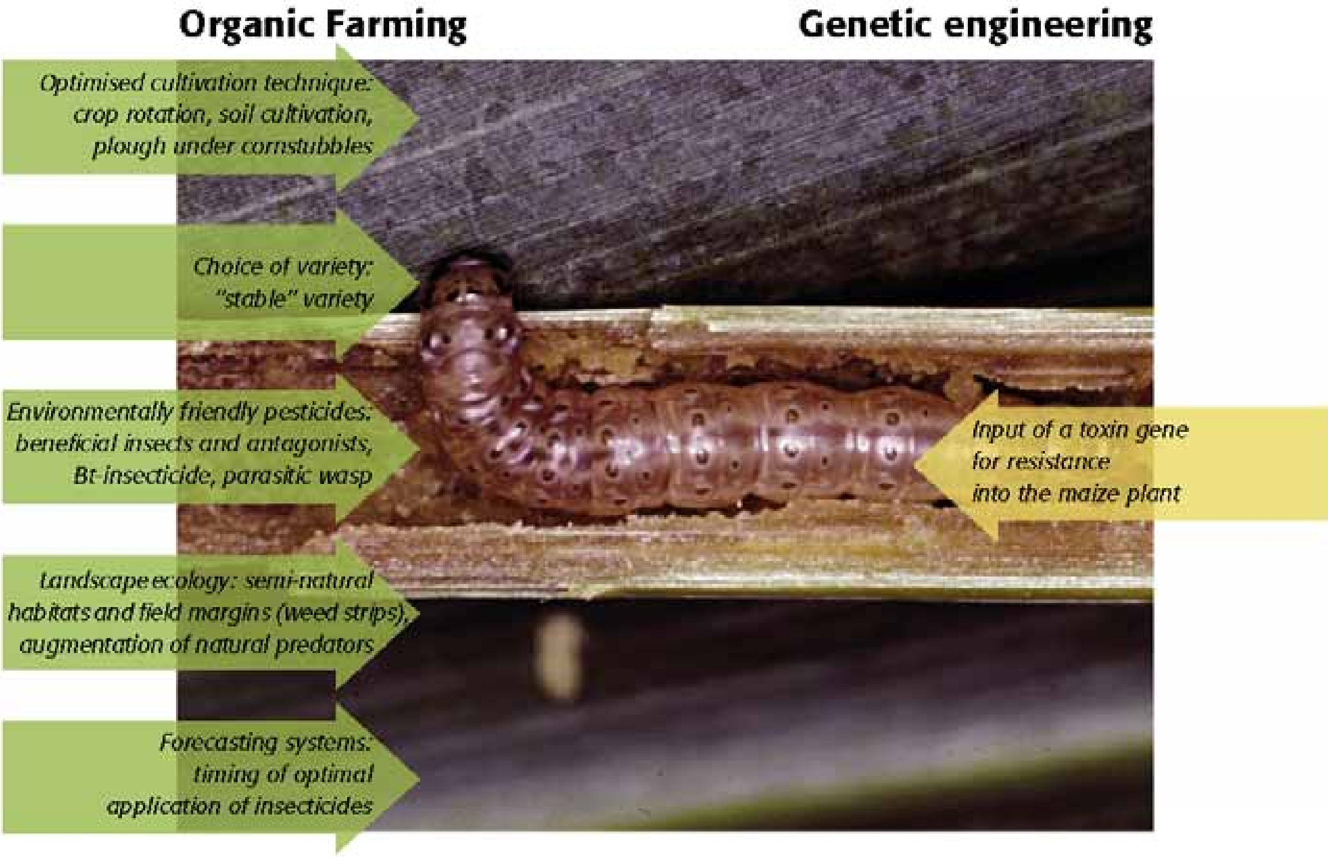
Several enzymes used in food processing are produced by genetically modified micro-organisms.

Enzymes	*Application*
Amylases	bakery, brewery, distillery, starch saccharification
Glycoamylases	sweets, starch saccharification
Pectinases	fruit and legume juice production
Cellulases	chop up plant parts
Chymosin	cheese production
Proteases	bakery, modification of gluten, meat processing
Lipases	flavour, oil and fat processing

Why does organic farming not use genetic engineering?

Argument 1: Genetic engineering is not consistent with the principles of organic farming

The production systems "organic farming" and "conventional farming" (with genetically modified plants) are based on very different basic principles:
Organic farming does not use synthetic chemical pesticides, herbicides and fertilisers. If direct control measures have to be taken, different agents from natural sources (for example plant extracts) and biocontrol agents can be used. Organic farming strives towards closed nutrient cycles. The succession of field crops is diverse and balanced, the soil is carefully cultivated and soil fertility is managed through the use of appropriate manures, green manures and leys. The crops, varieties and variety mixes are selected to suit the relevant site. The cultural landscape is enriched with ecological structures and the diversity of plants and animals is enhanced.[2] All these measures promote the natural capacity for self-regulation, as well as health and hardiness of soils, plants and animals. In solving production problems the emphasis is not placed on single measures (e.g. very effective pesticides, highly resistant cultivars) but on the combined impact of a variety of measures. Organic livestock production focuses on animal welfare and husbandry methods which prevent the need for veterinary treatments.



Single action versus systemic thinking, the example of the "corn borer"

The corn borer (Ostrinia nubilalis) is one of the grave pests in monocultures of maize and it occurs in Europe, East Asia, North Africa and North America. The crop loss is about 6 % worldwide. Corn borer larvae feed firstly on leaves and then move on to the stalks and cobs. In organic and integrated farming in Europe the corn borer is controlled by releases of the parasitic wasp Trichogramma. As preventive measures the ploughing-in of cornstubble and variety choice are used. With these measures the corn borer is effectively controlled.
In GM-maize a gene is introduced which produces a toxin of soil bacteria (Bacillus thuringiensis). The corn borer is killed while feeding on the so-called Bt-maize.

The different ways of thinking of organic farming and genetic engineering (GE)

Aspects	Organic farming	Genetic engineering (GE)
Basic principles and ethical position	• Based on a holistic consideration of natural systems. • Strives towards economically, socially and ecologically sustainable production. • A high value is placed on the dignity of the living being. • The impact of interferences to the agroecosystem are observed and the negative impacts are minimized. • Motto: "the whole is greater than the sum of the parts."	• Based on a simplified view of living organisms and of natural systems. • Aim of much of the GE approach is to obtain higher yields or to simplify production techniques. • The impact on the entire plant or animal as well as the connections and interactions within ecosystems are largely ignored and unknown. • Animals and plants are raw materials for human use. • Motto: "the whole is the sum of the parts."
Farmer/ knowledge	• Considerable know-how and major decision-making powers. • Based on vast empirical knowledge and skills of farmers and modern research to provide innovative new technologies.	• Much know-how lies with agro-industry. • Limited knowledge input – use inputs only as directed.
Social and economic aspects	• Attention is given to socio-political processes and sensibilities. • Adaptation to local situation/characteristics. • The diversity of plant varieties and livestock is a common good of high cultural value. • Low cost development and use.	• Universal varieties and inputs without adaptation to local situation. • Displacement of locally adapted cultivars. • Crop plants and livestock are objects of commercial exploitation (patenting). • Dependence on multinational companies. • Capital intensive development and use.
Product aspects	• Aim: foods with high (vital) qualities.	• Aim: product with optimised contents of specific compounds.
Production and ecological aspects	• Risks of generating resistant harmful organisms are minimized. • Optimising many partial impacts. Tackling the roots of problems. • Promotion of the natural capacity for self-regulation, as well as health and hardiness of soils, plants and animals.	• Risks are known and resistance management protocols are given to farmers but these are not always applied. • Amplification of individual impacts. Fighting symptoms.

Argument 2:
Genetic engineering does not offer lasting solutions

So far, none of the well-known agricultural revolutions had been able to solve the problem of "world hunger" and the same will be true for genetic engineering.

- The cause of hunger is not mainly a problem of production techniques but a political and social one (poverty, distribution of goods, corruption, lack of education, big losses after harvest).
- The solution "genetic engineered plant" is an isolated one; the whole production system and ecological and social contexts have to be involved, e.g. climate conditions, crop rotation, social and political conditions.
- The transgenic plants developed so far are designed for the mass markets with food and feed stuff. The genetically modified mutants of maize, soya, rape and cotton are characterized either by their resistance to a particular weed killer or they contain the genes for the expression of insecticidal toxins from the soil bacterium *Bacillus thuringiensis (Bt)*. The primary aim of the use of herbicide resistant plants is more efficient arable production. According to independent studies carried out in the USA yields of GM-plants are not generally higher, nor are less herbicides and pesticides generally used[3], but the weed control is simplified. More efficient production can only be profitable for holdings which have a lot of land and machinery at their disposal. Poor small farmers in the South who would not have the money to purchase mineral fertilizers and herbicides in the first place have no use for these genetically modified plants.

No GMO-solutions for most problems in farming

The genetic engineers have not yet found solutions for most of the problems faced by globally important crops : fusarioses, stem break and leaf spot in wheat, potato blight and flower beetle, rape stem weevil and brassica pod midge in oilseed rape. For maize too, there is no solution to the most prominent disease, i.e. stalk and ear rot. The reason for the lack of solutions presented by genetic engineering to tackle these pest and disease problems is the pests' and diseases' high flexibility and adaptability. They are genetically so variable or can adapt so quickly that genetic engineering will hardly ever be able to offer lasting solutions.[4]

Example "Golden Rice"

The so-called "Golden Rice" was genetically modified to produce more Vitamin A with the aim to give it to poor countries to solve the problem of lack of Vitamin A with resultant blindness. But, this is not a solution of the problem: one would have to eat 4 kg rice per day to get enough Vitamin A. Sustainable agriculture in contrast does not solve one single problem but tries to solve several problems with several measures: it has the general aim to fight poverty and support self-help, e.g. cultivation of vegetables, palms (palm oil) and orange sweet potatoes (e.g. a new conventionally bred variety contains 20–30 times more Beta-carotin as "Golden Rice") to provide a more varied diet (also prevent other vitamin and micro-element deficiencies).

◀ *Rice harvest in africa.*

Argument 3:
Genetic engineering harbours many as yet unquantifiable risks

The implementation of new techniques or chemical molecules harbour many risks which are unpredictable. Additionally, genetic engineering is not only a technique changing physical but also biological properties of organisms. This is a new dimension of influencing production systems and ecological systems.
On the next pages, potential risks of genetic engineering are described with examples of cases that have occurred.

Ecological risks

Impacts on ecosystems

Bt-toxins produced by Bt-plants remain in the soil and have an impact on the soil fauna, e.g. on Collembola.[5]

Vertical gene transfer, also long-term effects (particularly on cultural plant diversity)

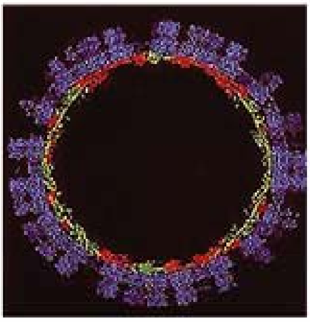
Research of the National Institute of Agricultural Botany (NIAB) Cambridge, England, showed gene flow from genetically modified to not modified oilseed rape in three of four trial plants.[6]

Damage to beneficials

Mortality of lacewings larvae raised on Bt-fed prey was 62%, compared to 37% for lacewings fed Bt-free prey. Three artificial diets fed to lacewing prey (i.e. corn borer) caused elevations in lacewing larval mortality ranging from 42–78%, compared to 6% mortality for lacewings raised on Bt-free prey.[7]

Transgenic plants becoming feral

Feral oilseed rape populations in Canada are resistant to three herbicides and have become one of the most troublesome weeds.[8]



Recombination between virus-resistant crop plants and viral genomes

The growing of crop plants which have been given a resistance to viral infections through genetic engineering can lead to the generation of new viruses.[9]

Development of resistances in insects and weeds

Resistant strains of cotton leaf worm and cotton bollworm have been found on GM-cotton.[10]

Example for development of resistances in insects: *Bacillus thuringiensis (Bt)*

Natural Bt-sprays have been successfully used in organic farming for forty years for Colorado beetle, corn borer and various caterpillars. The genetic engineering solution therefore uses a well known principle. But, it changes the principle in a way so that it looses all it ecological advantages: The Bt-spray includes the inactive protoxin, which has to be modified into active poison in the gut of the insects. It is not persistent in the environment because it is destroyed by UV light and degraded by micro-organisms. Moreover, its use is managed and is not applied until the pests damage exceeds the threshold limit. Therefore, the risk of pest resistance to Bt-spray is low.[7] In GM-Bt-plants the Bt-toxin is active during the whole vegetation period. Many more insects and other animals and micro-organisms are feeding on the plant and will ingest active poison. This leads to a high selection pressure and a high risk of resistant pests. If this were to occur the benefit of Bt-plants and Bt-spray is reduced and organic farming would lose an efficient plant protection agent.[11]

Differences between Bt-spray and genetically modified Bt-plant

Bt-spray	Genetically-modified Bt-Plant
Includes inactive protoxin.	Active poison present the whole vegetation period in all plant parts.
Only a few insects can modify the substance into active poison in their gut.	All insects and animals that feed on the plant ingest active poison.
Rapid destruction by UV light. No accumulation.	Protected from UV light in the plant cell, therefore active during the whole vegetation period.
Well direct use.	Prophylactic use.
Little chance for development of resistances.	High selection pressure leading to resistant pests.

Economic risks

Monopolisation of seed industry and patents on plants and animals lead to a crucial dependency of farmers

Dependence of agriculture on industrial enterprises (e.g. USA).

(Further) industrialisation of farming

GM-plants are mainly grown in monocultures and large fields.

Job losses

Rationalisation and concentration of agricultural production.

Negative impacts on GM-free (organic) production

Expensive separation and quality assurance systems are needed to guarantee GM-free products.

Liability in case of damages

GM-free farming can sue for damages in the case of loss of income as a result of contaminated produce (liability issue is not sorted out in the EU).

Health risks

Production of unexpected and undesirable substances as a result of the unpredictable integration of genes into the genome.

The genetic modification in a tobacco plant resulted in the unexpected occurrence of a toxic substance[12], more lignification of cell walls of GM-soya and maize[13], in changing levels of phytohormons in GM-soya.[14]

No adequate methods to assess health risks

It has been established that currently there are no adequate and effective animal models to identify and trace the sources of unintentional effects of GMOs on human health. New methodologies have to be developed that are of sufficient sensitivity and specificity to assess the potential of such unintentional effects.[15]

Horizontal gene transfer, particularly of antibiotic resistance marker genes, to the intestinal flora of organisms

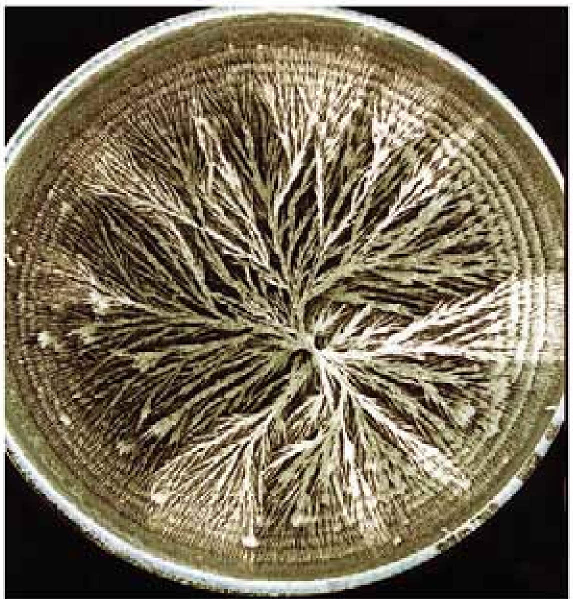
Micro-organisms in the intestinal tract of bees integrated manipulated DNA of oilseed rape plants into their own DNA.[16]

Risk of allergies, allergic reactions

The risk of food allergies increases by introducing foreign genes (which produce proteins) into foodstuff.

Unexpected reactions of organisms to GMOs

The genetically modified cattle growth hormone rBST is used in the USA in dairy cows to increase milk production. The desired increase in milk production is being achieved, but there are a number of animal health problems, particularly metabolic disorders, mastitis and fertility problems. Furthermore, increased incidences of deformities have been observed in calves born to cows given rBST. The milk produced by such cows also contains elevated amounts of white blood cells and contaminants, such as the rBST hormone. Unpublished studies compiled by the producers also showed an increased risk of breast cancer from consuming milk of rBST fed cows.[17]

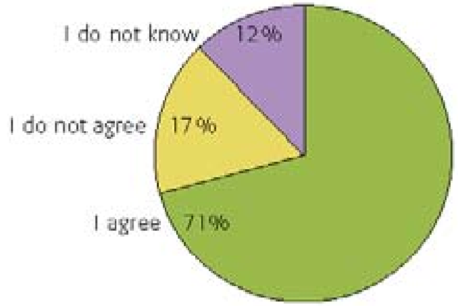


Reduced vitality of transgenic plants

Using picture developing methods, transgenic maize and potatoes were shown to have clearly reduced vital qualities (weakened self-regulation, 50% loss of vitality compared to conventional GM-free samples).[18]

Argument 4:
Consumers do not want genetically modified food

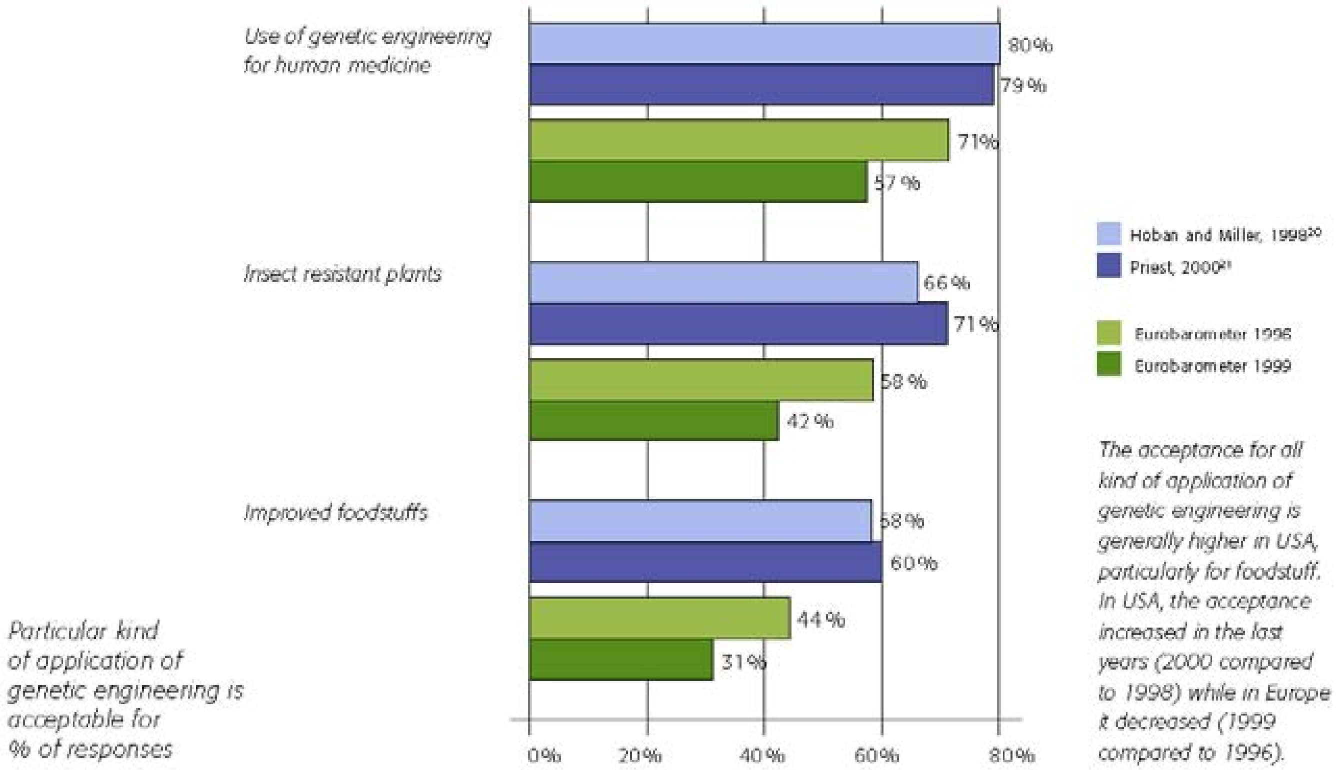
"I am against genetically modified food"



Position on genetically modified food

Polls have repeatedly shown that a majority of European consumers do not agree with the use of green gene technology and do not want to buy GM-foods. So did the latest study of "Eurobarometer"[19] concerning "Science and Society" where 16.029 people from 15 different European countries were asked to their position on genetically modified food. 95 percent of those asked said that they want the possibility to choose between genetically modified and conventional produced food. More than two thirds (71 %) were against genetic modified food in principle and nearly 60 % fear a negative influence of these plants to the environment. Scepticism increased with higher standard of knowledge.

Acceptance for genetic engineering in Europe and USA between 1996 and 2000



The acceptance for all kind of application of genetic engineering is generally higher in USA, particularly for foodstuff. In USA, the acceptance increased in the last years (2000 compared to 1998) while in Europe it decreased (1999 compared to 1996).

Summary: The underlying assumptions and concrete implementations of genetic engineering are opposite to the basic principles and solutions of organic farming. Genetic engineering harbours many as yet unquantifiable risks and offer no sustainable solutions. For these reasons organic farming worldwide does not allow genetically modified organisms and their derivatives to be used.[22]

Why and how organic farming is affected by genetic engineering?

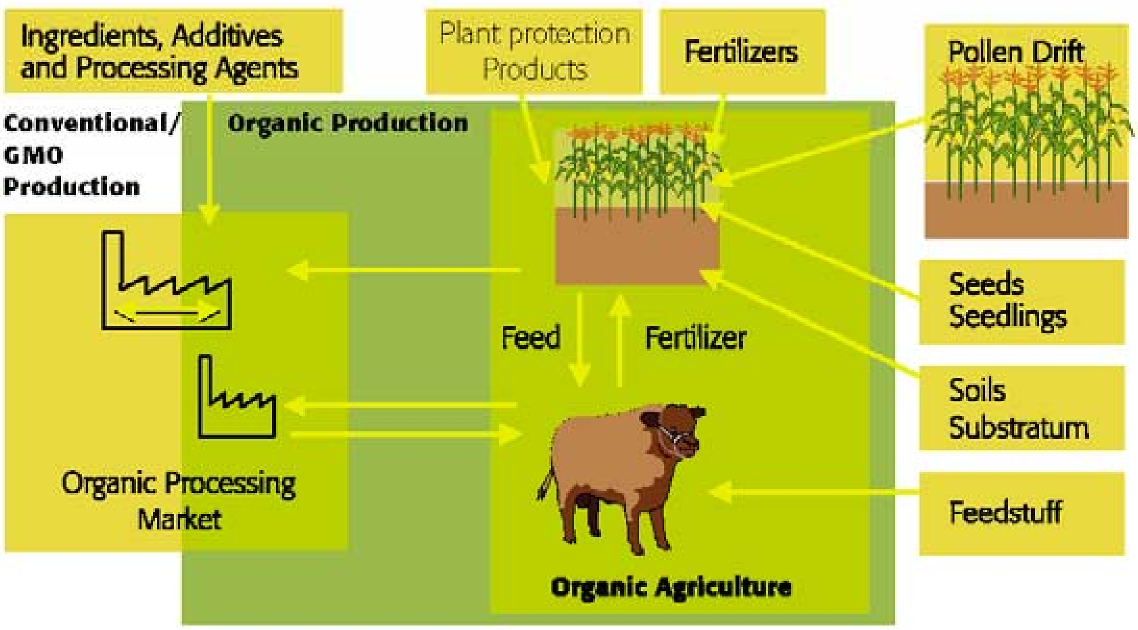
Organic farmers have decided not to use neither genetically modified organisms nor their derivates.[23] But nowadays products of genetically modified plants are being traded globally. The food and feed industry also utilizes numerous derivatives of genetically modified micro-organisms, such as enzymes and vitamins. The global flow of goods of genetically modified organisms has resulted in becoming increasingly difficult to protect organic products from contamination with GMOs.

These are the possible entries of GMOs (see page 16 for control measures for these problems):

- GMO contamination of seeds by way of pollen drift or intermixing.
- Uncontrolled entry of GMO pollen, seeds, plant parts and plants.
- Residues in shared harvesters and seed drilling machines.
- Permitted conventional production aids with critical ingredients.
- Permitted conventional feedstuffs or contaminated feedstuffs.
- Permitted GMO pharmaceuticals.
- Intermixing or contamination in collection points.
- Intermixing or contamination during global transport.
- Intermixing or contamination in transfer points.
- Intermixing or contamination during processing.
- Conventional ingredients, additives and processing aids.

Internationally and nationally organic farming organizations have introduced a number of measures in order to guarantee products are widely GM-free, e.g. improved control of produce flow at critical points, exclusion of critical substances, and internet-based market places for GM-free products. Further measures for the protection of GM-free agriculture must still be taken, including measures at the socio-political level.

Possible points of entry of GMOs into organic farming (overview)



Evaluation of contamination risk

Applications of genetic engineering and extent of the risk of contamination in organic farming (worldwide)

Source: Personal estimation of the situation by the authors

Sectors of organic farming → / Application of Genetic Engineering ↓	Plant production	Animal production	Food processing
			
Genetically modified plants and their products 	Pollen drift ●●● ◆◆◆ Fertilizers, soils, substratum ● ◆◆ Seeds, seedlings ●● ◆◆◆	Feedstuffs ●●● ◆◆◆	Contaminants ● ◆◆ Conventional ingredients ● ◆◆
Genetically modified animals 	Fertilizers and other production aids ○ ◆	Animals ○ ◆◆ Production aids ● ◆	Animal products ○ ◆◆
Gnetically modified micro-organisms and their derivatives (also pharmaceuticals) 	Plant protection products ● ◆◆	Pharmaceuticals (permitted) ●● ◆◆ Probiotica ○ ◆ Additives ●● ◆◆◆	Ingredients, additives, processing agents ● ◆◆

●●● currently high risk
●● currently medium risk
● currently low risk
○ currently no risk

◆◆◆ future high risk
◆◆ future medium risk
◆ future low risk

- *High risk means contamination occurs often and can be up to 1%*
- *Medium risk means contamination occurs sometimes and can be about 0.5%*
- *Low risk means contamination occurs seldom and is on the trace level*
- *Future means in 5 years*

How to keep organic farming "GM-free"

What measures have been taken and what is still to do?

Legislation

In many countries the legislation on genetic engineering bears similarity to a major construction site. As a basic rule one can say that worldwide genetically modified seeds, foods or feedstuffs must pass a governmental approval procedure before they are allowed access to the market. In addition to such an approval a number of countries also require that products made from GMOs are declared as such. However, the rules on declaration vary considerably: In Switzerland declaration is obligatory for seeds, foods or feedstuffs. In the EU currently foods and seeds are subject to declaration. In the USA and Canada neither foods nor feedstuffs are subject to obligatory declaration.
Furthermore, existing legislation places an obligation on organic farming to produce foods without resorting to genetic engineering.[24] Only if the obligatory declaration imposed on suppliers of GMOs is combined with chain-of-custody monitoring, will buyers enjoy transparency and freedom of choice. In order to strengthen the position of the organic farming sector there are now calls for the protection of GMO-free farming, and for liability regimes which would also help to protect the interests of the organic producers.

Regulations and measures of organic farming organisations

Organic farming organisations have analysed the problems and worked out regulations and restrictions:

- Exclusion of critical substances/compounds (e.g. food ingredients, processing agents, processing aids, feedstuffs) and/or limitation of use to components that are guaranteed to be GM-free and of organic quality. This involves a general discussion on which external aids should be authorized for use in organic farming.
- Strict spatial separation and complete documentation and control of produce flow (traceability) prevent contamination and intermixing.

On the next four pages you will find the problems, measures and open questions of the different sectors of organic production in detail.

Information services

Organic farming organisations in Europe have worked out several information services for GM-free production:

InfoXgen.com

www.infoXgen.com: Database for products without genetic engineering

- The database was built up by ALOG (Arbeitsgemeinschaft Lebensmittel ohne Gentechnik) and is now managed by the four control agencies Austria BioGarantie, alicon, bio.inspecta and biozert.
- It simplifies the search for products produced without genetic engineering: demand and supply of products without genetic engineering on different stages of food production and in different market sectors is compiled in the database.
- It supports food producers and processors who want to work without genetic engineering and are looking for corresponding intermediates. In addition, it supports the demand in this specific sector and ensures the sales forecast.
- The database infoXgen.com helps product-manufacturers working without genetic engineering to enter the market and to meet potential buyers or customers.

organicXseeds

www.organicXseeds.com: This database gives you fully up-to-date information on the availability of organic seeds throughout Europe.

- organicXseeds is a product of the Research Institute of Organic Agriculture (Forschungsinstitut für biologischen Landbau, FiBL) developed in an international collaboration.
- It is online since August 2000 and informs on organic and GMO-free seeds and seedlings.
- There are actually more than 3400 products from more than 100 companies from 10 countries in Europe online.
- For users (mostly farmers) organicXseeds is free of charge.

Other information services on the internet on organic farming and genetic engineering (on all these sites you will find several further links):

- www.biogene.org: Information service on GM-free production managed by FiBL (Research Institute of Organic Agriculture)
- www.fibl.ch, www.fibl.de: Research Institute of Organic Agriculture
- www.oeko.de: Institute for Applied Ecology
- www.soel.de: Stiftung Ökologie und Landbau
- www.ifoam.org: International Federation of Organic Agriculture Movements

Problems and measures in the individual areas: Agricultural production (plants, livestock)

	Seeds, seedlings	Pollen drift	Machinery
			
Problem	The seeds can become contaminated with GMOs by way of pollen drift during propagation or breeding or by intermixing during processing and cleaning. Additionally, organic farming has its own standards for seeds and vegetative propagating material and the breeding methods employed, which in some instances clearly deviate from those applied in conventional agriculture.	Organically managed fields in countries where GM-plants are grown can be contaminated through pollen drift (wind or insects).	Risk of contamination from residues in harvesters which are shared among conventional and organic farms. Contamination can also occur by shared seed drilling machines.
Solution/measures	Seed must come from certified organic production in preferably GMO-free areas. The isolation distances between fields for organic seed production and GM-crop fields have to be designated internationally. Contamination in seed handling facilities must be reduced through optimum produce flow segregation. Lists or databases listing suppliers of propagation material for organic farming have been put together and printed or put on the internet (e.g. the www.organicXseeds.com webpages provided by the FiBL).	Sufficient isolation distances have to be established; the design of which is still under discussion. The preferred solution to undesirable pollen drift would be GM-free countries. Plans of GM- and non-GM fields have to be generated. Neighboured farmers can be considerate of each other and place a contract not to plant GM-plants.	Machinery in areas where GM-crops are grown should only be shared between organic farmers.
Open questions	• What would be an acceptable tolerance level for contamination for organic seeds? • How much organic seed has already been affected by GMO-contaminations?	• What are sufficient isolation distances? • Who has to give his land for the isolation distances?	• Can rigorous cleaning of the machinery allow sharing of machinery?

Production aids for agricultural production	Feedstuffs	Pharmaceuticals
		
Aids that are permitted for use in organic farming (plant protection products, ectoparasitica for animals, silage additives, fertilizers and horticultural soils, products for bee diseases and ectoparasites, disinfectants, and cleaning agents used in milking premises) can contain critical substances, i.e. components the source product of which may have been genetically modified (maize, soya, rape etc.).	There are a number of possible pathways for contamination: Many of the organic standards still permit a limited amount of conventional feedstuffs to be fed. Depending on the country these could contain between 0 % and 3 % GMO (threshold limits for labelling) or they may contain critical components which could originate from GM-crops (e.g. extracted soyabean meal, lecithin, micro-organisms).	Some GMO pharmaceuticals are licensed in the EU. Organic farming permits their use as an exception (if required for animal welfare reasons). In this way, GMO (derivates) get into animals.
Companies have to supply evidence that the critical components are GM-free (primarily via produce flow rather than analysis).	In the long term, exclusively guaranteed GM-free, organically produced feedstuffs should be permitted (with produce flow controls). Every feedstuff used in organic farming should be controlled to be GM-free.	The standards should be reconsidered so that GMO-pharmaceuticals are excluded with the exception of legally required vaccinations.
• Is it possible to trace back every auxiliary aid to the production source?	• Is the availability of organically produced feedstuffs (particularly protein requirements) sufficient?	• Are GM-free pharmaceuticals sufficient to safeguard animal welfare? • Are there still GM-free alternatives to the critical pharmaceuticals?

Problems and measures in the individual areas: Transport and processing

	Collection points	Open or closed transport	Transfer points
			
Problem	Risk of contamination is high if organic and GM-products are not strictly separated.	The risk of contamination is very high if goods are not transported in closed containers.	With each transfer or reloading of open transited products contamination or mixing by error is possible.
Solution/measures	The collection of organic products should be limited in the future to installations not dealing with any conventional (potentially) genetically modified products (or dealing exclusively with organic products).	Transport should preferably be done in closed containers. In addition, containers must be cleaned to specific instructions to minimize risks.	Keep transfer and reloading to a minimum. Preferably critical products like maize, rape, soya and cotton should be transited in a container from the field to the processing industry. The transfer of organic products should be limited in the future to installations not dealing with any (potentially) genetically modified products.
Open questions	· In view of the market are only organic systems realistic (costs)?	· Are closed cycles of containers for GM-free or organic products (financially) feasible?	· Who controls transfer and reloading?

Processing	**Conventional ingredients, additives and processing aids**
	
The processing of conventional, genetically modified produce and organic produce in the same installation harbours the risk of contamination; complete cleaning is not possible if produce is of a dusty nature (mills).	Permitted conventional ingredients, additives and processing aids could potentially be genetically modified or be derived from GM-produce.
Segregation of batches between genetically modified and organic produce must be increased and cleaning must be improved. The optimum solution is the spatially separated processing of organic and conventional produce (the latter can always be genetically modified).	Potentially critical raw materials, micro-organisms and enzymes should no longer be permitted for the processing of organic produce or they should only be permitted if they are guaranteed GM-free. Internet marketplace for food production without genetic engineering: www.infoXgen.com.
· How much segregation is required between batches of GM and non-GM products?	· Are there still alternatives to all critical additives and are they available? · Is it possible to control all ingredients, additives and processing aids?

What "GM-free" means in organic production?

"Extent" and "depth" of freedom from genetic engineering in organic production

Organic production (including farming and processing) uses neither genetically modified organisms nor their derivates. This is enshrined in the regulation on organic farming of the EU (Regulation 1804/99/EC amending Regulation 2092/91/EEC) and several other countries and in the standards of the organic organisations.

"Extent": The ban is comprehensive and includes:

Food, food ingredients

Processing aids for food

Feedstuff, feed ingredients

Processing aids for feedstuff

Fertilizers, soil conditioners

Seeds, seedlings

Plant protection products

Livestock

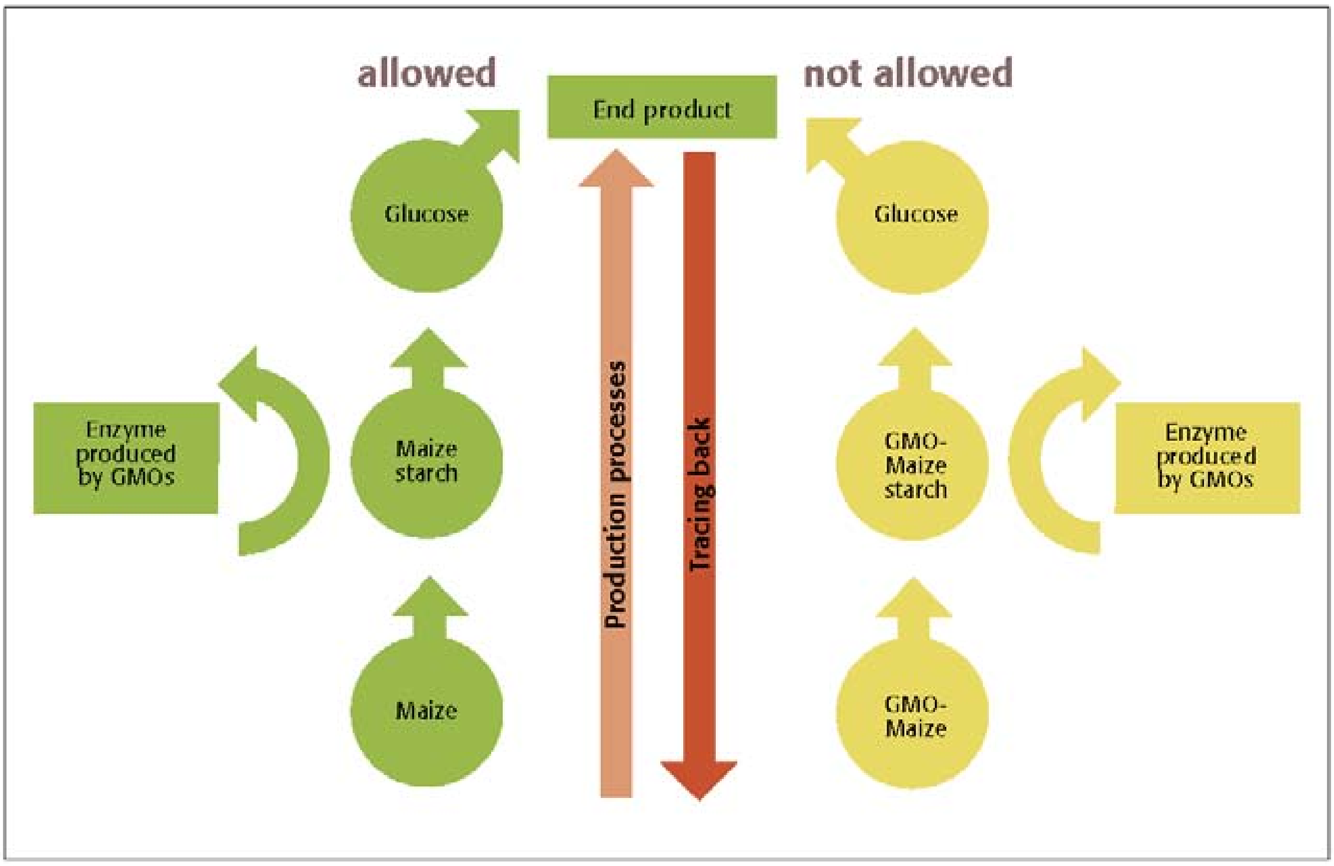
GMO pharmaceuticals are authorized

According to the EU Regulation on organic farming pharmaceuticals derived from GMOs are exempted from the prohibition on genetic engineering. The reasons given are on the one hand that these may be required for the welfare of livestock and that the avoidance of suffering is more important than the general prohibition of GMOs.
On the other hand sometimes there are no alternatives.

Exception

The ban does not extend to cleaning products, fuels and veterinary medicinal products.

"Depth" This aspect addresses the question as to how far back the production process has to be traced in order to assess whether permitted conventional substances have been produced without GMOs.
In order to assess a permitted conventional ingredient, additive or processing aid the production process has to be traced backwards to the point where the first organism with reproductive ability is encountered of which the substance is produced or which has produced the substance. If this organism is not a GMO the product will be permitted in organic farming. Processing aids and enzymes which have been used in the production of the substance in question do not need to be assessed. However, all substances present in the end product, i.e. all carrier substances and formulation aids (in plant protection products) must be considered.[25]



The first reproductive organism tracing back glucose is maize. Maize starch from GMO-Maize is not allowed. Enzymes produced by GM-micro-organisms are allowed in production processes, but not in the product.

Process control versus product analytics – the usefulness of threshold limits for labelling

It is the aim of organic farming to remain as GM-free as possible by taking suitable measures accompanying the produce flow. Realistically, this does not imply complete freedom from GMOs in the end product since traces of GMOs are already more or less widespread, depending on the country. A reasonable tolerance level must conform to the detection level and a correct notation would be "under detection level, not detectable". Most of the organic certifying organizations have not set lower tolerance values than those set by the respective governments (exception: the British Soil Association: 0 %). In the EU the proposed thresholds are 0.3–0.7 % for seeds (proposed Regulation on the marketing of seeds), 0.5–0.9% for foodstuffs (Novel Food Regulation) and similarly for feedstuffs (proposed Novel Feed Regulation).

Points made in the discussion as to why organic farming does not want lower tolerances or "non-detectable level":

1. Segregation

The principal efforts will be made in produce flow segregation. Complete produce flow segregation from the field to the end product is the main strategy used by organic farming in order to prevent contamination and intermixing. Everywhere, from growing to harvesting, to transport and processing the best possible measures and the complete documentation and process control shall ensure the separation of organic produce from conventional and GM produce (see figure on page 21 for illustration).

2. Production system

Organic farming is primarily a production system and does not guarantee residue-free products. This is a consumer expectation which organic farming is trying to fulfil by the agricultural and processing system and by organizing special quality assurance measures. But, in a world full of contaminated land and ubiquitous environmental pollution, this expectation can not be fulfilled completely.

3. Analytical limits

The analysis of produce for GMOs has become routine, however, the desired result, i.e. a figure of x % GMO is subject to numerous potential uncertainties:

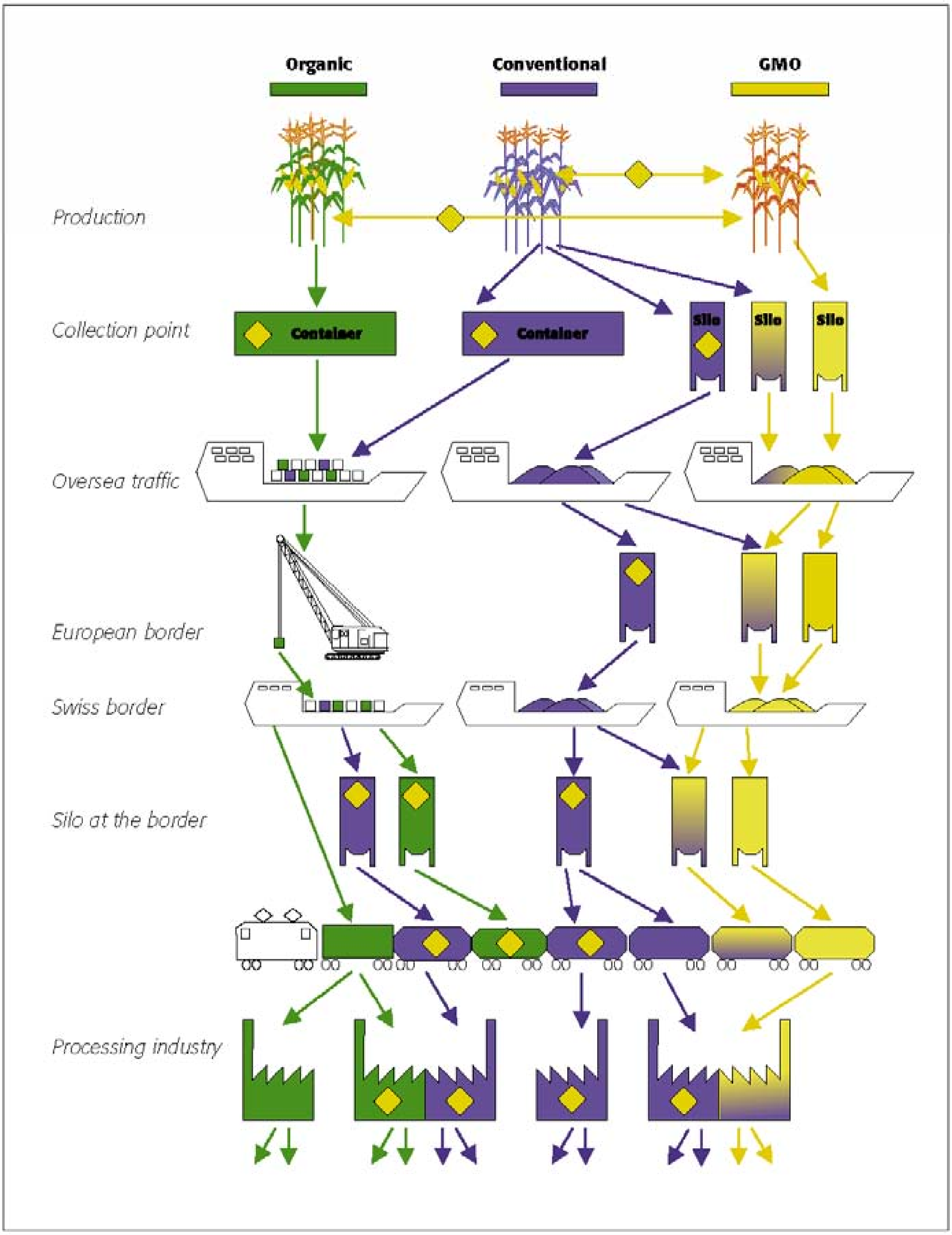
- Sampling has not been standardized. For representative sampling many samples would have to be taken from the optimally mixed batch, then mixed and a composite sample taken for the laboratory. The process is very elaborate.
- Processed products may no longer contain DNA or only traces of it, which means that analytical detection is hardly feasible.
- In processed, assembled products DNA-extraction is often difficult or not possible (e.g. feedstuff).
- Analytics in itself harbours many potential errors, as can be shown in interlaboratory tests. A value of less than 1 %, for example, can be determined with a certainty of +/– 25 %.

For these reasons organic farming focuses on process control rather than on analytical detection of undesirable substances in the end product. Setting threshold values can lead to the mere maintenance of a status quo in which improvements may no longer be made as long as the thresholds are not exceeded. Such a "standstill" would lead to a slackening of attention, and the risk of GMO contamination would increase. The consumers must be given the clear message that end product control is neither sufficient nor useful for organic products. The analysis of the end products serves merely to control the functioning of the process control and the detection of gaps and of systemic errors.

Critical points for contamination during produce flow[26]

(Swiss example)

◇ *Critical points for contamination of conventional (blue) and organic products (green) with GMOs (yellow). For GMO-free products the flow of goods has to be strictly separated.*



Legal protection for organic farming against genetic engineering

Organic farming suffers damage if seeds, foods or feedstuffs are contaminated with GMOs; if threshold limits for labelling are exceeded such products can not be sold as organic. The damage is of a financial nature as well as damaging to the image of the organic sector, since consumers expect and trust organic products to be produced without GMOs. These are quality factors for which they pay a premium.

Organic farming excludes the use of genetically modified organisms and also wants to guarantee this exclusion in the long term. While existing legislation requires organic producers to produce GM-free foods, it does not sufficiently safeguard the producers' interests in this regard. The following measures should be taken in order to offer the organic farming sector improved protection:

1. The protection of GM-free production must be established in the legislation.
2. The polluter-pays principle must be applied to GMO contamination to ensure that the burden for the avoidance of GMO contamination is not placed solely on the organic farming sector.
3. When considering market authorizations for genetically modified organisms, the protection of GM-free production of foods, feedstuffs and seeds should be given high priority.
4. Joint crop rotation plans in the farming sector should be required.
5. International rules for isolation distances between GMO and non-GMO fields should be developed. These rules must be variety-specific and adaptable to regional characteristics.
6. The laws and regulations of every country must answer the question as to who will have to pay for damages and contaminations caused by GMOs.
7. A moratorium on the production of genetically modified plants must be put in place until such time as the above issues have been addressed.

Conclusions

1. As the application of genetic engineering in farming and processing increases, the difficulties faced by organic farming become everymor problematic. The organic production system is not closed and can be contaminated by several paths with GMOs and their derivates.

2. Organic farming has analysed the problems and taken measures: Organic farming organisations have taken several quality assurance measures along the flow of goods and have enact restrictions for critical products.

3. Due to the measures undertaken so far, the information from all participants and the responsibles acting on all stages, contamination in organic products is low and occurs less than in other products.

4. Organic farming can, however, not guarantee GM-free products with 0.0 % GMO. Organic farming strives for 0 %. But technical inevitable contamination is accepted within the legal declaration limits (some countries and organic farming organisations have also set lower limits), as far as the process control is satisfactory. In order to prevent the insidious spread of GMOs the threshold limits for labelling and tolerances must be set as low as possible and practically realisable.

5. Organic farming will campaign further on for GM-free countries and regions, because this is the safest solution for GM-free production.

References

1 Actual facts and figures about GM crop production and enzymes on http://www.transgen.de

2 Maeder P., Fliessbach A., Dubois D., Gunst L., Fried P. and Niggli U. (2002): Soil Fertility and Biodiversity in Organic Farming. Science 296, 1694-1697.

3 see e. g. http://www.plant.uoguelph.ca/faculty/eclark/10reasons.htm; http://europa.eu.int/comm/agriculture/publi/gmo/full_en.pdf; http://www.biotech-info.net/Deutsche.pdf

4 Koechlin F., Nowack K., Brunner T. and Tamm, L. (2000): Future model Switzerland – agriculture without genetic engineering? 13th International IFOAM Scientific Conference, Basel; Ed. FiBL. available at http://www.biogene.org/e/themen/bioland/e-zuku_zsmf.htm. whole study: http://www.biogene.org/archenoah/projekte/zuku.html

5 Tappeser B., Eckelkamp C. and Weber B. (2000): Untersuchungen zu tatsächlich beobachteten nachteiligen Effekten von Freisetzungen gentechnisch veränderter Organismen. Wien, Umweltbundesamt. Monographien Band 129.

6 Simpson E.C., Norris C.E., Law J.R., Thomas J.E. and Sweet J.B. (1999): Gene flow in genetically modified herbicide tolerant oilseed rape (Brassica napus) in the UK. Gene Flow and Agriculture: Relevance for Transgenic Crops, BCPC Symposium Proceedings No. 72, April 1999, Keele, Staffordshire, UK: 75–81.

7 Hilbeck A., Baumgartner M., Fried P. M. and Bigler F. (1998 a): Effects of transgenic *Bacillus thuringiensis* corn-fed prey on mortality and development time of immature *Chrysoperla carnea* (Neuroptera: Chrysopidae). Environmental Entomology 27(2): 480–487.

Hilbeck A., Moar W. J., Pusztai-Carey M., Filippini A. and Bigler F. (1998 b): Toxicity of *Bacillus thuringiensis* Cry1Ab Toxin to the Predator *Chrysoperla carnea* (Neuroptera: Chrysopidae) using diet incorporated bioassays. Environmental Entomology 27(4): 1255–1263.

Hilbeck A., Moar W. J., Pusztai-Carey M., Filippini A. and Bigler F. (1999a): Prey-mediated effects of Cry1Ab-Toxin and Protoxin and Cry2A Protoxin on the predator Chrysoperla carnea. Entomologia Experimentalis et Applicata 91: 305–316.

8 MacArthur M. (2000): Triple-resistant canola weeds found Alta, Western Producer, Feb. 10.

Jorgensen R. and Andersen B. (1995): Sponteneous hybridization between oilseed rape (*Brassica napus*) and weed *Brassica campestris*: A risk of growing genetically engineered modified oilseed rape. American Journal of Botany 81: 1620.

Mikkelsen T. R. et al. (1996): The risk of crop transgene spread. Nature, 380: 31.

9 Jakab G., Droz E., Vaistij F.E. and Malnöe P. (2002): Durability of transgene-mediated virus resistance: High-frequency occurrence of recombinant viruses in transgenic virus-resistant plants. Tagung Perspektiven der Biosicherheit, 5.4.02 Bern.

10 Liu Y.-B., Tabashnik B.E., Dennehy T.J., Patin A.L., Bartlett A.C. (1999): Development time and resistance to Bt-crops. Nature 400: 519.

Gould F., Anderson A., Jones A., Sumerford D., Heckel D. G., Lopez J., Micinski S., Leonard R., and Laster M. (1997): Initial frequency of alleles for resistance to *Bacillus thuringiensis* toxins in field populations of *Heliothis virescens*. Proceedings of the National Academy of Science USA, 94: 3519–3523..

11 see e.g. Tappeser B. (1997): The differences between conventional *Bacillus thuringiensis* strains and transgenic insect resistant plants. Possible reasons for rapid resistance development and susceptibility of non-target organisms. Third meeting of the open-ended Working Group on Biosafety, Oct 13–17, Montreal.

12 Reddy S.A. and Thomas T.L. (1996): Nature Ecotechnology, Vol. 14: 639–642.

13 Stotzky G. (2001): Release, persistence, and biological activity in soil of insecticidal proteins from *Bacillus thuringiensis*. In: Genetically Engineered Organism, Eds. D. K. Letourneau and B. E. Burrows.

Coghlan A. (1999): Splitting headache. New Scientist 20. November 1999.

14 Lappe M. A., Bailey E. B., Childress C., Setchell K. D. R. (1999): Alterations in clinically important phytoestrogens in genetically modified food, herbicide tolerant soybeans. Journal of Medicinal Food, Vol 1 (4).

15 Kessler C. and Economidis I. (Eds.) (2001): EC-sponsored Research on Safety of Genetically Modified Organisms. Review of Results. European Commission, European Communities.

16 Kaatz H.-H. (2000) cited by A. Barnett, GM genes "jump species barrier", The Observer, May 28, 2000.

17 Fagan J. B. (1995): Genetic Engineering: The Hazards—Vedic Engineering: The Solutions, MIU Press, Fairfield, Iowa, USA.

18 Rist L. (2000): Theoretische und experimentelle Untersuchungen über den Einfluss der Genmanipulation auf die Integrität der Arten, Diss. Universität Gesamthochschule Kassel/Witzenhausen.

19 Eurobarometer 55.2: Europeans, Science and Technology. Veröffentlicht durch die Europäische Kommission, Dezember 2001, http://europa.eu.int/comm/research/press/2001/pr0612en-report.pdf

20 Hoban T. J. and Miller J.D. (1998): Consumer images and impressions. Paper presented at the Annual Meetings of the American Association for the Advancement of Science. Philadelphia, P.A.

21 Priest S.H. (2000): US public opinion divided over biotechnology? Nature Biotechnology 18: 939–42.

22 ALOG (2001): Warum keine Gentechnik im ökologischen Landbau? A. Beck und R. Hermanowski, 12.12. 2001. http://www.agrar.de/aktuell/alog.doc

Ökologischer Landbau und Gentechnik – ein Widerspruch! Gemeinsames Positionspapier vom 20.1.1999 von Arbeitsgemeinschaft Ökologischer Landbau (AGÖL) e.V., Stiftung Ökologie und Landbau (SÖL), Bundesverband Naturkost Naturwaren Hersteller (BNN-Hersteller) e.V., Verband der Reformwarenhersteller (VRH) e.V. / Neuform-Reformhäuser, Forschungsinstitut für biologischen Landbau (FiBL). http://www.soel.de/inhalte/oekolandbau/positionalog.html

23 see e.g. IFOAM Basic Guidelines (2002), Migros-Bio-Richtlinien (1.3.1999), BIO SUISSE-Richtlinien (1.1.1999, with changes from 23.9.1999), DEMETER Schweiz Richtlinien (1.1.2000)

24 Switzerland: Organic Farming Ordinance, EU: Regulation on Organic Farming, WTO: Codex Alimentarius

25 ALOG (2001): Interpretation der ALOG zum Verbot der Anwendung von Gentechnik in der Erzeugung und bei der Verarbeitung von ökologischen Lebensmitteln. http://www.infoxgen.com/recht/interpretation.htm

26 Wenk N., Stebler D. und Bickel R. (2001): Warenflusstrennung von GVO in Lebensmitteln. Basel, Prognos. Untersuchung im Auftrag des Bundesamtes für Gesundheit BAG in Kooperation mit Forschungsinstitut für biologischen Landbau (FiBL), Büro für Umweltchemie und Dr. Rudolf Bieri (Beratung für die Lebensmittelindustrie)

27 Gentechnik Lexikon http://www.interpharma.ch/info/wissens/lexikon/index.html

Photos

© Copyright of Photos; order of numbers on a page: top – down , left – right

Title: FiBL
Page 2: Michel Haring, University of Amsterdam
Page 4: Siegfried Keller, FAL
Page 5: (1) FiBL; (2) Gabriela Brändle, FAL
Page 6: Swissaid
Page 7: (1) Lemnatec; (2) and (3) FiBL ; (4) Percy Schmeiser; (5) bioscience network, http://www.bioscinet.bbsrc.ac.uk/heal.html; (6) Agricultural Research Service, USDA
Page 8: (1) FiBL; (2) and (3) Markus Senn, Internutrition; (4) and (5) FiBL
Page 9: (1) Midgley, Greenpeace; (2) Dott, Greenpeace; (3) Stefan Kühne, Biologische Bundesanstalt; (4) (FiBL); (5) Markus Senn, Internutrition; (6) Ursula Graf, FiV
Page 12: (1), (2) and (3) FiBL; (4) Buxbaum, Greenpeace; (5) Keystone; (6) FiBL
Page 14: (1)D. Lopes, Greenpeace; (2) Nimtsch, Greenpeace; (3) Markus Senn, Internutrition
Page 15: all FiBL
Page 16: (1) www.plock.ids.edu.pl; (2) and (3) Cereal Research Centre, Canada
Page 17: (1) Ralph Brunner, Greenpeace; (2) FiBL
Page 18: (1), (2), (3), (4), (5), (7), (9) FiBL; (6) Markus Kellerhals, FAW; (8) AGFF
Page 20: FiBL
Page 22: FiBL
Page 24: all FiBL

Imprint

Editor: Research Institute of Organic Agriculture (FiBL), Ackerstrasse, P.O. Box, CH-5070 Frick, Phone: +41 (0)62 865 72 72, Fax: +41 (0)62 865 72 73, E-mail: admin@fibl.ch, Homepage: www.fibl.ch
Research Institute of Organic Agriculture (FiBL) Berlin e.V., Geschäftstelle Frankfurt, Galvanistrasse 28, D-60486 Frankfurt, Phone +49 69 7137699-0, Fax +49 69 7137699-9, fibl@fibl.de, www.fibl.de

Authors: Karin Nowack Heimgartner (FiBL, Frick), Regula Bickel (bio.inspecta, Frick), Eric Wyss (FiBL, Frick)

Co-Authors: Alex Beck (FiBL, Berlin), Robert Hermanowski (FiBL, Berlin), Bruce Pearce (Elm Farm Research Centre, Newbury), Beatrix Tappeser (Institute for Applied Ecology, Freiburg)

Collaboration: Hans Hosbach and Andrea Raps (BUWAL), Markus Wittmer (BIO SUISSE), Gabriela Wyss (FiBL, Frick), Bernadette Oehen (FiBL, Frick)

Editorial staff: Thomas Alföldi (FiBL, Frick)

Layout: Markus Fricker, Auenstein; Ursula Mötteli, Aarau; Daniel Gorba, FiBL

Translation: Christopher Hay, Bruce Pearce, Peter Sim (English version), Christian Houba (French version), Karin Nowack (German version)

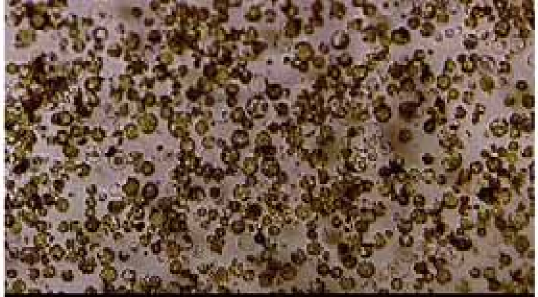
Lectorate German: Markus Bär

ISBN: English: 3-906081-30-3
ISBN: German: 3-906081-28-1
ISBN: French: 3-906081-29-X

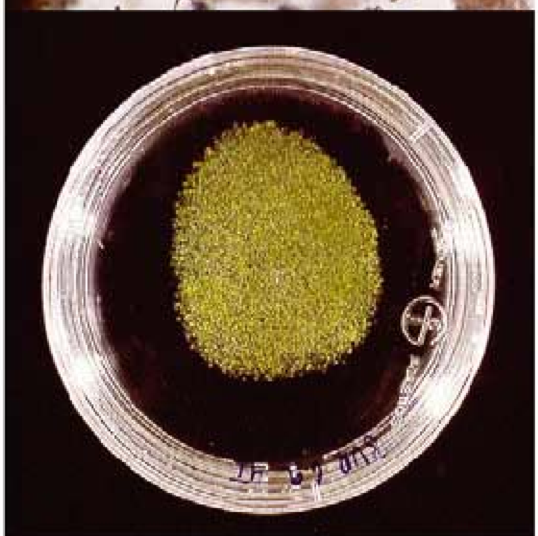
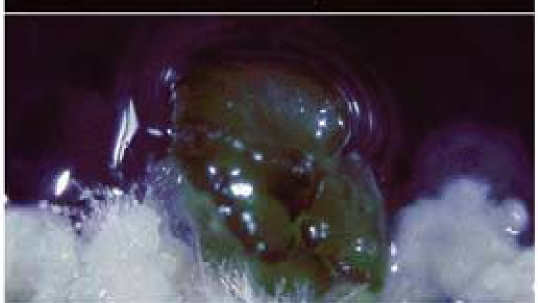
Price: 5,6 Euro/CHF 8.–

Sale: FiBL: admin@fibl.ch

© FiBL





Glossary[27]

DNA
DNA (desoxyribonucleic acid) is a double-stranded helix of nucleotides which carries the genetic information of a cell. It encodes the information for the production of proteins and is able to self-replicate.

DNA transfer
The transfer of DNA from one organism or cell to another.

Enzyme
Enzymes are proteins to carry out biochemical reactions (or act as catalysts) inside or outside the cell.

Gene
Genes are the fundamental units of heredity. A gene is an ordered sequence of DNA segments that encodes a specific protein or RNA molecule. The entirety of the genetic material in the chromosomes of a particular organism is called the genome.

Genetically modified organism (GMO)
Transfer of a gene from one organism into another using genetic engineering (for example a bacterial gene protecting from larval attack into a maize plant) which alters the recipient of the gene in a manner that would not have been possible naturally.

Genome
All of the genetic information of a particular organism is called the genome. The human genome consists of 23 different pairs of chromosomes.

PCR
Polymerase Chain Reaction. A method for replicating ("amplifying") very small traces of DNA. This replication solves the problem that genetic material is often found only in minute traces and thus prevents direct detection and analysis.

Proteins
The translation product of a gene. It can be visualized as a string of aminoacids, which are ordered through the definition of the genetic code of a particular gene.

RNA
Ribonucleic acid. Molecules with a variety of purposes. As messengers: RNA serves as a template for protein synthesis "translating" the information contained in the DNA. (Dogma in molecular biology: DNA → RNA → Protein). Some viruses contain RNA as their genetic material and can transcribe it to DNA, using a special enzyme, the reverse transcriptase. However, DNA can never be the messenger for the translation of the genetic code into the synthesis of proteins. The chemical structure of RNA is very similar to that of DNA.