«Future Model Switzerland – agriculture without genetic engineering?»

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Starting point of the present study was the question of how an ecologically, economically and socially sustainable agricultural of tomorrow could be like. What strategies are the most appropriate to solve the concrete problems of Swiss / of European agriculture? The present study examines six crops regarding these questions: potato, wheat, maize, rape-seed, salad and grape. It opposes current approaches in genetic engineering to both traditional growing methods and solution strategies as well as modern research approaches of 'integrated' and organic farming.

1. What are the most important pests in Europe?

The most important pests in Europe concerning the six examined plants are:

Crop	Problem/disease	Crop	Problem/disease
potatoe	Phytophthera Infestans (late blight of potatoe)	**rape**	Psylliodes chrysocephalus (rape flea)
wheat	Fusarium spp.		Meligethes aeneus (blossom rape beetle)
	Pseudocercosporella herpotrichoides (cereal eyespot)		Ceuthorthynchus napi
	Septoira nodorum (septoria disease)		Dasineura brassicae
maize	Fusarium culmorum, Gibberella zeae	**vine**	Plasmopara viticola (downy mildew)
	Ostrinia nubilalis; O.furnacalis (European corn borer)		Uncinula necator (powdery mildew)
	weed		Botrytis cinerea (grey mould)
salad	Bremia lactucae (downy mildew)		Mycoplasma (MLO)
	Pemphigus bursarius		Eupoecelia ambiguella, Lobesia botrana

In addition to these central problems, there exist about 100 further pests that cause major problems in cultures all over Europe.

The great number of relevant pests is remarkable (insects, fungi, bacteria, virus or wild-growing plants). It cannot be expected that either genetic engineering or research in organic agriculture offer single 'miracle solutions' against this great number of different pests.

2. Are the problems tackled with purpose?

Solution strategies in genetic engineering:
In 1998, herbicide-resistant plants grew on 72% of the commercial area under cultivation. Insect-resistant Bt-plants were cultivated on 28% of the area. All other modifications of characteristics (eg virus-resistance or modifications of the substance) clearly remained under one percent.

Herbicide-resistance: Concerning the six examined cultures in Switzerland, herbicides are only of a major problem in the cultivation of maize. This problem can be tackled efficiently with organic or integrated methods as well (mechanic and thermal regulation of herbicides, sowing by strip-milling , herbicides in integrated agriculture).
In this respect, the approach of genetic engineering offers solutions to a problem but it establishes an agriculture based on chemistry that has no future chances if seen under the aspects of sustainability.

Insect-resistance: Genetic engineering offers Bt-maize against the European corn borer and Bt-potato against the Colorado beetle. For both the European corn borer and the Colorado beetle well-established organic regulation methods are available. Against the European corn borer, it is the ichneumon fly Trichogramma. Against the Colorado beetle, the spore preparations of the ground bacteria Bacillus thuringiensis (Bt-spray) are successfully used as a biological insecticide; they show good results against other pests as well.
Together with a number of unsolved questions about unintentional ecological effects, the use of these transgenic plants (mainly concerning the potato) involves the risk of destroying the ressource Bt-spray because it is to be taken into account that the pests quickly form a resistance against the insecticide. In the USA, a reduction of insecticide was not put into effect.

For more than 90% of the urgent problems in Swiss/ European agriculture, there are either no answers or none with practical application coming from genetic engineering. The protagonists in genetic engineering research do not start out from a purposeful identification of the problem itself but they focus on the possibilities offered by the methods.

Solution strategies in organic and 'integrated' farming

The main solution strategies and research approaches in organic farming are the following:

Good crop-management (eg locally adapted cultivation, diverse crop-rotation-systems, times of breaks in cultivation, balanced fertilizing, enhancing soil-fertility and the capacity of the soil to reject diseases).

(Conventional) resistance breeding (support by genetic-marker-methods seems a possibility for enhancement).

Use of ecologically friendly pesticides and antagonists. (Examples from practice and research: Potato scab is inhibited by suppressive bacillus subtilis strains, blackleg of potatoes by pseudomonas fluorescens strains. Against the corn borer, the antagonist trichogramma brassicae, preparations of b. thuringiensis or Beauveria bassiana are known. In rape-seed, different whasps, nematodes and protozoas are important parasites against harmful insects. In the cultivation of salad, trichoderma-fungi showed good experimental results against different fungi. In vineyards, erwinia herbicola and fusarium proliferatum showed first good results against the powdery mildew.)

Prognostic and early warning systems have a great potential: the knowledge of the biology and the dispersal of pathogens combined with climatic factors such as temperature, rainfall, and humidity are fed into mathematical models. It is then possible to determine the risk of infection, to optimize the dates of application, and to avoid unnecessary use of insecticides. At the moment, these mathematical models are constantly improved and adapted to various local conditions.
In Switzerland, prognostic models on the cultivation of grape, pome, grain and potato were developed or commercially available products were evaluated and adapted. Up to now, warning systems were mainly developed for use in 'integrated' production. Since 1997, the FiBL evaluates these methods for use in organic farming.

Variety-mixtures belong to the preventive methods that are used in all cultivating systems. A mixture of varieties is altogether more resistant against diseases since the individual varieties react differently to pests and environmental influences.

Induced resistance seems to be a very promising method, which is at an experimental stage for biological substances at the moment. Plants have the capability to actively resist diseases. In general, an induced plant is resistant against numerous fungi, bacteria, and virus. This defence mechanism cannot only be induced by a pathogen, but also by various substances that simulate the pathogens' attack or intervene in the complex signal chain.

Conclusion: Genetic engineering is the answer - but what was the problem? Transgenic plants do not address the central problems of agriculture.
Solution strategies and research approaches in organic farming start out from the concrete problems in cultivation and the different pathogenes, which, in general, they do not fight as isolated factors but in a framework of an inter-disciplinary system that allows to take many different measures. Prevention plays a central part in this system.
These solution strategies and research approaches offer a great potential for the 'integrated' production as well.

3. Are there limits inherent in the system?

It is not by pure chance that research in genetic engineering offers no solutions in the fight against the most important pests in agriculture. For instance, the various pathogenes of mildew – one of the main problems in the cultivation of potato (late blight), grape (powdery and downy mildew), and salad (powdery mildew) – are very dynamic and quickly adapt to new plant-resistances. All plants that are resistant against the pathogenes of mildew are poly-resistant, taht is, they contain various partial-resistances, which altogether are responsible for a good resistance as a whole. Furthermore, the variety of these partial-resistances accounts for the fact that mildew cannot break through and adapt to the plant. The isolated use of individual resistance factors by genetic engineering in this context is questionable and it is uncertain whether this strategy will be successful in the end. Possibly, the linear genetic approach could favour the selection of new virulent pests which could attack poly-resistant varieties as well. It is very doubtful whether transgenic potatoes or grapes, with introduced chitinase- and/or glucanase-gene by cloning, will ever be able to functionate. (And: What is the effect of the fungicide chitinase on the mykorhizen at the roots, which are extremely important for the plant? In both experimental documents, this problem was left aside.)

Approaches in organic farming: Because of the flexibility and the dynamic of mildew-pathogenes, the varied 'mosaic approach' of organic farming seems to be the best strategy to prevent the breakthrough of resistances. The measures taken against mildew-pathogenes consist in: (conventional) breeding of resistant plants, habitat management, search for antagonists and eco-friendly fungicides, working out of early warning systems, variety-mixtures and research on inducing plant-immanent resistance mechanisms. This approach showed first positive results with salad (powdery mildew), potato (late blight), and grape (powdery and downy mildew). Nevertheless, the mildew-pathogenes still pose great difficulties in organic farming (eg preparations with copper are still indispensable). Much research is needed in this direction, which is actually done in international research programs.

4. Are the different systems of farming sustainable?

The methods of genetic engineering can be efficient for vast areas of land under the basic conditions of monocultural farming. They reinforce a high-input-agriculture based on monocultures, which appeared to be very problematic, as was shown above, as this agriculture is the main cause for well-known problems of the environment (water pollution, damage to soil-fertility, loss of variety).
The methods of genetic engineering hardly cause better economic efficiency: transgenic plants are hardly more productive and hardly need less pesticide than conventional plants. In addition, they involve many unpredictable and long-term risks (crossing-out of transgenic pollen, breakthrough of resistances, detrimental effects on 'non-target-organisms', antibiotic resistances, unexpected position-effects, allergies, etc).
Seen under the economic and social aspects of sustainability, the fact that transgenic plants can be patented whereas conventionally bred plants cannot is of great importance. The monopoly rights guaranteed through patents create growing dependency among the farmers concerned, in particular among the farmers from the southern countries, and they lead to a concentration of the world market with seeds on a few transnational lifescience-companies. New 'terminator-technologies' are susceptible of extending their control of seed even more.

Organic farming: It is evident that organic farming is eco-friendlier. Scientific research repeatedly showed evidence of the ecological advantages over conventional farming (higher soil-fertility, more variety, less residue). The evaluation of the social and economic aspects of organic farming is more controversial: organic farming is often more labour-intensive than conventional farming.
Organic farming maintains it's hold on the European market and even keeps on growing, as prove numerous statistics. This development was made possible by the following three facts: 1. great demand for organic products, 2. good marketing, 3. subventions by the state for ecological activities (direct subventions, subventions for areas in compensation).
At the level of individual farms, several studies prove that organic farming is a good economic alternative. Thanks to the strong diversification of most eco-farms new jobs are created.

5. Sustainable agriculture – what production?

The methods of organic farming meet best the calls for sustainability. As this present study shows, solutions or solution strategies exist for most of the central problems in agriculture in spite of comparatively modest funds. The numerous innovative and inter-disciplinary research approaches indicate that there exists a great potential for solving these problems. Consequent support of research could open up new capacities that are profitable for the national economy as well.

Swiss agriculture: close to nature – without genetic engineering

In view of the growing opposition against genetically modified food in Switzerland and Europe; in view of the growing economic difficulties with these substances; in view of the unsolved long-term risks; and in view of the innovative potential of modern research without transgenic modification, a Swiss agriculture close to nature – including both organic and 'integrated' production and refusing the use of GMO-products – offers great chances:

- for economic reasons: excellent promotion of Swiss agriculture on the international market with the label 'made in CH';
- for ecological reasons: avoidance of long-term risks and acceleration of the structural change in the direction of a sustainable agriculture;
- and for 'culinary' reasons: consumers get what they want: healthy food that is produced close to nature and free of genetic engineering.

(Florianne Koechlin, March 2000)