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ECOSYSTEM SERVICES AS A TOOL FOR PRODUCTION IMPROVEMENT IN ORGANIC FARMING

– the role and impact of biodiversity

Birgitta Rämert, Lennart Salomonsson, Paul Mäder (editors)

Centrum för uthålligt lantbruk

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Ecosystem services as a tool for production improvement in organic farming
– the role and impact of biodiversity

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– the role and impact of biodiversity

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Abstracts

Ecosystem services as a tool for production improvement in organic farming – the role and impact of biodiversity

FiBL Research Institute of Organic Agriculture, Frick, Switzerland
April 15–16, 2005.

The purpose of this workshop was to create a meeting to exchange knowledge between the two programs in organic production FiBL, Research Institute of Organic Agriculture and Formas – Eco and trade relevant research questions for a future research program with focus on the role and impact of biodiversity in organic farming.

Organic farming relies largely on locally available resources and is dependent upon maintaining ecological balance and developing biological processes to their optimum. Organic farming is also committed to conservation of biodiversity within agricultural systems. Over the past decade, long-term research projects have accumulated evidence that organic systems are beneficial to biodiversity. However, biodiversity is under threat. How can the organic agriculture improve the systems in a way that conserve and increase the biodiversity and using the related ecosystem services as a tool for improving the production to meet the challenge for food production in the future?

In this workshop we have fostered discussions of issues affecting biodiversity in organic farming and how biodiversity could be related to ecosystem services on a field and a landscape level. Challenges and threats for biodiversity in organic farming in a global perspective have been discussed.

The workshop is presented here by an abstract of the presentations. The discussion highlighted the needs for further research on how to integrate ecosystem services in the organic production as production tools, and how environmental benefits from such integration can be recognized by society. The discussion also indicated the needs for research farms/laboratories for systems research on multifunctionality and imple-mentation of ecosystem services as design principles for future sustain-able farming.

Paul Mäder (FiBL), Lennart Salomonsson and Birgitta Rämert (SLU)

List of workshop participants

Kjell Andersson, SLU
Sara Antell, SLU
Beat Bapst, FiBL
Jan Bengtsson, SLU
Maria Björkman, SLU
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Sara Elfstrand, SLU
Nils Fall, SLU
Roger Finlay, SLU
Andreas Fliessbach, FiBL
Barbara Früh, FiBL
Ulrika Geber, SLU
Gunnela Gustafson, SLU
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Magdalena Presto, SLU
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Lennart Salomonsson, SLU
Hans-Jakob Schärer, FiBL
Jörg Spranger, FiBL
Karin Svanäng, SLU
Jörgen Svendsen, SLU
Kristian Thorup-Kristensen, Arslev
Karin Ullvén, SLU
Anna Wallenbeck, SLU
Franco Weibel, FiBL

Workshop SLU/FiBL

Ecosystem services as a tool for production improvement in organic farming – the role and impact of biodiversity

Key words: biodiversity, functionality, mixed crops/animals, habitat management

Aims

- Knowledge exchange between the two programs in organic production (FiBL and Formas-eko)
- Create relevant research questions for future research program with focus on the role and impact of biodiversity in organic farming

Location

Research Institute of Organic Agriculture, FiBL, Frick, Switzerland; www.fibl.com
e-mail: admin@fibl.org
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Organised by

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Aspects organisation

- Participants from Sweden: Total of around 30
- The workshop addresses the Science of both Plant and Animal Husbandry. A morning session with general aspects of biodiversity in agricultural production, and in the afternoon a more specialised session with aspects in crop production and animal production, respectively.
- Further guests: selected colleagues from FAW and/or FAL

Time schedule

April 14 to17 2005

- 14.4.: evening: arrival, hotel accommodation, individual dinner
- 15.4.: work shop at FiBL, guests will be picked up at 8.00 at the hotel, social dinner at an Italian Restaurant (Trattoria Rustichello) Oeschgen/AG
- 16.4.: field excursion on farms and to the DOK field experiment, social dinner at Restaurant Schwert; Schupfart/AG
- 17.4.: back travel

Costs

All costs of the Swedish guests will be covered by the Swedish University of Agricultural Sciences (SLU)
The costs of FiBL staff has to be covered by FiBL's budget.

Workshop program at FiBL
15th April 2005

Morning plenary session **Chairman: Paul Mäder**
Room: Aula

08.30 – 09.00	Organic farming in Switzerland	Urs Niggli, FiBL
09.00 – 09.25	Biodiversity in organic farming – challenges and threats	Lennart Salomonsson, SLU
09.25 – 09.50	Functional biodiversity	Jan Bengtsson, SLU
09.50 – 10.20	*Coffee break*	
10.20 – 10.45	Field margins to improve pest control in organic vegetable production	Lukas Pfiffner, FiBL
10.45 – 11.10	Biodiversity as tool in nutrient supply	Kristian Thorup-Kristensen, Årslev
11.10 – 11.35	Biodiversity as a tool in animal husbandry	Gunnela Gustafson, SLU
11.35 – 12.00	Sustainability of organic and integrated farming (DOK trial)	Paul Mäder, FiBL

12.00 – 13.30	**LUNCH BREAK**

Afternoon session I **Crop Production** **Chairman: Lennart Salomonsson**
Room: Aula

13.30 – 13.45	Biodiversity in the landscape – impact of organic farming	Maj Rundlöf, Lund University
13.45 – 14.00	Green manuring in organic vegetable production	Martin Koller, FiBL
14.00 – 14.15	Soil microbial diversity related to carbon fluxes	Andreas Fliessbach, FiBL
14.15 – 14.30	Soil microbial diversity and function - impact of organic amendments	Sara Elfstrand, SLU
14.30 – 14.45	Variety mixtures in letuce production	Hans-Jakob Schärer, FiBL
14.45 – 15.15	*Coffee break*	
15.15 – 15.30	Sustainable apple production	Franco Weibel, FiBL
15.30 – 15.45	Intercropping as a pest management strategy against turnip root fly	Maria Björkman, SLU
15.45 – 17.00	**SUMMARY and DISCUSSION**	

Continue, 15th April

Afternoon session II Animal Production Chairman: Kjell Andersson
Room: Kursraum 2

13.30 – 13.45	Non Antibiotic Udder Health Strategies in Organic Dairy Herds	Jörg Spranger, FiBL
13.45 – 14.00	Breading Strategies in Organic Dairy	Beat Bapst, FiBL
14.00 – 14.15	Farming Control of Endoparasites in Ruminants and Poultry	Veronika Maurer, FiBL
14.15 – 14.30	Organic Pig Farming	Barbara Früh, FiBL
14.30 – 14.45	Pigs suitable for organic pig production	Anna Wallenbeck, Lotta Rydhmer, SLU
14.45 – 15.15	*Coffee break*	
15.15 – 15.30	Nutrients supply, health aspects and meat quality in organic pig production	Magdalena Presto, SLU
15.30 – 15.45	Organic housing systems for slaughter pigs	Anne-Charlotte Olsson, Jörgen Svendsen, SLU
15.45 – 16.00	Feeding of different layers kept in an organic feed environment	Gabrielle Lagerkvist, SLU
16.00 – 17.00	**SUMMARY and DISCUSSION**	

19.00	**SOCIAL DINNER AT AN ITALIAN RESTAURANT**

16th April 2005

Field excursion

08.30	Starting at Frick by bus. Participants will be picked up at the hotel
09.15	DOK field experiment
10.30	Agrico vegetable producer association
12.15	*Lunch at Restaurant Heyer, Biel-Benken*
14.00	Departure by bus
15.00	Mixed farm at Wauwilermoos (Pius Marti) Central Switzerland Arable and vegetable crops, dairy cows, pigs, horses
17.00	Departure by bus
18.00	Back at hotel
19.00	Departure by bus at the hotel
19.30	*Social dinner at Schupfart, Restaurant Schwert*
22.00	Departure by bus
22.30	Back at hotel

Gunnela Gustafson, Swedish University of Agricultural Sciences (SLU), Department of Animal Nutrition and Management, e-mail: Gunnela.Gustafson@huv.slu.se

Biodiversity as a tool in animal husbandry

Biodiversity in general has the power to generate resilience in an ecosystem.

In a short time perspective (1 to 2 human generations) it is desirable that agricultural production systems are robust, in order to meet variations in weather conditions, animal health, farmers' health and social life, market, processing industries, politics, without causing ultimate troubles for the farmer or his/her animals. In a long time perspective larger changes in farming conditions might occur, hopefully gradually. To meet such changes it is crucial to keep up genetic variation in plants and organisms and biophysical possibilities for food production in a broad sense. But because it is a long time perspective does not mean that we can think about it later, we have to think about it in every decision.

By studying different indigenous cultures, we find profound knowledge and experiences about phenomena in nature that are crucial for life in their environments. Just think of all qualities of the snow that people dependent on that have names for! New innovations have often been a result of access to new and more powerful inputs, like coal or mineral oil and electricity. Those inputs are so powerful and cheep that we could overuse them and overcome many difficulties in a fairly easy way and separate farming systems into independent parts. It has taken some time to realise that there are environmental drawbacks of this heavily supported agriculture, but a lot of efforts are now put on finding more sustainable solutions. A holistic interactive perspective of life on earth by many scientists has led to an effort among them to develop guiding principles for food production based on systems ecology embracing natural and social systems. The development of organic farming is a parallel in perspectives among farmers and consumers.

In organic farming and animal husbandry there is a pronounced goal to decrease the dependence on non-renewable resources due both to their effects on our climate and to declining supplies. However, there has been little progress in this, due to the facts given above about cheep, abundant and powerful inputs. A future view of the farm animals also as energy suppliers might seem unrealistic today, but not tomorrow, and as energy suppliers, different species have different capabilities.

Exchanging tools like advanced housing and feed processing, and preventive medication for biodiversity in animal and plant species, means that we need to learn more about other characteristics of different species than production, and also how the species can be used in different environments. Working with the farm more like a complete unit also needs more of knowledge about self-organizing systems as a tool for planning. The development of ecology in science gives us that new opportunity. Last but not least, knowledge about how to read and interpret the behaviours of the parts of and interactions in farming systems is crucial for a successful management and performance. As mentioned earlier, we can get an idea about how much detailed information there is from other cultures. We have also gained a substantial amount of new useful knowledge about animal husbandry through science, but the knowledge that is needed to direct animal husbandry into a more systems based concept is yet very much lacking.

Kristian Thorup-Kristensen, Danish Institute of Agricultural Sciences (DIAS), Department of Horticulture, e-mail: Kristian.ThorupKristensen@agrsci.dk

Biodiversity as a tool in nutrient supply

A high biodiversity is an environmental goal, but it is also important for the efficiency and stability of the agricultural systems themselves. For environmental as well as for agricultural purposes, biodiversity is therefore seen as an important goal in organic farming.

Biodiversity is often regarded broadly as an unspecific but desirable quality, but for many purposes, it is possible to work with biodiversity in a more systematic way. The plants which we grow as main crops, green manure crops or cover crops have different life strategies and characteristics. The plants have developed these differences through their adaptation in nature, and we can use them to develop better farming systems.

In our work on root growth of cereals and vegetable crops, we have found a large diversity in root characteristics. The rooting depth among vegetables ranges from 25 cm for onion to more than 250 cm for long season cabbage crops.

Vegetable rotations including e.g. onion, lettuce, potato and seleriac may be diverse, but all of these crops are relatively shallow rooted. In our experiments we have shown that we can improve the use of nitrogen by introducing deep rooted crops, which can take nitrogen from the subsoil layers unavailable for the shallow rooted species. In this case it is not the diversity as such, but diversity in one specific characteristic of the plants which can help to improve the system.

Much of our work has focused on green manures and cover crops. When growing green manures we have a much larger diversity to choose from, as we are not limited to species which can be sold profitably. Among these many species there are lots of differences to work with, and our studies have shown that new species can be introduced with important "new" characteristics.

As an example, crucifer crops such as white mustard and fodder radish have deep root growth, and can be very efficient cover crops for preventing nitrogen leaching losses. However, they are not winter hardy and they are not suited for establishment by undersowing. Other types of crucifer crops are winter hardy, and we have even identified a crucifer crop (dyers voad) which is well suited for undersowing in cereals. In vegetable rotations with crucifers as main crops, crucifer cover crops may be undesirable due to disease problems, and we may need deep rooted species from other plant families for such rotations. While the experimental results show that inclusion of deep rooted cover crops may be a very powerful tool to improve crop nutrition in organic rotations, the example shows that we need a number of different species to allow us to use this efficiently.

There are many other differences among plant species which we can use to improve cropping systems. Regarding crop nutrition directly, significant differences in factors such as C/N ratio of plant material, sulphur uptake, phosphorus utilization from strongly bound phosphorus fractions in the soil, or plants with or without mycorrhiza on their roots. To be able to use these differences in practical farming, the plants must fit into the cropping system as main crops or green manure crops. To fit into the system, their general growth habit, whether they are pioneer plants, or are adapted to later stages of succession, and whether they are annual, biannual or perennial are important characters. E.g. cover crops grown only during a short period in the autumn must show fast establishment and growth, whereas cover crops for intercropping or undersowing must not compete too strongly with the main crop, but still be able to develop efficiently after main crop harvest.

Jan Bengtsson, Swedish University of Agricultural Sciences (SLU), Landscape Ecology at the Department of Ecology and Crop Production Science, e-mail: Jan.Bengtsson@evp.slu.se

Biodiversity in organic farming

In the first part of this talk, I will discuss various ways in which biodiversity can be related to ecosystem services, such as biological control and pollination, and how biodiversity can be regarded as an insurance in variable environments. In the second part, I will give some examples from our own research on the effects of organic farming and landscape heterogeneity on diversity and biological control (e.g. Weibull et al. (2003) Biodiversity and Conservation 12, 1335; Östman et al. (2001) Basic and Applied Ecology 2: 365). Finally, I will present the results from our meta-analysis on the effects of organisc vs. conventional farming on diversity and total abundance of various organism groups (Bengtsson et al. (2005) Journal of Applied Ecology, in press).

We found that, in the mosaic landscape in central Sweden, landscape heterogeneity was more important for diversity than organic farming. In addition, the abundance of pollinators was higher, and biological control of aphids was more efficient, on organic farms and in mosaic landscapes. In the meta-analysis, there were overall positive effect of organic farming on species richness (≈ 30 % higher) and abundance of organism groups (≈ 50 % higher). However, the results were heterogeneous among studies, organism groups, and study scales. Our results thus suggest that organic farming varies in its effects on diversity and abundance depending on organism group and landscape context. Hardly surprising but quite interesting, I think.

I conclude that understanding the role of biodiversity in organic farming requires more studies conducted at the scales at which management decisions are made, such as whole farms, whereas studies on small plots often are of limited value.

Biodiversity in organic farming – challenges and threats

Lennart Salomonsson, Swedish University of Agricultural Sciences (SLU), Department of Rural Development and Agroecology, e-mail: lennart.salomonsson@cul.slu.se

Organic farming is very much about trying to implement an ecological centrism in a monetary-centric society. This creates many kinds of challenges, and threats.

If we look at the biosphere today, we can see that the human species dominates it – both directly by using much of its goods and services to satisfy our needs (or often our greed), and indirectly by the decisions we make on the formation of much of the biosphere's structures and processes. Today almost all green land and mammals are affected by human decisions: "What shall exist on this land, and for what purpose". Human societies are also now exceeding the capacity of nature to receive waste products of society – globally. For example, we emit far more carbon dioxide to the biosphere than the amount that is captured and stored by natural processes, and we emit heavy metals at a much faster rate than that which naturally occurs through geological processes, etc. *Globally we are facing a challenge to re-design our societies to better fit in to bio-geological processes, in time and space, and to scale our activities to renewable ecological functions and sustainable processes.*

All this sped-up human activity, and the ability to support the current level of world population, has been possible by using very powerful energy carriers, particularly oil and natural gas, to multiply human work capacity. These energy carriers, which create and maintain most of the high quality energy used by our high-tech societies, are used up at a far faster speed than the speed at which they are created – they are truly "non-renewable". Strong indications are now coming that the world oil extraction is now at it's maximum ("peak oil"), and will last for only another 50 years. *We are facing the challenge of losing our main driving force.*

The EU common agriculture policy (CAP) is now being rapidly reformed; moving from production subsidies to "farm" subsidies, and increased environmental and rural development support. This could open up the potential for creating real incentives for European societies to make "contracts" with European farmers to allow ecosystems services to be produced on their farms – environmental services that have no market but are vital for all living systems. *We are facing the challenge to use EU institutions to re-design our farming systems.*

Organic farming could be a foundation for implementing the re-design challenges outlined above. In this process of re-designing the European agriculture system, I see the following main bottlenecks:

- *To integrate ecosystem services as a foundation of the production system.*
- *To integrate multi-functionality in our management systems.*

- *To integrate the work of nature in our valuation systems.*
- *To develop "incentive structures" for implementations.*

But this development is also under threat, and we see today a development of the 'conventionalisation' of organic farming – changing technique, but not design. Today we can see organic farms that develop towards a format that is just a copy of the conventional farming, only with "different labels on the sack". That is, a simple exchange of the purchased conventional fertilizers with purchased well-processed organic fertilizers, and a substitution of synthetic pesticides with "organic" pesticides.

A continued development based on fossil fuel will overload the biosphere's capacity to absorb pollutants, and will create technological structures with low fitness to ecosystem functions. Likewise, a continued focus on monetary valuation, will omit nature's life support functions.

Biodiversity in the landscape – impact of organic farming

Maj Rundlöf, Henrik G Smith and Helena Nilsson, Lund University, Department of Animal Ecology, e-mail: Maj.Rundlof@zooekol.lu.se, Henrik.Smith@zooekol.lu.se

Recent declines in distribution and diversity of animals associated with farmland have been attributed to agricultural intensification. One explicit goal of organic farming is to preserve and develop biodiversity. The aim of our research project is to evaluate the consequences of organic farming on biodiversity in relation to landscape context. We have established a research system consisting of 12 farm-pairs, each pair includes one organic farm matched with one conventional. Six of the farm-pairs are situated in a heterogeneous landscape and the remaining six in a homogeneous. Data on butterfly and bumblebee diversity and abundance has been collected, as well as nectar and host plant data to assess habitat quality.

The results indicate a significant effect of both farming system and landscape, with organic farming and heterogeneous landscape more beneficial. The effect of farming practice seems to be more important for butterflies in a homogeneous landscape, thus organic farming has a larger positive influence on butterfly diversity in the intensively managed plains. Effects of farm practice and landscape context on butterfly diversity are consistent if pest butterflies are removed from the dataset. Pest butterflies (*Pieris napi, P. rapae, P. brassicae*) are more abundant on organic farms and not affected by the landscape context. The effect of farming practice is largest for long-tongued bumblebee species, and a larger fraction (34.7 % vs. 2.8 %) of bumblebees visited annual nectar plants in the heterogeneous landscape than in the homogeneous landscape. The conclusion so far is that organic farming has a positive effect on biodiversity. The effect differs depending on the landscape context, which implies that location of organic farms can be important to reach biodiversity goals.

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Feeding of layers of different genotypes in an organic feed environment

Prohibition on use of synthetic amino acids, GMO or products derived there from, and limited access to approved raw materials restrict possibilities to compose a nutritionally balanced diet in organic egg production. Differences exist between genotypes of birds to resist feather pecking and cannibalism. An experimental genotype (SH, "Swedish Hen"), selected for egg production for over 25 generations on low protein diet (13,5 % cp, 0,23 % met), was tested against two common commercial hybrids; LSL (Exp. 1) and Hyline (Exp. 2). The birds were fed a control or organic diets, with different sources of protein. LSL and Hyline had a higher production (20-80 weeks) than SH, but production deteriorated more severely in the former genotypes when fed the low protein/methionine diets (2,3 and 2 g methionine/kg). There was no difference in laying rate caused by diets, but egg weight and egg mass were significantly lower in the groups fed the low protein diet. Regardless of diet LSL showed more feather pecking and peck injuries than SH hens. SH had a significantly higher average of misplaced eggs in Exp. 1 (SH=5,5 %, LSL<0,5 %) and they also showed some egg eating behaviour. Albumen quality (H-units) and shell quality were better in LSL, the latter especially in hens fed the low protein diet, but SH had higher yolk pigmentation. In Exp. 2, feathering was almost complete throughout the whole cycle. However, both genotypes showed inferior plumage condition when fed the low protein diet. The difference in feed intake was less in this study (N.S.) and also in the average number of misplaced eggs (SH 2,9 % vs Hyline 1,0 %, p<0,02). Albumen quality and shell characteristics were better in Hyline, which in contrary to the LSL showed a higher yolk pigmentation than SH. SH used the outdoor runs more than LSL, as well as the groups fed the low protein diet, probably due to an increased feed scavenging. On the other hand, Hyline used the outdoor area twice as much as SH. The experiments showed differences between genotypes but all performed better on a diet with a high protein quality. Consequently, it is difficult to fulfill KRAV´s goal that 100 % of the feed should consist of organic feed stuffs, without supplements with synthetic methionine or fish meal.

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Martin Koller, Anja Vieweger, Paul Mäder (FiBL, Frick); René Total, Regula Bauermeister, Robert Baur (agroscope FAW); Daniel Suter and Jochen Mayer (agroscope FAL), e-mail: martin.koller@fibl.org

Green manuring in organic vegetable production – first results

Green manuring is an important tool in organic vegetable growing by fixing nitrogen, recycling nutrients in the rotation, and maintaining soil fertility through adding organic matter. The aim of this project was to optimise the incorporation of different green manure mixtures and to optimise green manuring during winter after vegetable crops with a late harvest in autumn.

In the *first experiment* we cultivated two mixtures of green manure (phacelia-annual-clover[1], ryegrass-crimson-clover[2]; both mixtures sawn in late august), followed by white cabbage in the next year (June to October, variety 'Guard'). Control plots remained bare during wintertime, half of them being fertilized organically prior to planting in spring and the other half remaining without any fertilizers. The green manures were ploughed-in freshly, dried before application, or were strip-wise incorporated by a "rototiller". Both green manure mixtures exerted a poor presence of clover, which may be explainable by the late sowing date and relatively high soil N_{min} content in autumn.

Cabbage yield was 38 % higher in plots with purchased organic fertilizer compared to unfertilized plots. The yield after *Phacelia* green manure was 13 % higher, irrespective of the incorporation technique. After ryegrass the cabbage yield was equal or slightly deeper than without fertilization.

Strip incorporation of green manures is suggested feasible, however with a considerably higher labour input for hand weeding.

In the *second experiment* three different undersowing types (grass-clover[3] sawn in July or mid-August and subterranean clover[4]) and two green manuring treatments after crop harvest (winter peas and rye) were compared with winter fallow (without and with organic fertilizer or garden waste compost). These treatments were applied to the crops in the following rotation: autumn leek (2003), white cabbage (2004) and maize (2005).

In leek (without preceding green manure) no differences in the yield were observed, even though the soil surface was almost completely covered by the undersown green manure at crop harvest. Grass-clover under-sown to leek reduced the incidence of caterpillar attack. 40 % higher cabbage yield in plots with organic fertilizer (150 kg N/ha) compared to unfertilized was found in the second year. After legumes (subterranean clover, winter peas) yield of fresh matter was 5 % (not

[1] *Phacelia, Trifolium alexandrinum and T. resupinatum*
[2] *Lolium perenne, Lolium multiflorum ssp. westerwoldicum and Trifolium incarnatum*
[3] *Lolium perenne and Trifolium repens*
[4] *Trifolium subterraneum*

significant) higher than unfertilized, but after grass mixtures yield compared to unfertilized was 14 to 18 % lower.

Yield was not reduced in crops with subterranean clover, therefore we assume that the yield reduction was due to a poor quality (wide C:N ratio) of the incorporated green manure. N_{min} in soil and nitrogen contents of green manures and crops are now analysed to substantiate this hypothesis.

Lukas Pfiffner, Research Institute of Organic Agriculture (FiBL), e-mail: lukas.pfiffner@fibl.ch

Habitatmanipulation to improve pest-control in annual crops

Many agroecosystems are unfavourable environments for natural enemies due to high levels of disturbance. Fragmentation and loss of suitable habitats has caused natural enemies to decline in species diversity and abundance, and has even resulted in extinctions and loss of biocontrol function. Therefore a diversification through habitatmanagement is essential to create a suitable ecological infrastructure within the agricultural landscape to resources such as food for adult natural enemies, alternative prey or hosts, and shelter from adverse conditions.

The concept of a multi-level approach of pest-control on organic farms was presented. It combines indirect with direct plant protection measures and habitat manipulation using functional biodiversity may play a significant role to enhance natural enemies. Non-crop habitats are known to play an essential role for reproduction and survival of natural enemies offering food resources, overwintering sites and refugees. Using selective plants in field margins adjacent to the crops is a key issue. After a general improvement of biodiversity on-farm a specifically tailored biodiversity to the needs of key antagonists on crop level is necessary to increase pest-control.

However, more knowledge on temporal-spatial dispersal pattern of natural enemies between non-crop and crop habitat on local and regional scale is needed to assess the efficiency for pest-control function. Nevertheless, also factors disrupting biocontrol by intraguild predation, barrier effect of margins and side effects of non-specific pesticides have to be considered in future investigations.

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Intercropping as a pest management strategy against turnip root fly (*Delia floralis*)

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In recent years there has been an increasing interest for the positive effects of enhancing species richness within a cultivation system. Intercropping can be one way of adding diversity to a crop system. In the case of insect damage, intercropping has in many cases led to reduced insect attacks.

The aim of this project is to study the effects of intercropping on the different stages of the lifecycle of the Turnip root fly, *Delia floralis* Fall. (Diptera: Anthomyiidae) which is an insect pest of cruciferous crops. The larvae cause damage or death of plants by feeding on the root system and it can be a large problem for vegetable farmers in Northern Europe.

During 2003 and 2004, a field trial with white cabbage and an intercrop of red clover was performed. Egg laying was monitored throughout the season with the aim to estimate the effect of intercropping on egg laying and to study the behaviour of the egg laying females. By studying the egg laying near the border between parcels of intercropping and monoculture, an attempt was made to understand the scale at which flies makes their choice. This can be important for the future design of intercropping fields. An border effect was detected in 2004.

A more diverse field can provide more habitats for natural enemies of the turnip root fly. This includes both parasitoids (e.g. *Trybliographa rapae*, *Aleochara bilineata* and *A. bipustulata*), and predators (e.g. *Bembidion* spp). The effect of natural enemies was studied in the field experiment with an egg predation study where eggs were placed in the field and recollected for examination of predation rates. This result of this study is still under analysis.

To study the overall predation effect from egg to pupa, an experiment was carried out were barriers were placed around plants to exclude natural enemies. Here a possible effect of predation was found, but there were no difference in effect size between intercropping and monoculture plots.

In a greenhouse experiment the interactions between feeding larvae and plant responses to intercropping and insect attack was examined. Different numbers of eggs were inoculated on plants of white cabbage grown in monoculture and varying densities of red clover. Plants responded to intercropping and insect attack by growth effects and changes of the glycosinolate content of roots and leaves. Pupal weight were lower when larvae had been feeding on plants growing in intercropping.

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Nutrient supply, health aspects and meat quality in organic pig meat production

Diets used in organic pig production should mainly be based on home-grown crops and domestically produced feedstuffs. Organic animal production is regulated by rules set by International Federation of Organic Movements (IFOAM), local control organisations (KRAV) as well as EU-regulations. Cereal grains are very important ingredients in both conventional and organic diets and constitute the major source of nutrients and energy. Because of the regulations concerning feed in organic animal production, there are constraints in finding available feedstuffs rich in protein, which have a desirable amino acid profile. Meat meal, feedstuffs originating from GMO and oil extraction and pure amino acids, as a way to balance the amino acid profile of the diet, is prohibited. A high dietary inclusion of protein is therefore necessary and this leads to a poor utilisation of ingested protein, which will increase the losses of nitrogen to the environment. Roughages are significant potential sources of protein and will improve the sustainability of cropping systems when included in the crop rotation. Further, it can also be considered to induce satiety and a possibility to maintain a natural behaviour repertoire, which is an important component in organic animal production.

The aim of this project is to study the influence of different levels of amino acids in the diet on performance, carcass quality and behaviour of growing/finishing pigs. Furthermore, the purpose is to provide data on the nutritional properties of some homegrown protein feed resources that are potentially available and could be utilised in organic pig meat production, but where information is lacking or is deficient. In the first experiment three different levels of amino acids (recommended, 7 % and 14 % lower levels) in a phase feeding system, with a low-energy diet provided ad libitum was studied. During two years, a total of 192 outdoor born pigs ((Landrace*Yorkshire) * Hampshire) were raised indoors in conventional pens or outdoors on pastures. Live weight and feed consumption were recorded continuously during the experiment and carcass parameters were assessed at slaughter. Behaviour studies were done at three occasions, at 60, 110 and 140 days of age. Amino acid level did not influence growth rate, feed conversion ratio or lean meat content but affected the activities performed by the pigs. Rooting activity occurred more often by pigs with lower levels of amino acids than recommended ($p<0.001$). Outdoor pigs grew faster than indoor pigs (916 g vs. 826 g; $p<0.001$) but feed conversion ratio did not differ. No significant difference in lean meat content was found between outdoor and indoor pigs (56.7 % vs. 57.9 %; $p=0.132$), however, dressing percentage was higher for outdoor pigs (74.0 vs. 73.0; $p=0.027$).

Social behaviour parameters including sniffing, nibbling, pushing and tail biting occurred more often indoors than outdoors. In order to document the health status among outdoor pigs, faecal and blood samples were collected to study the occurrence of parasites and infections.

This project is a part of the joint research programme "Ekogris", which is a three year project founded by Formas (The Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning).

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Organic housing systems for slaughter pigs – some results from ongoing research

In Sweden, organic pigs are generally produced only according to the rules of the economic association KRAV (2001). According to these rules, the pigs shall be held outdoors on pasture during the so-called pasture period, whereas indoor housing in a simple barn with access to an outdoor pen is permitted during the so-called stabling period. The KRAV-rules have been established to increase animal well-being, for example, by offering more possibilities for the animals to express their specific needs and behaviour patterns. However, animal well-being is only one of several objectives in organic farming, and the requirement for pasture production also affects other important decisions, such as, feed utilisation, nitrogen losses, energy requirements, animal durability, etc.

The EU permitted systems for organic slaughter pig production (EU directive 1804, 1999) with indoor housing and year round access to an outdoor pen with solid flooring and without additional access to plant covered soil, are not permitted in Sweden. One argument presented by KRAV is that the pigs cannot root in a normal way. Other arguments are that the consumer needs to see clearly that organic pig production is different to conventional production systems. Similar discussions are also heard in Denmark (Aarestrup Larsen & Kongsted, 2001), and it is expected that consumers in Denmark may also demand that the animals have access to yards with pasture for organic slaughter pig production.

To promote an increased organic pig production there is a need for presenting different production alternatives to the producer. In an ongoing project an uninsulated stable for 128 organic slaughter pigs in 8 pens has been built with two different pen designs; four pens with “straw flow” and four with deep straw bedding. All pigs have access to an outside pen area with concrete flooring. Two pens with deep straw bedding and two pens with “straw flow” also have access to a yard with pasture during the summer. One group has access to the entire yard at once, whereas the second has access to a new small pasture area once weekly. Different types of grass mixtures are also being tested. The housing systems not only affect the animals, their production and well-being, but also affect, e.g., manure handling and nitrogen losses. Thus, the aim of the project is to analyse and describe the consequences that different production systems for organic pig production will have on animal production and health, labour and working environments, manure management, crop nutrient utilisation, structural field damages, and economy.

Preliminary results have shown that:

- Trough feeding inside must be used to be able to monitor and confine the animals if necessary, since all the animals will then be inside at feeding.
- During the winter it is necessary to improve the cleaning of the outside solid concrete floors in both pen types.
- There were no clear differences in behaviour between the two pen types.
- Having access to roughage or pasture did not affect pig behaviour in general, but affected their choice of pen area when active.
- The total activity of the pigs significantly depended on their age and the environmental temperature.

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Organic Pig Production in Switzerland – Research Questions

A wide range of research questions is related to organic pig production. As EU-Regulation 2092/91 will demand 100 % organic feed in the next years, questions regarding the availability of the needed feeding components must be solved. Another challenge is to find pig breeds better adapted to the organic feeding and housing practises; currently mainly conventional breeds are used. These conventional breeds have a high potential for production, and they demand a high quality of feed. One of the main problems in organic farming is the supply with protein sources. Therefore we are searching for protein plants that can be grown in Switzerland.

Other research questions are related to the housing of the pigs. The main health problems – respiratory problems, E. coli and weaning diarrhoea – arise from inadequate housing and management in regard to the need of the animals. The organic pigs in Switzerland have access to an outdoor run, but it is not obligatory to provide free-range grazing. This means that there is a lack of opportunity for them to develop natural behaviour. The aim must therefore be to improve the husbandry systems in order to enhance animal welfare.

In order to reduce weaning diarrhoea a trial was set up with phytotherapeutic and homeopathic treatments. The aim of the advisory project is to evaluate the problems related to housing and management, to improve the management and building of stables as well as to optimize the treatment of the piglets and sows with alternative medicines in order to reduce the use of antibiotics.

A solution for the castration of the male piglets also needs to be found as the castration of the male piglets will be forbidden from 2009 onwards. The alternative to castration is to change the management to fattening boars. This possibility might, however, not be an option for all organic farms. Another way could be the castration with a narcotic. The general narcotic does not seem to be suitable for the farms because it is very time consuming. The local narcotic, however, would be a better solution, but stress for the piglets is extremely high. The inhalation methods seem to be the most efficient regarding the stress for the animals. Therefore the technical standard must be improved.

Overview of FiBL's activities and of organic farming development in Switzerland

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The roots of FiBL go back to the pioneer times of organic farming. After a long period of discussing the need for innovation in organic and biodynamic farming, FiBL finally started its work in 1973. Its launch was prepared by many organic farmers who expected science based and practice linked research activities. Since the very beginning, FiBL has developed its own strategy by i) fostering the whole knowledge chain in organic farming (research, development, dissemination), ii) building up capacities in organic farming (standards, certification procedures, training tools, organic journals, umbrella organization of organic farmers, labelling in organic farming) and iii) doing international networking (IFOAM, ISOFAR etc.). FiBL has remained a private research institutes. 70 % of its funding is project-wise by public and private grants. 30 % of its revenues is a basic grant of the Swiss government. Thanks to bilateral agreements between the EU and Switzerland, FiBL is fully integrated into the 6th EU Framework.

Currently, FiBL is working in 9 research groups and 4 dissemination groups with 120 permanent staff in Switzerland. All fields of agriculture are addressed by research or advisory work. In Germany, the focus of FiBL (12 permanent staff) is on internet services in the field of organic farming , organic seeds, evaluation of organic inputs, GMO coexistence and databases / certification. In Austria, the focus of FiBL (2 permanent staff) is livestock health and on-farm-research. FiBL Germany and FiBL Austria are funded project-wise by national grants in the respective countries. For all activities see www.fibl.org.

After a long pioneer phase (1935 to 1990), organic farming has been growing fast the last 15 years in Switzerland. In 1992, the Swiss government introduced ecological direct payments (cross compliance, decoupled subsidies), and in 1993, the 2nd biggest supermarket chain Coop started with an ambitious organic program. An excellent communication with the green bud of BIO SUISSE, the umbrella organisation, and a well developed research and extension scheme supported the success of organic farming. With an annual per capita consumption of 100 Euro, Switzerland has the best developed organic market world wide (2nd in line is Denmark with 50 Euro). The Swiss organic market amounts to 800 million Euro (4 to 4.5 percent of the whole food market). 11 % of all farms are organically certified, in some mountain regions of Switzerland, up to 50 % of the farms are managed organically. Recently, annual growth rates have decreased, now amounting from 2 to 5 percent. Current forecasts are aiming at 20 % of Swiss agricultural land by 2011.

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Pigs suitable for organic production

Which traits characterize a good sow in different environments (conventional vs. organic)? Do we need special breeding programmes for organic pig production? If so, which selection traits should be included?

Sow reproduction and behaviour studied in field and at research station

In a field study, based on 100 sows in 3 organic and 100 sows in 4 conventional piglet producing herds, sows are studied during their first 3 parities. The farmers record piglet weight, piglet mortality, sow body condition and sow behaviour. At SLU's research station Funbo-Lövsta, 40 sows are followed more intensively during their 4 first parities in indoor and outdoor environment. At Funbo-Lövsta piglet weight, piglet mortality, sow body condition, oestrus, udder health, farrowing behaviour and nursing behaviour are recorded.

Organic breeding values for growing-fattening performance

To find out if we need special breeding programmes for organic pig production we analyze slaughter plant records for genotype by environment interactions. The breeding values of 30 AI boars (based on data from conventional herds) will be compared with breeding values based on data from organic herds. Weight and leanness registrations from 3000 organically raised offspring of the 30 AI boars are collected.

Oestrus before weaning

Oestrus before weaning is a well known phenomenon in organic pig production. It is thought to be caused by later weaning, 7 weeks instead of 5 weeks after farrowing, and loose housing where the sow can escape from her piglets. Oestrus before weaning often results in a delayed oestrus after weaning which makes synchronized farrowing in groups difficult. At Funbo-Lövsta, 23 % of the sows ovulated before weaning during the first lactation and 43 % of the sows ovulated before weaning during the second lactation. A higher proportion of the sows ovulated before weaning during the spring than during the fall. Sows that ovulated before weaning had a longer interval from weaning to next oestrous.

Piglet mortality reasons differ between environments

Preliminary results from Funbo-Lövsta show that sows farrowing outdoors get less stillborn piglets than sows farrowing indoors. One explanation for this might be that stillborn piglets easily disappear outdoors. This will be investigated further when we analyse video tapes from the farrowing. The preliminary results also show that a higher frequency of the piglets are crushed to death outdoors than indoors.

The environment influences sow behaviour

Preliminary results from the field study show that sows in organic production are judged by the farmers to be less aggressive and more careful towards the piglets, better to nurse and have better maternal behaviour. These sows are also judged to be more aggressive and fearful towards the farmers, as compared to sows in conventional herds.

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Soil Fertility and Biodiversity in Organic Agriculture

In 1978 the DOK long-term field experiment was installed at Therwil close to Basel comparing the farming systems „bio-Dynamic", „bio-Organic" and „(K)conventional" (Mäder et al, 2002). Soil organic matter decreased in all farming systems except for the bio-dynamic system, where composted manure was applied and values even showed a slight increase (Fliessbach et al, submitted).

Microorganisms play a key role in soil quality and fertility as they are involved in nutrient cycling and transformation processes, soil aggregate stability, as well as in plant pathology or plant growth promotion. Understanding structure, dynamics, and functions of soil microbial populations represents one key to the understanding and definition of soil fertility and soil quality.

In a comparative approach we compared three methods to determine the soil microbial community in farming systems of the DOK field experiment. Effects of the farming systems, and the actual crop were assessed by analyzing soil microbial biomass, soil DNA, colony forming units (CFU), community level substrate utilization (CLSU) patterns with Biolog™ EcoPlates, phospholipid fatty acids and etherlipids (PLFA/PLEL) and terminal restriction fragment length polymorphism (T-RFLP) profiles of bacterial 16S rRNA genes (Widmer et al, submitted).

The soil microbial biomass parameters (microbial biomass, DNA and CFU) were strongly affected by the farming systems, whereas only CFUs showed a significant effect of the two crops in two positions of the crop rotation winter wheat and grass-clover. Differences among the FYM-based farming systems were only significant for microbial biomass and DNA contents. CLSU, PLFA/PLEL and T-RFLP profiling allowed for a differentiation of soil bacterial communities in relation to the influence of farming systems and crops. Main impact of FYM application was followed by intermediate effects of the two crops winter wheat and grass-clover. Among the three organically manured systems soil bacterial community structure was hardly significantly different. Our results suggest that for a successful soil quality management the fertilization regime and crop rotation are of major importance and that approaches consisting of a package of methods are needed to describe and assess microbiological soil characteristics.

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Soil microbial diversity and function – impact of organic amendments

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Green manure is an important source of plant nutrients, especially in organic cropping systems where mineral fertilizers are not used. The soil microbial decomposition of the applied organic material is essential for the release of plant nutrients to the crop. Increased knowledge concerning which organisms that are active in the decomposition might be important for improved nutrient management in organic farming. In my PhD-project, I study the effect of different forms of green manure on the soil microflora. The aim is to increase the understanding of the link between the quality of green manure and the soil microbial community responses. The study includes the effects of both long- and short-term amendments as well as a comparison with other organic fertilizers. The microbial parameters that are studied are microbial biomass and community structure, estimated with the phospholipid fatty acid analysis, enzymatic activities of extracellular enzymes active in the transformation of nitrogen, phosphorous and sulphur and the microbial catabolic profile as determined by the Biolog® system. Special focus is put on the effects of incorporation of fresh green manure on trophic interactions in the soil.

The results so far show that long-term green manure amendments have effects on the soil microbial community structure, but also that these effects are similar to those of other organic amendments such as farmyard manure and sawdust. The abundance of different microbial groups and total microbial biomass was generally increased by green manuring relative to unfertilized and N-fertilized soil. For some microbial groups, there were also significant differences between different organic treatments. For example, the abundance of mycorrhiza was significantly lower in soil amended with green manure compared to farmyard manure and sawdust, but higher than in soil amended with sewage sludge. The enzymatic activities showed a varying response to the long-term green manure amendments. The activities of protease and arylsulfatase were not significantly higher than in the mineral fertilized treatment, whereas the phosphatase activity was significantly increased. There were no differences in catabolic profile between the treatments, except for the sewage sludge treated soil, which showed a reduced capacity to utilize different substrates.

Long-term green manure amendments have thus changed soil microbial community structure and soil enzyme activities. Despite this, no differences in catabolic profile were observed between soils from different fertilizer regimes, except for soil amended with sewage sludge. Further studies will focus on the short-term dynamics of microbial communities after green manure amendments, and also on identifying specific microbial and faunal groups that feed on the green manure through ^{13}C-tracing.

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State of the art of organic dairy cattle breeding: Results of a survey and analysis of the use of bulls on Swiss organic Braunvieh-farms

A survey on 1000 organic dairy cattle farms was done to obtain information on the state of breeding affairs in Switzerland. The response of 60 % was very high and might be looked as a representative sample. The chosen farms phenotypic milk performance was averaged for organic as well as for traditional farming. The farmers weighted functional traits to be very important in breeding. The same results were also founded by a survey in Austria (Schwarzenbacher, 2001).

Additionally the bulls used on organic farms were compared with the bulls used on traditional farms. A total of 25067 organic and 28003 traditional mating of Swiss Braunvieh was analysed. The found breeding values showed that in the scope of selection strategies the functional traits were not as important. It is concluded that organic farmers seem to have an organic breeding strategy in mind but in mating it is not applied with the same consequence.

On one hand the chosen organic breeding strategy has to be reconsidered and on the other hand there seems to be a backlog in consulting and sensitizing the farmers.

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Strategies for parasite control in organic layer flocks

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Internal and external parasites are among the major health problems in flocks of laying hens. According to the organic regulations, parasitic diseases have to be controlled by the selection of appropriate breeds, by husbandry and feeding practices and by treatments with natural compounds before chemically-synthesised antiparasitic treatments are allowed. In the case of external and internal parasites of poultry this demand is met to various degrees.

The chicken mite, *Dermanyssus gallinae*, is the most important external parasite of hens in Europe. The mite can be controlled by measures taken in the environment of the hens due to its temporary feeding behaviour. Mite populations can be substantially reduced by cleaning and disinfection of the houses between flocks. If necessary, mechanically acting substances are applied during the production cycle, and an acaricide of natural origin (pyrethrum) is available as a last option. In the future, the reliance on this acaricide/insecticide should be reduced; therefore new natural products are needed.

The situation in the case of internal parasites of laying hens is different. The control of the endoparasitic nematodes (mainly *Ascaridia galli* and *Heterakis gallinarum*) is almost entirely based on one registered anthelmintic (Flubendazole) in many EU countries. This compound is at present extensively used in organic egg production. Approaches to prevent and control gastrointestinal nematodes of poultry by proper run management and by the use of plant products are currently under development. However, these approaches are still less effective than in the control of parasites in ruminants.

Research on prevention and control of poultry parasites is one topic within the Integrated Project "QualityLowInputFood".

More details on this project can be found on the website www.qlif.org.

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Strategy components for mastitis control in organic dairy herds

Since EU regulations provide a framework of a graduated herd health scheme detailed health control measures are to be elaborated for extensions services and veterinarians. Exemplary for all aspects of animal health, a strategy of udder health control in swiss organic dairy farms is presented. While in conventional strategies current health depressions can be regulated preliminary by using pharmaceutical products like antibiotics, the reduction of these drugs is a crucial concern of organic farmers. Thus, two major threads of strategies are preferred in organic mastitis control: specific organic herd level prevention measures and certain therapies minimizing usage of chemicals. These two threads are seen in respect to the EU Regulation 1804/99 and thus are implemented consecutively. The herd environment improvement (management, hygiene, feeding, and husbandry) is the precondition of the use of antibiotics free therapies. On the other hand, in the beginning of a herd health improvement programme it could be necessary to exceed antibiotic treatment level to provide a microbiologic charge decline within the animals. Furthermore untreatable cows have to be identified and culled, if necessary. After these basic measures antibiotic free treatment strategies (homeopathics, milking out, ointments, teat sealants etc.) can be successfully implemented. In different Projects in Germany and Switzerland these protocols are applied with long-term positive effects on herd udder health. The projects are presented. The lack of knowledge about the specific factors effecting udder health as well as the open question of most suitable therapies and dry off prevention strategies in organic dairy farms is the reason to conduct the mastitis work package within the QLIF project. These questions should be partially answered the next few years.

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Sustainability of organic and integrated farming (DOK trial)

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The land area of organic agriculture in Europe and in many other countries of the world has increased considerably in the last years and organic agriculture is investigated intensively in many fields of research (Macilwain, 2004). Earlier the organic farming movement was created by pioneers, whose ideas and innovations formed an alternative to the so-called „green revolution“ that came along with pesticide use and synthetic fertilizers. In recent time, environmental problems caused by agriculture became more evident.

In 1978 the DOK long-term field experiment was installed at Therwil close to Basel, comparing the farming systems „bio-Dynamic“, „bio-Organic“ and „(K)conventional“. In the first years of the trial, crop yield and feasibility of organic farming were investigated. Soils were analysed with respect to long-term effects on fertility and were rated in the view of farming effects on the environment. Today the quality of organic products and the analyses of nutrient fluxes (C, N, P) as related to microbial activities are the main research interests in the DOK trial. Long-term trials such as the DOK-trial offer unique opportunities for this kind of research (Drinkwater et al, 1998, Reganold et al, 1987, Mäder et al, 2002).

The DOK-trial compares the three systems mentioned above on the basis of the same intensity of organic fertilization (i.e. the same number of animals per area), the same crop rotation and the same soil tillage. Fertilization and plant protection are different and performed according to the respective farming system. An exclusively minerally fertilized conventional treatment is mimicking stockless farming and unfertilized plots serve as controls (Mäder et al, 2002).

Crop yields of the organic systems averaged over 21 experimental years at 80 % of the conventional ones. The fertilizer input, however, was 34–51 % lower, indicating an efficient production. The organic farming systems used 20–56 % less energy to produce a crop unit and per land area this difference was 36–53 %. In spite of the considerably lower pesticide input the quality of organic products was hardly discernible from conventional analytically and even came off better in food preference trials and picture creating methods.

Maintenance of soil fertility is important for a sustainable land use. In our DOK field plots the organically treated soils were biologically more active than conventional, whereas chemical and physical soil parameters differed less significantly.

	Organic	*Conventional*
Winter wheat yield	4.7 t/ha	5.6 t/ha
Fertilizer (NH_4NO_3-equivalent)	122 kg/ha	360 kg/ha
Energy (Diesel-equivalent)	340 l/ha	570 l/ha
Plant protection (active ingredients)	0-200 g/ha	6.0 kg/ha
Soil microbial biomass corresponding to ca.	40 t/ha 700 sheep	24 t/ha 400 sheep

The organic farming systems show an efficient utilization of natural resources and a higher floral and faunal diversity – features typical for mature ecosystems. We therefore conclude that organically manured land use systems with grass-clover in the crop rotation and using organic fertilizers from the farm itself are a realistic alternative to conventional agricultural systems.

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Sustainable apple production

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Organic fruit growing in Europe has experienced remarkable growth rates since the mid 1990's. Southern states, especially Italy, Spain and France, growing also olives, citrus and chestnuts have the largest land area with organic fruit. Mainly increasing interest of supermarket chains is responsible for this buoyancy, but also the availability of better plant protection products e.g. granulosis virus and mating disruption against codling moth, Neem oil against Rosy Apple Aphid. State subsidies varying from 600 to more than 1600 Euro ha/y in the EU-countries are less decisive for the conversion of top fruit production. Market share of organic table fruit is only 1 to 2 %, reaching 4 to 5 % in Switzerland. For Switzerland, we estimate a market potential of around 12 to 15 %, which is already achieved with organic vegetables. In order to reach that percentage for several key problems better solutions have to be found, e.g. control of scab, fire blight, sooty blotch, brown rot, weed management, fertilisation and crop load regulation. Also the assortment of organically producible "modern-standard" varieties is not satisfying, in particular with stone fruit.

Economics of organic fruit growing is comparatively healthy, however depends on one third higher farm gate prices for the product to compensate yield losses that are usually 15-30 % of conventional production. In Switzerland the direct cost free benefit of organic orchards is 16 % higher (11'661 Euro) compared to integrated fruit production; but labour hours exceed those of IFP by 7%, due to blossom thinning by hand, manual weed control and mice control.

Supermarkets have a tendency to just "substitute" conventional with organic fruit when requiring disease susceptible varieties with no cosmetic blemishes. This can/does feed back to the growers resulting in "substitutional" production with disease and pest sensitive orchards managed with intensive "organic" spray and fertilisation programs. This certainly does not correspond with either the original concept of organic farming or with expectations of organic consumers. Thus, still a lot of development – also on the marketing side – has to be undertaken.

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The potential of variety mixtures in lettuce production

Head and Iceberg lettuce together are 2nd most important vegetable in CH. There is a fast rotation of varieties due to new resistances available and due to quality aspects. One major disease affecting yield is downy mildew (*Bremia lactucae*). There might be 100 % loss due to downy mildew. No product is registered in Switzerland for protection against downy mildew in organic production.

However, there are several possibilities for (at least partial) prevention: Crop rotation (4 years break), choice of varieties, healthy seedlings, planting density (max. 9-10 plants par m^2), planting on mulch (plastic or paper), planting high, careful watering (no overhead, allow fast drying after watering), early harvest, complete elimination of crop debris and cultivar mixtures.

Cultivar mixtures are recognized to offer useful disease control but require that the cultivars of a mixture have different disease resistance. Wolfe (1985) defined cultivar mixtures as "mixtures of cultivars that vary for many characters including disease resistance, but have sufficient similarity to be grown together." Cultivars used in the mixture must possess good agronomic characteristics and must be phenotypically similar for important traits including maturity, height, quality and others.

Cultivar mixtures do not completely suppress or eliminate the disease. Rather, mixtures reduce the rate of disease progress by eliminating large numbers of spores at each cycle of pathogen multiplication. The mechanisms by which cultivar mixtures suppress disease are summarized as follows: a) Dilution effect. Increasing the distance between susceptible plants reduces/slows the rate of plant to plant spread. b) Barrier effect. The presence of resistant plants in the canopy provides a physical barrier against spore dispersal, interrupting spore movement. c) Induced resistance. Induced resistance occurs when biochemical host defences are triggered by inoculation with an avirulent race. d) competition between host plants. In one pathogen generation, the combined effect of these mechanisms in slowing the pathogen spread may be small. It is the multiplicative effect over several pathogen generations that leads to the greatest suppression of the disease.

In two experiments lettuce variety mixtures were used to investigate their value for control of downy mildew. Mixtures of six varieties were grown in single variety plots (108 lettuce plants/plot) and as systematically arranged alternating cultivars within each mixture plot. It was observed that the reduction of disease in mixtures was higher early in the growing cycle, at harvest time the mean disease level of pure stands was similar to the disease level in the variety mixture. A slightly higher yield (trimmed head weight) was observed in mixtures compared to the mean of the pure stands.

Experiments with lettuce variety mixtures in the UK showed that mixtures might yield 10-15 % more than the mean of components and significant reductions in downy mildew severity at harvest were observed on a susceptible cultivar. Experiments in France showed that the commercial quality of mixture harvest was accepted by the market.

From these experiments it can be concluded that variety mixtures have an influence on disease development of Bremia lactuca in a field and they might improve yield of a susceptible cultivar grown in a mixture. Therefore, variety (cultivar) mixtures can be one piece of the puzzle against disease. However, breeding progress, production systems and market development may influence the use of mixtures in commercial organic lettuce production.

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