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Contributions of Organic Farming to a Sustainable Environment

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INTRODUCTION

Heavy reliance on non-renewable resources, reduced biodiversity, water contamination, chemical residues in food, soil degradation and health risks to farm workers using pesticides all bring into question the sustainability of conventional farming systems (e.g. Mattson et al. 1997).

Organic management practices combine traditional conservation-minded farming methods with modern technologies in order to exclude inputs such as synthetic pesticides and fertilisers. For example, these practices emphasise soil fertility, natural pest control, diverse crop rotations, habitat diversity and self-regulating processes. Organic production systems rely largely on using locally available resources, maintaining ecological balances, and developing biological processes to their optimum (Stolton et al. 2000). The protection of soil and the environment is fundamental to organic farmers. By respecting the natural capacity of plants, animals, and the landscape, organic farming aims to optimise quality in all aspects of agriculture and environment.

Originally, organic farming was a sector of agriculture that developed largely independent of governmental influence. However, since the late 1980s, direct governmental influence has increased and currently every EU-country directly promotes organic farming through various agri-political measures (Lampkin et al.1999). The most important reasons given for the political support of organic farming are its positive effects on the environment. Of course, this political support is justified, as long as organic farming demonstrates fewer negative environmental effects than its counterpart, conventional farming. Therefore, this paper will discuss in detail the relative positive effects of organic farming in comparison to conventional farming.

For an analysis of the sustainability of farming systems, a common definition of the term "sustainability" is required: Sustainability can be defined as the ability of a system to 'continue into the future'. This includes the maintenance of soil fertility, yields, the genetic base of crops and animals, water quality, nature conservation, profitability and other socio-economic factors.

Based on the review study 'The environmental impacts of organic farming in Europe' of Stolze et al. (2000), this contribution will focus on the question: How far can organic farming contribute to a sustainable environment? Furthermore, some selected environmental issues will be discussed including detailed research results (e.g. Mäder et al. 1996, Pfiffner 2000) in order to expand the resulting qualitative multi-criteria analysis.

THE METHODOLOGICAL APPROACH

The review study (Stolze et al. 2000) was based on a multi-criteria analysis. In order to gather a comprehensive, European-wide base of information, a written survey of experts was conducted in 18 European countries (the 15 EU-countries plus Norway, Switzerland, and the Czech Republic). By means of a structured questionnaire, experts were instructed to provide a summary of their respective national literature on environmental relevance of organic farming. The reviewed literature displayed a multitude of methodological approaches. Although numerous studies were available, the quality, extent and comparability of the information was very diverse. Thus, a quantitative assessment was not appropriate. Instead, a qualitative multi-criteria approach was taken and each step emphasised transparency. A detailed description of the methodological approach can be found in Stolze et al. (2000). The methodological challenges of this review study are characterised by the following aspects:

- Variability within and between farming systems - definition of farming intensity
- A comparison system on a relative scale
- Land area-related or product-related comparison?
- Appropriate selection of indicators - based on the OECD list

RANGE WITHIN AND BETWEEN FARMING SYSTEMS - DEFINITION OF FARMING INTENSITY

The obvious system with which to compare the environmental effects of organic farming is conventional farming. However, the term 'conventional farming' encompasses a very broad spectrum: a) farming as typically found in practice, b) integrated farming, and c) expanded integrated farming which includes quality environmental management. Similarly, one can differentiate systems within organic farming: a) organic farming, as it is commonly encountered in practice, b) organic farming by top-quality enterprises using the best possible management practices, and c) the highest level of organic farming which also meets specific agri-environmental measures. It is evident that the result of a comparison between organic and conventional farming depends on the subsystems chosen for comparison (Table 1).

Table 1: Range and complexity of farming systems

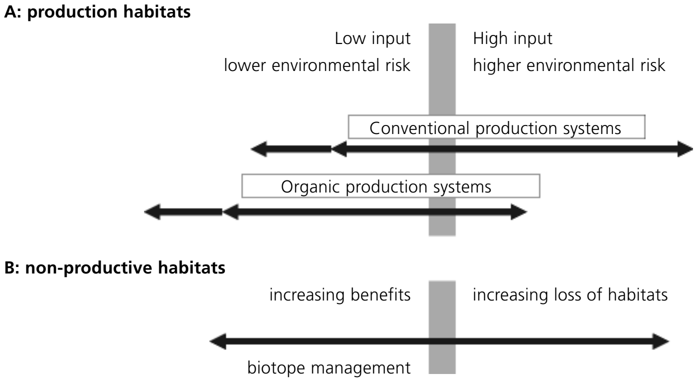
Conventional systems	Organic systems	Characteristics
C 1 Conventional	**O 1 Organic***	Typically found in practice
C 2 Integrated(*/**) (ICM)	O 2 Best organic management*/(**)	Using best, up-to-date management practices, within the specific system
C 3 Best Integrated management (**) plus agri-environmental measures	O 3 Best organic management** plus agri-environmental measures	Plus specific measures decreasing environmental and resource use, e.g. providing exclusive areas for nature

* Inspected farming production

** Inspected farming production including agri-environmental program (e.g. field margins)

This comparison at the farm level needs to include two scales: Range of production intensities and biotope management (Figure 1). For the selected research results which are not easily brought into the outlined structural scheme, we assume that in most cases the systems typically found in practice were compared.

Figure 1: Comparison of farming systems including two scales: Range of production intensity and biotope management



A COMPARISON SYSTEM ON A RELATIVE SCALE

In principle, one could compare different land use systems on an absolute scale according to their fulfilment of certain environmental criteria. This would allow quantification according to the achievement of these criteria. However, such a procedure would require target levels on an absolute scale for all indicators used. There are good economic and scientific reasons why such target levels for each indicator should be strongly differentiated by region. For this reason and in view of the problematic data situation, it was deemed necessary to compare organic with conventional farming on a relative scale.

This scale ascertains whether organic farming ranks much better (++), better (+), equal (0), worse (-), or much worse (—) than conventional farming with regard to specific environmental indicators. The null hypothesis is that no difference exists between the environmental effects of organic and conventional farming. This hypothesis is accepted, if there is clear evidence that no difference between farming systems exists or reliable information for this is not available. Only if the reviewed literature unequivocally verifies a difference between organic and conventional systems is it stated as such.

LAND AREA-RELATED OR PRODUCT-RELATED COMPARISON?

The majority of reviewed comparative studies relate the environmental effects of organic farming to land area, while relatively few studies have attempted to compare the environmental effects per unit of produced output. Therefore, a comparison of environmental effects will be carried out per hectare of land area. When relating environmental effects of different farming systems to the land area, it can lead to other conclusions than if one relates these environmental effects to the unit of produced output. This has agri-political implications which will be further discussed elsewhere.

SELECTION OF INDICATORS BASED ON THE OECD LIST

The assessment is based on the OECD indicator system (1997). In several places simplifications and - where it seemed appropriate - modifications have been made. The following indicator categories were differentiated accordingly: Biodiversity & Landscape, Soil, Ground and Surface Water, Climate and Air, as well as Farm Input and Output (Table 2). These categories are specified in detail using additional indicators. The previously mentioned literature review was conducted at the indicator level and the results from these assessments at the indicator level were then aggregated to an overall assessment of each indicator category.

COMPARISON OF DIFFERENT FARMING SYSTEMS - IMPACT OF ORGANIC FARMING ON KEY ENVIRONMENTAL INDICATORS

In Table 2, the results of the comparison of organic and conventional farming systems are shown in a summarised form. This portrayal not only takes into account the authors' assessment of the indicators, but also specifies the subjective confidence interval. This again reminds the reader that the subject area is hampered by the shortage of precise information. The subjective confidence interval indicates - based on the literature reviewed - the deviation from the final results.

BIODIVERSITY AND LANDSCAPE

Generally, agriculture can contribute significantly to the conservation and enhancement of biological and habitat diversity within an ecosystem. Impacts on wildlife depend on farming intensity, land use, semi-natural habitats, field margins, and buffer zones. There is also a large variety of agricultural landscapes, ranging from small-scale hedged landscapes to the large-scale open landscapes of intensive arable production. Since farmers manage the majority of the land area, their management has a significant impact on flora, fauna, and the environment. For example, semi-natural habitats and field margins have been shown to be important refuges for many plants and animals and thus play a key role in maintaining biological diversity on farmland (e.g. Pfiffner & Luka 2000).
Biodiversity may be of particular importance for enhancing the levels of beneficial organisms and other nature conservation aspects of organic farms (Altieri 1995). In fact, linking organic farming activities to the enhancement and conservation of biodiversity on agricultural land can provide a very valuable, positive model for agriculture as a whole. Positive interactions between farming and biodiversity are often related to well-adapted traditional and low input (e.g. organic) farming systems. Negative impacts are often related to an intensification and local concentration of agricultural production. Intensive agriculture and excessive use of agrochemicals has resulted in a significant decrease in wildlife in agricultural land (e.g. Sotherton 1998).

The main findings of the review study of Stolze et al. (2000) show that organic farming clearly performs better than conventional farming with respect to floral and faunal diversity. Due to the ban of synthetic pesticides and N-fertilisers, organic farms provide potentials which result in positive effects on wildlife and landscape conservation. At the farm level, organic farming can lead to a higher habitat diversity by providing a wide range of habitat niches, breeding possibilities and a better food supply. Indeed, a review of 44 research studies effects of farming systems on beneficial invertebrates and birds clearly shows a better performance of the organic farming system (Tab. 3). Furthermore, the diversity of cultivated species is higher on organic farms than on conventional ones.

Table 2: Assessment of organic farming's impact on the environment compared to conventional farming base on a multi-criteria analysis

INDICATORS	**+ +**	**+**	**o**	**-**	**- -**
ECOSYSTE		X			
Floral diversity		X			
Faunal diversity		X			
Habitat diversity			X		
Landscape			X		
SOIL		X			
Soil organic matter		X			
Biological activity	X				
Structure			X		
Erosion		X			
GROUND AND SURFACE WATER		X			
Nitrate leaching		X			
Pesticides	X				
CLIMATE AND AIR			X		
CO2		X			
N2O			X		
CH_4			X		
NH_3		X			
Pesticides	X				
FARM INPUT AND OUTPUT		X			
Nutrient use		X			
Water use			X		
Energy use		X			

Legend: Organic farming performs: ++ much better, + better, o the same, - worse, - - much worse than conventional farming; if no data was available rating was "o the same"

X Subjective confidence interval of the final assessment which is marked with X

1) the assessment is difficult due to lack of data.
Subjective confidence interval of the final assessment marked with X
Source: Stolze et al. (2000), modified

Wildlife conservation often requires areas of wild nature (e.g. areas without any landuse). Although organic farming as any form of agriculture cannot directly contribute to the majority of specific wildlife conservation goals, it is currently the least detrimental farming system with respect to these issues.

Table 3: Effects of organic and conventional farming on fauna - a review of 44 investigation world wide

Animal group	Abundance - number of individuals			Species diversity - number of species		
	ORG >CON	ORG=Con	ORG <CON	ORG >CON	ORG=Con	ORG <CON
Earthworms	17	1	0	4	3	0
Carabids	13	2	0	6	2	0
Spider	6	1	0	0	0	0
Birds	5	0	0	2	0	0
Diplopods	4	0	0	1	1	0
Bugs	2	1	0	1	1	0
Mites	2	0	1	1	1	0
Total	49	5	1	15	7	0

ORG > CON: better performance in organic farming

ORG = Con: No significant difference

ORG < CON: better performance in conventional farming

Source: Pfiffner 2000 mod.

SOIL

Soil is one of the most important natural resources for agriculture. The maintenance and enhancement of soil fertility is a central objective of organic farming, especially since many indirect regulation factors for crop management rely on well functioning soil-plant interrelationship. The impact of organic farming on soil properties has been well covered by research in most relevant aspects; only data about soil erosion are somewhat scarce.

Results show that organic farming tends to conserve soil fertility better than conventional systems, as revealed by higher diversity and occurrence of soil biota and a higher energy efficiency of soil microbial populations (Table 4).

Organically managed soils usually have higher organic matter content and significantly higher biological activity. As far as soil structure is concerned, most studies found no clear difference between the farming systems. Furthermore, many typical measures of organic farming practise have a high erosion control potential (Siegrist et al. 1998). However, organic farming's soil conserving performance or potential is highly site dependant.

Table 4: Effects of different farming systems on soil biota after 14 years of farming in the DOC-long-term trial, Switzerland. Relative results to integrated farming with FYM (=100%)

	Bio-dynamic	**Organic**	**Integrated-FYM[1]**	**Integrated-M[2]**
Biomass (SIR)	136	119	100	81
Soil-Respiration	110	102	100	93
Dehydrogenase	181	144	100	78
Protease	170	129	100	79
Alcaline phospatase	303	183	100	78
Sacharase	145	125	100	94
Mycorrhiza	139	130	100	95
Earthworm biomass	149	166	100	79

[1)] Integrated farming with farmyard manure [2)] Integrated farming with only mineral fertilizers
Source: Mäder et al. 1996.

GROUND AND SURFACE WATER

The investigations reviewed indicate that organic farming results in lower or similar nitrate leaching rates than integrated or conventional agriculture. Farm comparison trials showed leaching rates up to 50% lower on organic fields in the late eighties (Verejken 1990). Although today the differences are much lower due to improved nitrogen management on conventional farms, an average of 20% lower leaching rates on organic farms in comparison to integrated farms with an improved N-fertiliser management is observed (Piorr and Werner 1998). Critical cases of nitrate leaching on organic farms are ploughing of legumes at the wrong time followed by the choice of an unfavourable crop, or composting of farmyard manure on very permeable soils. There are alternatives which have been developed and introduced into practice.

Another very relevant aspect is the fact that organic farming does not pose any risk to ground or surface water pollution from synthetic pesticides. Although incorrect organic farm practices could bear some potential risk for polluting ground and surface water, the detrimental environmental effects from organic farming tend to be lower than those from conventional farming systems. Hence organic farming is the preferred agricultural system for water reclamation areas.

CLIMATE AND AIR

The climatic change is globally recognised as one of the most relevant environmental problems. To assess farming systems with respect to climate and air, relevant greenhouse gases (CO2, N2O and CH4), NH3 emissions and air contamination due to pesticides are selected as indicators. Research on CO2 emissions show varying results: On a per-hectare basis, CO2 emissions are 40-60% lower in organic systems, whereas on a per-unit output scale, the CO2 emission tend to be higher in organic systems. Quantitative results on N2O and CH4 comparing different farming systems are scarce. Experts estimate that organic farming have a lower N2O and CH4 emission potential on a per

hectare scale and higher on a per unit output scale. Calculations of NH3 emissions show evidence that organic farming has a lower emission potential.
Due to the ban of synthetic pesticides in organic farming, significantly lower air contamination from pesticides is ensured than in conventional farming.

FARM INPUT AND OUTPUT

The efficient use of natural resources is the prerequisite for a sustainable and environmentally sensitive agriculture. On-farm balances of nutrients, water and energy were taken into account in order to assess farming systems. Studies show that nutrient balances of organic farms are generally close to zero. In all published calculations, the nitrogen, phosphorous and potassium surpluses on organic farms were significantly lower than on conventional ones. Most of the research indicates that energy consumption is lower on organic farms for annual as well as for perennial crops. Unfortunately, no research results on water use on organic and conventional farms are available.

SUMMARY AND CONCLUSIONS

- For each indicator organic farming is ranked at least equal to conventional farming, while in the majority of environmental indicators organic farming performs better or much better. In two cases, the subjective confidence interval could allow conventional farming to appear as the preferable system (partly due to the lack of evident data). However, when considering the aggregation level of the indicator categories, the analysis becomes more uniform. With the exception of climate and air, organic farming performs better than conventional farming in all categories. None of the indicator categories showed that organic farming performed worse.

- A summary assessment of all indicator categories was not carried out in the table, however, the result is clear: organic farming is, in an area-related comparison, more environmentally friendly than conventional farming. This result confirms one of the basic assumptions of the political support for organic farming, as mentioned in the introduction.

- On the one hand, the environmental performance of farms depends on the farming intensity, while on the other hand it depends on bio-tope management of non-productive areas.

- The combination of organic farming with the conservation of semi-natural habitats and valuable field margins offers a real option to meet many environmental goals, especially biodiversity, on agricultural land.

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is one of the technical deliverables of this project. It does not necessarily reflect the Commission's views and in no way anticipates its future policy in this area.

REFERENCES

Lampkin, N., Foster, C., Padel, S. und Midmore, P. (1999). The policy and regulatory environment for organic farming in Europe. Organic farming in Europe: Economics and Policy, Volume 1. Universität Hohenheim; Stuttgart-Hohenheim, 166 pp.

Mäder, P., L. Pfiffner, A. Fließbach, M. von Lützow und J. C. Munch (1996): Soil ecology - The impact of organic and conventional agriculture on soil biota and its significance for soil fertility. In: Fundamentals of Organic Agriculture. Proceedings of the 11th IFOAM Scientific Conference, August 11 - 15, 1996. Copenhagen. T. V. Oestergaard. Vol. 1, 24-46.

Mattson, P.A., Parton, W.J., Power, A.G. & Swift, M.J. (1997): Agricultural intensification and ecosystem properties. Science 227: 504-509.

OECD (1997). Environmental Indicators for Agriculture. Paris, 62 pp.

Pfiffner, L. (2000). Significance of organic farming for invertebrate diversity -enhancing beneficial organisms with field margins in combination with organic farming. In: Stolton, S., Geier, B. and McNeely, J. A., (eds.), 2000, The Relationship Between Nature Conservation, Biodiversity and Organic Agriculture, Proceedings of an International Workshop, Vignola, Italy, 1999. IFOAM, Tholey-Theley, Germany, p. 52-66.

Pfiffner, L., Luka, H. (2000). Overwintering of arthropods in soils of arable fields and adjacent seminatural habitats. Agriculture, Ecosystems and Environment 78: 215-222.

Siegrist, S., Schaub, D., Pfiffner, L. & P. Mäder (1998): Does organic agriculture reduce soil erodibility? The results of a long-term field study on loess in Switzerland. Agriculture, Ecosystems and Environment 69: 253-265.

Sotherton, N.W. (1998): Land use changes and the decline of farmland wildlife: an appraisal of the set-aside approach. Biological Conservation 83: 259-268.

Stolton, S., Geier, B. and J.A. Mc Neely Edts. (2000): The relationship between nature conservation, biodiversity and organic agriculture. Proceedings of an international workshop in Vignola, Italy 1999, p224. IFOAM; ISBN 3-93055-05-2.

Stolze, M., Piorr, A., Häring, A. und Dabbert, S. (2000). The environmental impacts of organic farming in Europe. Organic Farming in Europe: Economics and Policy, Volume 6. Universität Hohenheim; Stuttgart-Hohenheim, 127 pp.

Verejken, P. (1990): Integrierte Nährstoffversorgung im Ackerbau. Schweizerische Landwirtschaftliche Forschung 29: 359-365.

Piorr, A. und Werner W. (1998). Nachhaltige landwirtschaftliche Produktionssysteme im Vergleich: Bewertung anhand von Umweltindikatoren. agrarspectrum 28. Verlags Union Agrar.