ORGANIC FARMING RESEARCH IN THE EU, TOWARDS 21ST CENTURY

ENOF

ENOF WHITE BOOK

Barcelona, 1999

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EXECUTIVE SUMMARY

The ENOF Concerted Action

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The ENOF Concerted Action

ENOF is the acronim of «*The European Network for Scientific Research Co-ordination in Organic Farming*». ENOF has been a Concerted Action (CA) funded by The European Commission under the framework of RTD & D Programme in the Field of Agriculture and Agro-industrie, including Fisheries (AIR Programme, AIR3-CT94-2143). Organisationally, ENOF has a «*Steering Commitee*», comprising the CA Co-ordinator, from *LEAAM- Agroecologia* (*CID-CSIC*, Spain), and 5 Sub Co-ordinators, one for each research area. The areas initially established being the following:

I– Crop Production and Weed Control (*Rheinische Friedrich-Wilhems-Universität*, Germany)

Il– Soil Fertility and Environmental Aspects (*Université Libre de Bruxelles*, Belgium)

III– Animal Husbandry, Grassland and Fodder Production (*Louis Bolk Institut*, Holland). Later, these were divided into two sections:

IIIa– Animal Husbandry

IIIb– Grasslands and Fodder Production

IV– Legal and Economic Aspects (*Università degli studi di Ancona*, Italy)

V– Crop Protection (*Scottish Agricultural College*, United Kingdom)

The main objective of ENOF has been to establish and maintain contacts between European Organisations working on, or developing, organic farming techniques, whether in *Education*, *Research*, *Experimentation*, *Demonstration* or *Dissemination:* particularly through R + D Projects. In brief, more concret proposed objectives were:

1. To create a forum for scientific discussion of Organic Farming
2. To link up different European Research Teams
3. To co-ordinate European research into Organic Farming
4. To identify necessary lines of investigations that are currently non-existent
5. To propose recommendations for future scientific policy in Organic Farming

The role of ENOF has been gathering all the information available on the subject and on the state of current research, highlighting, wherever possible prevailing priorities in Research. Those priorities are presented on this White Book.

Summarising, the more importants subjects in which Research is needed are:

Crop Production and Weed Control

rhizosphere and plant-microbial interactions

grain legumes grown in southern Europe

gaseous losses of nitrogen

crop to weed interactions
strip-cropping systems
soil and soil microbial activity
description of product quality especially of vegetables
vegetable production
breeding programmes oriented on site-adapted cultivars
biodynamic preparations
special strategies on problematic weeds

Soil Fertility and Environmental Aspects

research must consider soil fertility in a global context
regional scale is important
fertility must refer to the whole rotation and not on each crop taken isolate
nutrient balance sheet at farm level
environmental impact and availability of Potassium and Phosphorus
accurate indicators of environmental impact of OF

Animal Husbandry

creation of a joint platform for organisations and institutions involved in organic livestock
new methodologies to assess welfare
the development of systems and practices to avoid mutilation
the examination of the part of human - animal interaction in animal welfare
methods to evaluate housing systems.
inventory of the consequences of the implementation of EU-regulations for the farming traditions of different countries
optimum group size of housed animals with respect to welfare
cost/benefit assessment of measures to improve welfare
cost of converting to organic livestock systems
evaluation of the consequences of new technologies (ie. automated feeding, milk robot)

Grasslands and Fodder Production

maintenance of soil fertility
breeding and selection of clover varieties under different organic circumstances
mixtures of grasses and clover
improving mixtures with herbs
the role of permanent pastures in relation to production level, quality, species diversity
the effects of finely adapted machinery on the uptake of soil minerals and soil compaction
ecology and control of perennial weeds;
development of site adapted systems based on the soil quality and climate conditions

Economic and Legal Aspects

new methodologies must be developed
market studies to better understand the need of consumers and orient the supply

to devise the level of detail and the procedures to collect relevant data with standardized procedures at the EU level

to adapt statistical methodologies and sampling techniques to organic farming caracteristics

interdisciplinary and holistic research should also be supported

alternative forms of market organisation should be explored

Crop Protection

innovative experimentation in organic farming is to be preferred to comparison

evaluation of agronomic and environmental indices

better disease management

study of natural populations of microbes as antagonists of pathogens

host plant resistance

botanical insecticides

studies on polyculture as a factor to increase natural enemy of pathogens

infochemical studies of insect herbivore-insect parasitoid/predator and insect herbivore-host plant interactions

Research into plant defence systems against pest and pathogen attack

Beyond the needs of research already outlined, and as can be easily deduced from the previous box, a change in mentality is needed when drawing up and evaluating organic farming projects. Methodological change is a necessity given the special characteristics of organic farming.

In order to carry this out, one of the most important steps must be to have available a network of «model farms» directed by research centres, or by regional, or national governments with agricultural skills, to provide scientists with sufficient data so they will be able to take into account the internal functioning of the organic farming systems.

Local problems will be solved by setting up «pilot farms», in other words, real farms run by farmers receiving local, regional or national government subsidies and co-operating with scientists and technicians.

The European Co-ordination network for Scientific Research into Organic Farming should continue, at least, to make good use of the work done by ENOF. However, it should also maintain permanent contact between European researchers, facilitating readily available information about organic farming production systems and disseminating this information as well as holding regular meetings with the intention of spreading the latest results of research.

We acknowledge the effort and the involvement of the people who has been working in ENOF. Specially to the Subco-ordinators, which has been one of the reasons of the success of this Concerted Action.

ORGANIC FARMING RESEARCH IN THE EU, TOWARDS 21ST CENTURY

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CHAPTER 2

RESEARCH IN ORGANIC FARMING IN THE EU

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RESEARCH IN ORGANIC FARMING IN THE EU

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Environmental awareness in the EU

On the 25th of March 1957, the governments of Holland, Belgium, Luxembourg, France, Italy and the Federal Republic of Germany signed the Treaty establishing the European Economic Community (TEEC). For the first time since the Second World War, some of the most important states in Europe decided to work together to construct a common market. This objective was to be achieved via the co-ordination of different policies, among the most important of which was the Common Agricultural Policy (CAP).

The TEEC summed up the objectives of the CAP in five points (art. 39); none of which mentioned the environment. Circumstances in Europe at that time led to the first phase of the CAP being more concerned with production and improving the lot of farmers. From that perspective it can be stated that CAP was a success. Unfortunately, however, protecting the environment was not considered a primary objective.

In October 1972, the Heads of State and Government met at the Paris summit, where they invited the Council of Ministers to adopt a Programme of Action on the Environment. This mandate was concretised in 1973, with the publication of the first European Community Programme of Action on the Environment.[1]. This was the first of five Programmes of Action in which the EEC (and later the European Union, since 1993) have tried to balance economic development, improvements in the quality of life and the protection of the environment. This first document was also the inspiration behind the founding of the Least Favoured Areas directive in 1975[2].

In 1980, the Commission presented a report entitled Reflections on the CAP: four problems. This report began by noting the progressive deterioration in the environment. After this consideration, the EEC decided to modify the CAP to take into account the need to reduce the high levels of production and to protect the environment and the rural scene.

Five years later, in 1985, the Commission published a Green Book entitled Perspectives of the Common Agricultural Policy", which recognised Environmental protection as one of the most important functions of agriculture and opened a wide ranging debate on its future. This publication, together with the rules laid down in the Joint European Act (1987) and the decisions taken at the

[1] Declaration of the Council of the European Communities and of the representatives of the Governments of the Member States meeting in the Council of 22 November 1973 on the programme of action of the European Communities on the environment. OJ No C 112, 20.12.1973

[2] Council Directive 75/268/EEC of 28 April 1975 on mountain and hill farming and farming in certain less-favoured areas. OJ No L 128, 19.5.1975, p. 1.

Council of Europe in 1988, led the European Community to develop the third reform of the CAP in 1992.

The basic aspects of this reform were centred on:

a. The modification of the Common Market Organisations (CMO)
b. The creation of aid mechanisms, centred on the reorientation of rural economies towards new economic activities

The most important achievements of the reform are summarised in the following five points:

a. A high level of balance in agricultural markets, acting both on production –reducing it– and consumer demand –increasing it
b. An improvement in the competitiveness of European agriculture through a reduction in prices
c. The diffusion of environment-friendly agricultural methods and a reduction in agricultural surpluses
d. The redistribution of aid
e. The maintenance of a sufficient number of farmers to rationalise production structures

Another important mechanism was the establishment of a new grants system whose objectives were to accompany the planned changes in the context of the CMOs, attain the objectives of the Common Agricultural Policy and the Environment and to contribute to guaranteeing sufficient income for farmers.

This reform, and its impact on Organic Farming, is being studied by different Research Projects funded by the European Commission.

Meanwhile, on the 17th of May 1993, the fifth Programme of Action on the Environment was published[3], having been previously approved by the Council and representatives of the Member States on the 1st of February 1993. In the chapter on Agriculture and Forestry the medium and long-term aims were expressed up to the year 2000. Explicit reference being made to Organic Farming.

Nevertheless, integration between both Joint Policies (Agriculture and Environment) has not been achieved yet, due, principally, to the great differences existing at various levels.

[3] The Community Programme for policy measures regarding the environment and sustainable development: Towards sustainability OJ C 138, 17.5.93

Agricultural and environmental policy - a comparison

	CAP	Environmental Policy
Age	Old: set up in 1958	Recent: commenced in 70s, codified in the SEA in 1987
Legal basis	art. 38 - 47 EC Treaty	art. 130r - 130t EC Treaty
Nature of the competence	Exclusive: this common policy is decided by EU	Subsidiary: EU intervenes only when its action is more efficient than the one of Member States

Decision-making procedure	Qualified majority	Programmes: co-decision Implementation measures: co-operation (except: fiscal measures, land use, water resources management, energy supply: unanimity, unless Council decides to opt for qualified majority)
Scope	Sectoral: but moving towards rural areas policy	Horizontal: the principles of environmental policy must be integrated in all the other EC policies
Objectives	–increase in agricultural productivity; –fair standard of living for the agricultural community; –stabilisation of markets; –availability of supplies; –reasonable consumer prices	–preserving, protecting and improving the quality of environment: –protecting human health; –prudent and rational utilisation of natural resources;
Principles	–market unity; –financial solidarity; –Community preference	–precaution; –prevention; –rectification at source; –polluter-pays-principle
Nature of the instruments	(mainly) Interventionist: economic instruments like price support and direct payments	(mainly) Regulatory: normative instruments
EU Budget share	Big: Since EU has the exclusive competence of managing the agricultural sector through economic instruments.	Small: due to the subsidiary, horizontal regulatory characteristic

Joint Research Policy

Research policy has a legal base, where agricultural arguments are concerned, in article 41 of the European Community Treaty (TEC). Additionally, the Joint European Act established a specific new foundation by adding articles 130F to 130P. More specifically, and in accordance with article 130I, the Community must establish a programme for research financed by community funds.

Community Research can be divided into three types of action:

1. Direct Action. These are activities directly administered by the Commission and paid for in their totality by funds from the Community Budget. This research is carried out by the Joint Research Centre (JRC). The JRC came into being as part of the EURATOM[4] treaty (to be more precise under the mandate set out in article 8). There are currently eight research centres open in five Member States. One of these centres being the Environmental Institute in Ispra (Italia)

[4] Treaty establishing the European Atomic Energy Community, signed in Rome on 25 March 1957.

2. Indirect actions: or shared cost research. Administered by Research Centres, Universities and Private Laboratories, with financial assistance from the Commission. In general, this subsidy can represent up to 50 % of total research costs.

3. Concerted Actions. In such cases the Community confine itself to defining the framework within which researchers can work. Their role here is merely to co-ordinate research, so avoiding duplication.

Research into Organic Farming (OF) within the Joint Research Policy

AGRIRES 0C

This was the first research programme dealing with agricultural issues to be financed by the Community. It was very limited; its objective was the fight against swine fever. It was active from 1973 to 1976. Research projects related to OF were not subsidised because their objectives were considered too specific.

AGRIRES 1C

During the period 1976-1978, the Commission developed a new agricultural research programme. Its name, (the joint research programmes (EEC) and programmes for the co-ordination of research in the field of animal leucoses, livestock effluents, beef production and plant protein production) clearly defined its objectives and field of operations. It included shared research and activities (shared-cost research contracts and concerted actions, respectively). There is no information in CORDIS[5] about the projects financed under this programme: the only reference is to 32 workshops and 55 individual exchanges of scientists that were carried out.

AGRIRES 2C

With an 18·6 million ECU total budget during a period of 60 months, the Commission initiated a new research programme under the heading: «Joint research programmes (EEC) and programmes for co-ordinating agricultural research 1979-1983», this was the last of the pre-FW programmes. This programme was divided into four fields and ten programmes. It was the first time that protecting the environment figured as one of the objectives. More concretely, the programme was divided into:

Field 1. Socio-structural objectives

1.1 Programme for the appropriate use of land and rural development

Field 3. Production efficiency

3.2 Programme on integrated and biological pest control

There are no references in CORDIS to the different projects developed under this programme.

AGRIRES 3C

This programme was the first to be developed under the umbrella of a Framework Research Programme. It financed 113 projects in four areas and seven sub-areas:

–Utilisation and conservation of agricultural resources

- Energy in agriculture

[5] CORDIS is the acronim of the Community Research and Development Information Service

  - Land and water use and management

–Structural problems

  - Mediterranean agriculture (the AGRIMED programme)
  - Other less-favoured regions
  - Agrofood

–Improvement of animal and plant productivity

  - Animal husbandry
  - Plant productivity

–Co-ordination of research

No references to Organic Farming have been found in the CORDIS database

CAMAR

The «Research and technological development programme (EEC) in the field of competitiveness of agriculture and management of agricultural resources», offers us the first project related to Organic farming. In fact it comprised three projects and a concerted action.

The programme was divided into four sectors and 23 sub-areas:

–Conversion, diversification, including extensification of production, reduction of costs and protection of the rural environment:

  - Introduction of new and improved varieties of crops, out of season products and by-products
  - Alternative livestock production systems
  - Examination of farm woodland production systems
  - Improved biological and integrated pest control as well as improved and reduced use of fertilisers, fungicides, herbicides and pesticides
  - Development of alternative agricultural practices, especially organic farming
  - Support for development of the common agricultural structures policy
  - Identification of alternative uses for land no longer required for agriculture

–Product quality, new uses for traditional products, and aspects of plant and animal health:

  - Definition, measurement and determination of quality in agricultural products
  - Pre- and post-harvesting techniques
  - Effects of residues, toxins and other noxious substances occurring in agricultural products
  - Preparation and packaging of agricultural products
  - Detecting and controlling crop and animal diseases that threaten the Community
  - Developing alternative uses and improving the quality of traditional products

–Socio-economic aspects and specific actions for all regions in the Community lagging behind in development:

  - Assessment of the structural, social and economic consequences of applying the agricultural policies of the Community in these regions
  - Investigation of constraints to development in these regions and orientation of subsequent research and development actions

- Specific regional problems arising from the conversion, diversification and extensification of crop and animal production
- Specific regional problems arising from conversion to woodland and forest production
- Specific regional actions to overcome problems posed by the poor composition of water and the excess or lack of it
- Actions to improve agricultural mechanisation in specific regions
- Integrated rural development

–Methods and services to disseminate agricultural research information:

- Integrating Community agricultural research information systems
- Developing agricultural information technology
- Applying computers and information modelling to agricultural production systems

AIR

The Third Framework Programme unified different individual programmes connected with agriculture, forestry and fisheries into a specific new programme called the Specific research and technological development and demonstration programme (EEC) in the field of agriculture and agro-industry, including fisheries". The programmes that were unified were the FAR, FLAIR, ECLAIR[6] & CAMAR programmes. This was the first project administered by three DGs (DG VI, DG XII y DG XIV)[7]

The program included research and technological development projects, demonstration projects, accompanying measures and concerted actions, and financed some 436 projects, of which seven were related to Organic Farming. It is worth mentioning here that one of these projects was the ENOF Concerted Action.

FAIR

The last programme studied in this work is known as the «Specific RTD programme in the field of fisheries, agriculture and agro-industrial research». With a total of 684 million ECUs (increased at first to 728 and later to 739.5), it approved 351 projects.

They were divided into the following areas:

–Integrated production and processing chains

Integrated food and non-food projects combining all necessary skills and technologies, particularly biotechnologies, related to the individual links in the production chains. Particular emphasis is placed on collaboration between producers and users of biological raw materials in joint projects, closely co-operating with scientists. Five action lines:

- Industrial uses for cereal crops
- Industrial uses for vegetable oil crops
- Industrial uses for protein crops
- Forestry-wood chain
- Biomass for energy and non-food uses

[6] FAR: Community research and coordination programmes (EEC) in the fisheries sector, 1988-1992
FLAIR: Multiannual research and development programme (EEC) in food science and technology, 1989-1993
ECLAIR: First multiannual programme (EEC) for biotechnology-based agro-industrial research and technological development, 1988-1993

[7] DG Agriculture, DG Science Research and Development and DG Fisheries, respectively.

–Scaling-up and processing methodologies:

To develop improved methodologies for designing and testing innovative agro-industrial processes and for the application of biotechnology, while reducing the economic risks currently associated with investment in new technology.

–Generic sciences and advanced technologies for nutritious foods:

To develop generic technologies through the application of biotechnology to produce commercial crops with enhanced performance, improved production efficiency and improved nutritional qualities. Other activities concentrate on the generic scientific phenomena involved in the conversion of biological raw materials into food and multidisciplinary research into nutritional diseases and disorders.

–Agriculture, forestry and rural development:

Optimisation of methods, systems and primary production chains; quality policy for agricultural products; diversification of production and farming sector activities, and new uses of land; animal and plant health, animal welfare; multifunctional management of forests, i.e. production, leisure and protection; and, scientific support for rural development.

–Fisheries and aquaculture:

Impact of environmental factors on marine resources; environmental impact of fisheries and aquaculture activities; biology of species for optimization of aquaculture; socio-economic aspects of the fishing industry; and, improved methodology.

–Other activities, mainly implemented by concertation:

To promote the concertation of efforts in areas where the Member States have extensive programmes through the establishment of European concertation networks. Examples of areas where this is appropriate are:

- Primary production in agriculture, forestry, fisheries and aquaculture with the main emphasis on competitiveness, sustainability, quality, security of supply and interactions with the environment
- Conservation, development and management of the natural, semi-natural and man-made landscape
- Rural, including mountain and coastal, development with particular attention on training and alternative economic activities
- Food production and processing, including socio-economic, health and safety aspects.

In CORDIS references can be found to 8 projects related to Organic Farming.

ENOF Concerted Action

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STRUCTURE

Organisationally, ENOF has a «*Steering Commitee*», comprising the CA Co-ordinator, from *LEAAM- Agroecologia* (*CID-CSIC*, Spain), and 5 Sub Co-ordinators, one for each research area. The areas initially established being the following:

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Il– Soil Fertility and Environmental Aspects (*Université Libre de Bruxelles*, Belgium)

III– Animal Husbandry, Grassland and Fodder Production (*Louis Bolk Institut*, Holland). Later, these were divided into two sections:

IIIa– Animal Husbandry

IIIb– Grasslands and Fodder Production

IV– Legal and Economic Aspects (*Università degli studi di Ancona*, Italy)

V– Plant Protection (*Scottish Agricultural College*, United Kingdom)

The Co-ordinator has been the person responsible for reporting contractual and administrative affairs to the European Commission. The co-ordinator has taken responsibility for the Administrative and Scientific co-ordination for «Annual Reports», «Publications», «Mailing List», the «Data Base» and the «Web Page», as well as the final presentation of the «White Book». The Sub co-ordinators, for their part, have been responsible for co-ordinating their respective areas, as well as aiding the Co-ordinator in the Workshops, evaluation of Research and the writing of the «White Book».

Centres involved in research into organic agro-forestry have been able to become Associated Laboratories, some of which have been invited to participate in Workshops and other proposed scientific meetings.

OBJECTIVES

The main objective of ENOF has been to establish and maintain contacts between European Organisations working on, or developing, organic farming techniques, whether in *Education*, *Research*, *Experimentation*, *Demonstration* or *Dissemination:* particularly through R + D Projects. These groups have included private, as well as public Universities and Research & Experimentation Centres. ENOF has gathered all the information available on the subject and on the state of current research, highlighting, wherever possible prevailing priorities. ENOF has also contacted and established relations with other networks associated with the topic.

In brief, more concrete proposed objectives were:

1. To create a forum for scientific discussion of Organic Farming

2. To link up different European Research Teams

3. To co-ordinate European research into Organic Farming

4. To identify necessary lines of investigations that are currently non-existent

5. To propose recommendations for future scientific policy in Organic Farming

DELIVERABLES

As a result of the founding of the Network, and in accordance with its objectives, a «Mailing List» has been set up of Centres and/or individuals that have expressed an interest in being on it.

ENOF has also established a «*Web Page*»: www.cid.csic.es/enof

where further information about its activities can be found, along with material on relevant current events. It has received about 3900 visits since 26/09/96.

A *Newsletter*, *NENOF*, has been created, which has now published 8 numbers, and an annual Workshop has been held, the *Proceedings* of which have been published later. All publications have been in English, but have also included Abstracts in other European languages.

The «*NENOF» Newsletter*, has been used to publish the latest information appropriate to the Network, the main relevant events that have taken place, or are soon to happen, as well as other scientific articles which fall within the field of Ecological agro-forestry. Eight numbers have been published.

Numbers 1 & 8 were devoted to mainly informative, general contents. Numbers 2 to 7, apart from more general themes, were devoted to specific areas:

Nr. 2. Crop Protection

Nr. 3. Crop Production and Weed Control

Nr. 4. Grasslands and Fodder Production

Nr. 5. Soil Fertility and Environmental Aspects

Nr. 6. Legal and Economical Aspects

Nr. 7. Animal Husbandry

A «Data Base» of research into Organic Farming has been created, based on ENOF's own questionnaire, which has been included in the *Newsletter* and is available on the *Web Site*, as well as information from the CORDIS and AGREP networks and other national data bases through ERGO. In fact, all of those who have joined the ENOF network have sent in data about their research and experiences as requested in the centre pages of the *NENOF* Newsletter.

ENOF's work in CORDIS

One of the main functions of ENOF has been the evaluation of research into Organic Farming under the different EU Research Programmes, mentioned into next Chapter. The most important factor in this evaluation has been consulting the CORDIS database.

With the intention of obtaining information about Organic Farming projects, the database was consulted using the following syntax:

Search for: «organic farming» OR «ecological farming» OR «biological farming» OR «organic agriculture» OR «ecological agriculture» OR «biological agriculture»

Searches were not carried out using the terms «Sustainable» or «Integrated», since these terms encompass many projects having little to do with OF. Apart from which the ENOF Steering Committee considers that «sustainable» or «integrated agriculture» and «organic farming» can by no means be considered synonymous.

The results of this search can be summarised as follows:

Number of projects found 24

Number of Programmes 10

Number of programmes under the Frameworks scheme 6

Number of Programmes of Action 4

The «Mailing List» currently has 663 addresses of adherents to the Network, all of whom receive the *NENOF Newsletter* and 234 of whom receive the *Proceedings* of the Workshops. The maps in figures 1 and 2 show the distribution of these publications in Europe, indicating which are also distributed to other continents.

The «Data Base» currently includes 204 references, particularly relating to recent projects developed in Europe. It is notable how many projects are being developed in Holland and Germany in contrast to the scarcity of those being developed in Portugal, Greece or Ireland (Figure 3). More than 40 percent of the references have been obtained through ENOF (Figure 4).

The four «WORKSHOPS» organised by ENOF, were held in four different countries.

The First was held in Bonn (Germany), in December 1995, at the University of Bonn (Institute of Organic Agriculture), and was co-ordinated by Prof. Dr. Ulrich Köpke, and designated «*Biodiversity and Land Use: The Role of Organic Farming*». Some 20 scientists attended, and 15 papers were presented. The *Proceedings*, took up 155 pages, and were published in May 1996.

The Second took place in October 1996, in Barcelona (Spain), at the Barcelona Museum of Zoology and the Centre for Research & Development of the CSIC. It was organised by LEAAM-Agroecología, and the general theme was the problems inherent in converting to Organic Farming. The workshop were sub-titled: «*Steps in the Conversion and Development of Organic Farming*». This meeting also had 20 participants and 15 papers were also read there. The *Proceedings*, took up 129 pages, and were published in June 1997.

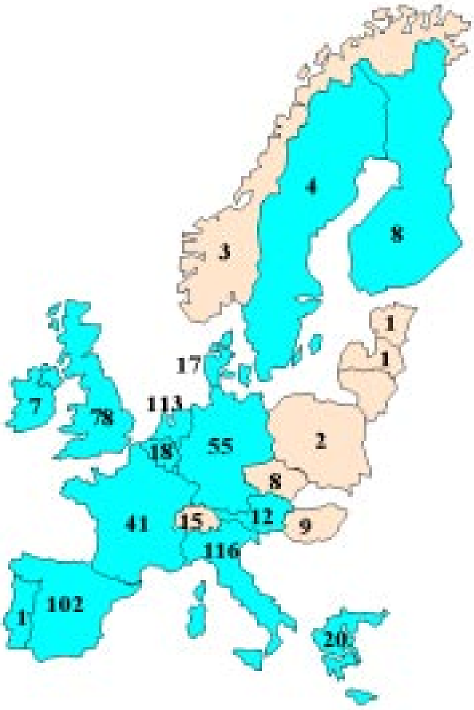
The Third was held in Ancona (Italy), at the University of Ancona (Portonovo National Park) in June 1997. It was organised by Dr. Zanoli, and dedicated to the «*Resource Use in Organic Farming*». The total number of participants was 35 and 20 papers were read and 6 posters presented. The *Proceedings* took up 359 pages and were published at the beginning of 1998.

The Fourth took place in Scotland at the University of Edinburgh (Scottish Agricultural College), at the end of June 1998, co-ordinated by Dr. McKinlay, under the main heading of «*The Future of the Organic Farming Systems*». There were 25 participants and 6 speakers. The *Proceedings*, took up 109 pages and were published at the beginning of 1999.

Those who have expressed an interest in receiving, free of charge, the «*NENOF*» Newsletter, have sent us their details to be included in the «*Mailing List*», which remains open to anyone wishing to join it. Individuals and Centres involved in Research and experimentation into Organic Farming, or those belonging to a Library or an Official Organisation, have also asked for the *Proceedings* of the Workshops.

As an end product of the CA, the present «WHITE BOOK» was produced. We acknowledge the effort and the involvement of the people who has been working in ENOF. Specially to the Subco-ordinators, which has been one of the reasons of the success of this Concerted Action.

Mailing list

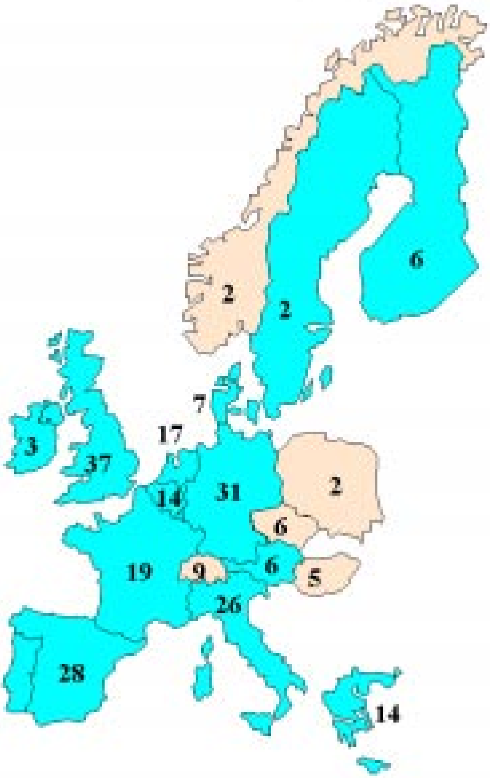


European Union	
Austria	12
Belgium	18
Denmark	17
Finland	8
France	41
Germany	55
Greece	20
Ireland	7
Italy	116
Netherlands	113
Portugal	1
Spain	102
Sweden	4
Unites Kingdom	78
TOTAL	*592*
Europe (Non EU)	
Czech Republic	8
Esthonia	1
Hungary	9
Latvia	1
Norway	3
Poland	2
Switzerland	15
Turkey	1
TOTAL	*40*

America	
Antigua	1
Brasil	1
Canada	5
Costa Rica	1
Chile	2
Peru	4
USA	15
TOTAL	*29*
Others	
Egypt	1
Pakistan	1
TOTAL	*2*
TOTAL	*663*

Figure 1.

Proceedings



European Union	
Austria	6
Belgium	14
Denmark	7
Finland	6
France	19
Germany	31
Greece	14
Ireland	3
Italy	26
Netherlands	17
Spain	28
Sweden	2
Unites Kingdom	37
TOTAL	*210*
Europe (Non EU)	
Czech Republic	6
Hungary	5
Norway	2
Poland	2
Switzerland	9
TOTAL	*24*
TOTAL	*234*

Figure 2.

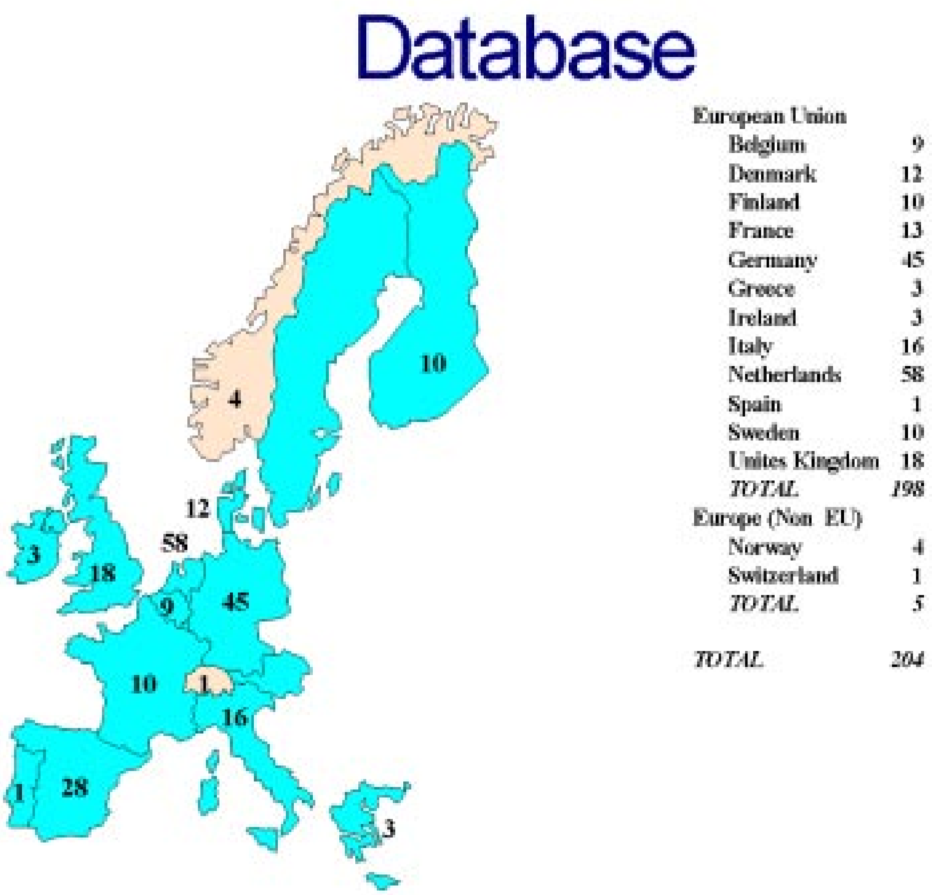


Figure 3.

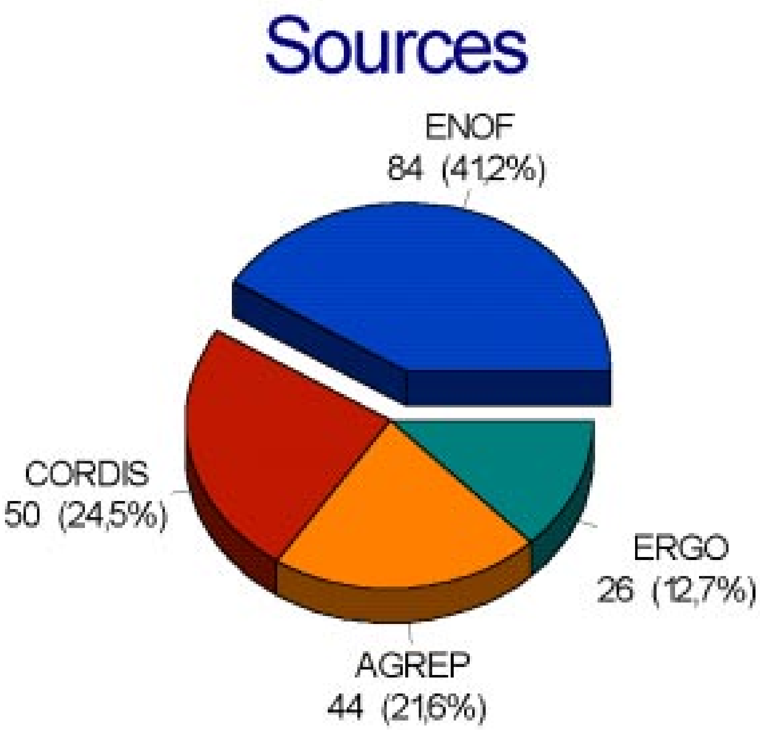


Figure 4.

ORGANIC FARMING RESEARCH IN THE EU, TOWARDS 21ST CENTURY

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CHAPTER 3

REVIEW OF CROP PRODUCTION AND WEED CONTROL: STATE OF ARTS AND OUTLOOK

U. Köpke

REVIEW OF CROP PRODUCTION AND WEED CONTROL: STATE OF ARTS AND OUTLOOK

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I INTRODUCTION

Survey based on ENOF database

About 130 documents related to the optional terms given above as keywords, were found in the ENOF database. Most of the contributions came from Northern European countries than from countries in Southern Europe confirming the results given in the Chapter dealing with crop protection. Since projects found in the database do not fully cover the information available on research available for the topic of crop production and weed control in Europe, the following contribution is extended by information gained from other sources and sub-coordinator's current knowledge. Selfevidently, interactions exist with topics mentioned as well in other White Book chapters underlining the holistic approach of Organic Agriculture.

Oriented on the research programmes under way the items were differentiated in seven sub-chapters: 1. crop rotation, precrop effects and nutrient management 2. strip cropping 3. product quality 4. vegetable growing 5. breeding 6. biodynamic preparations and 7. weed control. The number of hits found in ENOF's data base related to the keyword mentioned in subchapter's headlines is given in brackets.

Introduction: Aims and principles of Organic Agriculture

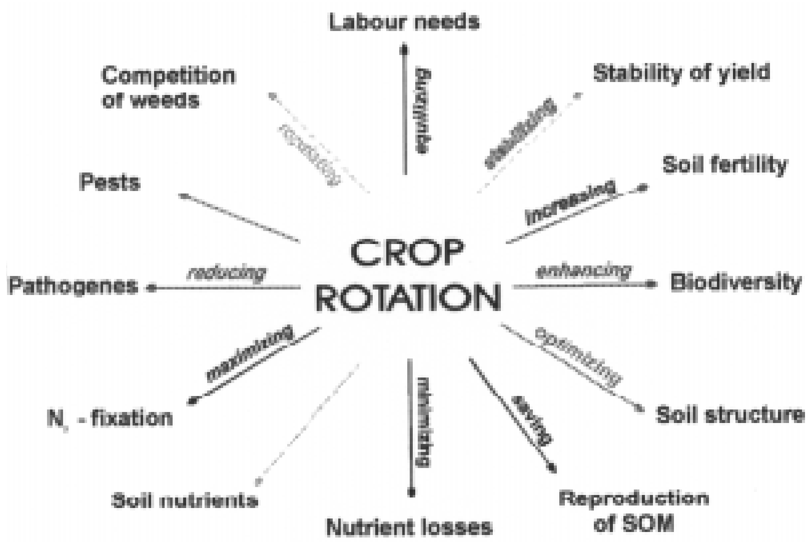
Organic Agriculture pursues its mission running an *organ*isational principle: to organise and manage a mixed farm within a nearly closed system, an *organ*ism alike (Köpke, 1995). Since site conditions are individual properties by definition, a farm can be conceived as an individual entity (Koepf, 1981). In comparison to mainstream agriculture, organic agriculture depends more on specific site conditions and is therefore forced to combine the best site-adapted elements to a holistic approach (Köpke, 1999a). Under central European conditions and humid temperate climate, organic agriculture's relationship within environmental quality is enhanced by a mix of crop and life stock farming that creates diversified production systems (Baars, 1998/99; Köpke, 1999a).

II Main Areas of research

1. Crop rotation (68), precrop effects (30) and nutrient management (60)

Consequently agronomic strategies are based on the cornerstone of agronomy, the design of an optimal site-adapted crop rotation. In Organic Agriculture optimal rotation has to fulfil several functions (Table 1). Diversification of crop rotation homogenises the labour demand in the farm. It stabilises the yields, it regulates weed competition, it controls pests and reduces pathogens. Optimal rotation has to optimise the soil structure, it has to increase soil fertility saving the reproduction of soil organic matter maximising nitrogen fixation, mobilising other nutrients from soil and minimising nutrient losses. Most of these aspects are directly related to stability of yields. No wonder that during the last decades must research activities in Organic Agriculture were oriented on crop rotation and nutrient management. These topics did receive special attention in concerted action AIR3-CT94-1940 (Fertilization Systems in Organic Agriculture, FERSY), too.

Table 1. Functions of an optimal site-oriented crop rotation



In relation to nutrient management in contrast to conventional agriculture, Organic Agriculture has to deal with scarcity of nutrients. From this point of view *management* has to be considered as the *optimised combination of resources* that are restricted (nitrogen) (several hits found in database for Aberdeen, U. K., Fargnières, France, Bonn, Germany, Wageningen, Netherlands) or have to be unlocked by achieving the optimised utilisation (e.g. potassium and phosphorus via increased rooting density and efficiency of nutrient absorption (hits to Wageningen, Netherlands, Bonn, Germany, Partala, Finland (mycorrhizal fungal communities)). Nutrient management can therefore be defined as a systematic target –oriented organisation of nutrient flows (Köpke, 1995). The holistic approach under the aspects of nutrient management in practice means: Nearly closed cycles of nutrients and organic matter within the farm. Mainstreams of nutrient flows are fixed in the long term by organising and optimising the site adapted optimal crop rotation (Köpke, 1998; Watson *et al*., 1998).

Strategies making the nitrogen in the system internally available via N_2-fixation can also be based on basic research performed by scientists not primarily oriented on Organic Agriculture. A broad spectrum of publications dealing with this subject exists. Most research projects which are oriented on Organic Agriculture focused on fodder legumes in pure stands or grown in combination with grasses (e.g. Høgh-Jensen, 1996; Høgh-Jensen & Schjoerring, 1996; Schmidtke, 1997). Nearly all institutions which delivered projects to ENOF´s database do run experiments oriented on this topic having several intersections to the research areas reported in the chapters of this White Book (hits on research oriented on sustainable ley-arable farming systems were found: Aberdeen, U.K.; Partala, Finland; Müncheberg, Germany; Brussels, Belgium; Bonn, Germany).

Only few field experiments were oriented on grain legumes such as faba beans, peas or lupines. During the last two decades different approaches to estimate the amount of symbiotically fixed nitrogen without using sophisticated methodologies have been developed. Although species used for nitrogen fixation are quite different all over Europe, a general relationship can be used. In pulses the amount of symbiotically fixed nitrogen is closely correlated to grain yield and the amount of N in grains (Hauser, 1987, 1992; Köpke, 1987/1996). The amount of N-fixed can therefore be derived from the amount of grains produced. Highest amounts of N-fixed can be achieved by selecting those species which are best adapted to given site conditions and by further selection of the highest yielding variety within the highest yielding species. Farmers ought to decide on an individual site basis whether they may expect higher yields from faba beans, peas, lupines, chick peas, lens etc.. All other agronomic strategies which can increase grain yields of pulses will simultaneously further increase nitrogen fixation (Köpke, 1995).

Similar strategies were developed for fodder legumes. Dinitrogenfixation can be maximised by selecting those species and cultivars which are best adapted to given site conditions. Clear relationships between dry matter yield and nitrogen fixation in fodder legumes exists. The higher the percentage of clover in grass/clover mixtures and the yield per cut in those stands, the higher the amount of symbiotically fixed nitrogen (Boller, 1988). Meanwhile coefficients and charts exist from which the amount of nitrogen which is symbiotically fixed by pulses or fodder legumes can be estimated based either on mean nitrogen content of grain yield or in the case of grass/clover mixtures by estimating or measuring the amount of dry matter yield produced and the share of clover in the yield mass.

Positive precrop effects are mainly determined by available nitrogen to following crops. This nitrogen must not be derived from legume residues but can be soil-borne N as a function of the soil milieu formed by the legumes (e.g. Huber, 1988; Köpke, 1987/96). Precrop effects were quantified for faba beans up to 100 kg N/ha fertiliser-nitrogen-equivalence. In grass/clover mixtures N-budget is often calculated as negative, but optimised soil structure can enhance growth of following crop. Hence, precrop effect is primarily driven by the soil structure status and its further dynamics which are not fully understood.

Beside the aspect to maximise nitrogen fixation nutrient management has to focus on keeping the nitrogen potentially available in the long term via optimised sink to source relationships. Beside directly applied farm produced manure and composts (Piorr, 1992; Bachinger, 1995a, b; Stein-Bachinger, 1996,) optimisation of nutrient flows is regulated by the amount of nitrogen fixed by legumes and via adequate sinks for nitrogen in following non-leguminous crops. Residual nitrogen, i.e. nitrate in the liquid phase, has to be minimised to avoid nitrate losses via leaching during periods where no plant sinks can act.

By selecting the appropriate site specific strategy, an efficient use of N-fixed and soil borne N is ensured by sinks of following or undersown non-legumes (Köpke, 1996). Legumes leave reasonable high amounts of nitrate in the soil after harvest. These amounts of rest N are suspected to be leached during winter and early spring and to get lost from the farming system in the liquid phase. It's quite obvious that this effect is a function of weather conditions during winter and effects of soil milieu, i. e. mobilisation or immobilisation conditions modifying the nitrogen based precrop effect of pulses of fodder crops which is potentially high but can not be predicted precisely in terms of plant available nitrogen and its effect on yield on the long term.

Consequently some research projects do report on strategies to hinder nutrients to disappear out of the farm based on:

–contra movement (liquid phase: especially nitrogen; in some cases on light soils potassium and phosphorus, too).

–retardation (solid phase: erosion control, mulch cover), or

–fixation (hindering gaseous losses by using the absorption complex e. g. NH_3 emission from farmyard or compost heaps, respectively).

In the liquid phase oriented on nitrate, downward flow has to be hindered by creating sinks, for instance via efficient nitrogen uptake by growing plants. Leaching is avoided by orienting vertical downward flow vertically upward (contra movement). Accumulation of soil nitrate under pulse crops is a function of the relatively low rooting-density of the legumes and the heterogeneous root-distribution. Accumulation of soil nitrate can be avoided via narrow row distances, inter-cropping with non-legumes or undersown brassicas due to a more homogeneous distribution and a more homogeneous uptake of soil nitrate as a function of the rooting pattern (Justus & Köpke 1995; Justus, 1996).

Meanwhile these different strategies to avoid nitrate losses and to optimise precrop effects of pulses can be differentiated oriented on the given site conditions. On soils having a high release of soil borne nitrogen intercrops or weeds can reduce aphids in beans driven by the amount of nitrogen taken up by the legumes (one example underlining that pests [and diseases] can be regarded as a function of unbalanced plant nutrition, Patriquin *et al*., 1988; Justus, 1996). On these soils non-legumes are used as intercrops. Concepts to reduce nitrate losses when growing grass/clover mixtures in humid climate have to focus on postharvest and postploughing conditions. Transfer of symbiotically fixed nitrogen to following crops after ploughing grass/clover mixtures can be optimised by minimising prewinter mineralisation, in particular by:

–proper timing of ploughing – for example delaying the primary cultivation of grass/clover in autumn; and/or

–reducing tillage intensity (deapth, frequency), while still maintaining the standard crop rotation (wheat following grass/clover); or

–changing the crop rotation using catch crops acting as nitrate sinks following grass/clover mixture to fix pre winter mineralised nitrogen followed by summer crops; or

–cultivating main crops that show a high nitrogen uptake before winter (i. g. rapeseed) (Hess, 1989).

The above mentioned strategies are elements of recently published comprehensive studies on Organic Agriculture in water catchment areas (Haas *et al*., 1998; Agöl-Bund, 1997). One further hit in the database on water quality in a water protection area was found for Leipzig, Germany.

Looking on non-legumes as following crops efficiency of nutrient uptake is of greatest interest. Under this aspect optimal rooting systems consist of a high rooting-density of fine, young and active roots having higher nutrient uptake especially K and P when compared to rooting systems consisting of the same root mass invested in thicker roots (Claasen, 1994; Köpke, 1994). It is quite clear that the soil volume is better influenced by the rhizosphere of the first case mentioned.

Optimised crop rotation performed in mixed farm systems with farmyard of different rottening stage supplied show increased soil fertility. Meanwhile a broad spectrum of parameters characterising soil fertility, soil microbial biomass and activities is available. (Several contributions on theses topics see in Mäder & Raupp, 1995). To study the effects of organic farming systems for developing sustainable soil fertility, long term effects have to be evaluated. Funding of long-term field experiments like the DOC trial in Therwil, Switzerland (Alföldi *et al.*, 1995), the long-term trial in Darmstadt, Germany (Raupp, 1995) and a long-term trial performed in Sweden (Granstedt, 1995) is urgently recommended. Some other long term field experiments do exist but might be given up in the next future due to limited funding resources (e.g. systems – field trial in Göttingen, Germany). Important information that might be gained from these experiments especially oriented on soil physical, soil, microbial and biochemical parameters is feared to be lost.

A joined project focussing on organic matter dynamics and N-mineralization in organic farming systems (University Wageningen, Luis Bolk Insitute, Flower Bulb Institute, Research Station for arable farming in field production of vegetables, Netherlands) should be brought into interaction with those researchers running the above mentioned long term experiments.

2. Strip-cropping (2)

In mixed farms soil fertility is maintained and extended beside growing of fodder crops by using predominantly farm produced manures and composts. These tools are not available in stockless farms. Green fallows consisting of grass and clover can be used in set-aside programmes of the EC for the transition to Organic Farming – a chapter, a whole ENOF-workshop dealt with (Isart & Llerena, 1996). Amounts of up to 275 kg N/ha have been accumulated with grass/red clover or lucerne mixtures with just two cuts (Dreesmann, 1993; Dreesmann & Köpke, 1990). Since the shoot mass of green fallows cannot be harvested, mineralisation of green fallow residues produce high soil nitrate contents under following crops. A considerable amount of this nitrate can be suspected to be leached in rainy summers. Beside the above mentioned grass/clover strategies, management of green fallow has to pay special attention either to the competition of stands in order to control the source (N supply by reducing the percentage of clover) or by using grass/clover cuts for manuring and soil covering in strip-cropping cereal stands. Strip-cropping of spring wheat where residues of grass/ clover are used as mulch for weed control and N source gave higher yields and protein contents of grains and therefore higher baking quality by avoiding lodging due to thicker and shorter culms as a function of higher number of margin rows when sown in east-west direction (Schulz-Marquardt *et al*., 1994, 1995). This procedure ought to be legalised as it might be a true efficient way to produce organic cereals which do not pollute ground water with an «untimely» mineralised N outside the growing season. A similar procedure of soil fertility management can be used in vegetable production where grass/clover mulch layers beside acting as an N-source can control weeds efficiently. Modifications such as bi-cropping systems (Clements & Donaldson, 1997, Clements et al. 1997), or double row – seeding of wheat into grass/clover stands can be run successfully under special site conditions where sufficient precipitation can fulfill water uptake needs of the crops combined.

Strip cropping systems are considered to be suitable for stockless arable farms but not yet used in projects oriented on these farm types (crop rotation project, Witzenhausen, Germany).

One hit was found in the database concerning cereal/clover intercropping and the sanitary effect on cereal diseases (Reading, U. K.) confirming results of Weber *et al*. (1994, 1995). Links exist to a set-aside management project announced by Godden (Brussels, Belgium).

3. Product quality (55)

At least 11 % protein content of wheat grains are regarded as necessary for sufficient baking quality. Positive precrop effects of nitrogen fixing precrops cannot fulfill these aims with confidence. Use of liquid manure applied to growing *cereal* stands were proved by several authors to increase grain nitrogen content and *baking quality* efficiently. On the other hand relationship to *gluten quality* as a function of cultivars and manuring has not been deeply investigated. Moreover, recent results have shown that some varieties can bring high baking volume with protein content lower than 11 % (Wirries & Büning-Pfaue, 1995; Wirries, 1998).

Regarding *whole meal products* further investigations are proposed to be carried out whether the current baking technology developed for flour can be improved. Regarding baking quality modified or new parameters have to extend the spectrum of parameters that fit to whole meal processing.

A joined project is run by the Swedish Agriculture University in Uppsala together with the Czech University of Agriculture (Prague, Czech Republic) comparing product quality from different farming systems and suitable varieties chosen for malting and baking purposes. A project located in Gembloux (Belgium) is focussing the production of high baking quality of wheat in Organic Farming, having links to some other Belgium researchers.

Meanwhile recommendations were given for high quality wheat varieties. Gluten of different wheat qualities in Organic Agriculture is analysed by DSC. Results will be compared with those of the quantitative determination of high-molecular-weight-subunits of reduced gluten by RP-HPLC, of force/stretch-diagrams of the complete gluten and those of other well known methods. This project is run bound into the researcher group «Optimising strategies in Organic Agriculture», OSIOL, (DFG-project, Bonn, Germany) aiming the prediction of baking quality on the analysed flours.

One hit was found concerning development of product quality in Finish Organic Agriculture performed in cooperation with the Swedish University of Agricultural science.

From the concerted action FERSY one task for further research in *potatoes* was described as follows: Effects of manuring (and other cultivation factors on histological parameters like tissue strength and skin stability) should be investigated with regard to effective analytical methods, physiological background of the parameters and the significance for crop production and nutrition. Shelf-life of potatoes including a broad spectrum of parameters including degradation tests was investigated by the researcher group OSIOL (Bonn, Germany). Similar analysis has been performed in Czechoslovakia covering analysis of dry matter, starch, nitrate, ascorbic acid, glucoalcaloids, sensoric analysis and shelf life. Links exist to laboratories in Germany and Vienna, Austria.

Most of these parameters characterising product quality are necessary to be analysed in several other vegetables produced as baby food or for adults nutrition. Further efforts should be followed in evaluating so called «picture-forming» methods (sensitive cristallization, circular chromatography and «Steigbilder» or capillary-dynamolysis). Product samples of different origin or which were derived from field experiments with different treatments and which were put into codes were assigned with great accuracy (Alföldi *et al*., 1996, further research on quality see: Raupp (Ed.) 1996). «Picture-forming» methods should be investigated and developed more intensively with respect to characterise product quality better.

4. Vegetable production (15)

Demand for organically produced vegetables in industrialised European countries is high. Highly specialised vegetable producers can fulfil needs of several leafy crops with short vegetation periods and fast development and showing high demand for nutrients only by purchasing considerable amounts of organic manure from outside the farm. Cooperation with other farms e.g. livestock producers having surplus of organic manure is necessary. A tool to optimise organic farming might be the so called eco-balance or life-cycle-assessment (LCA) by which imbalances can be analysed and compensated by cooperating farms also under the aspect of efficient nutrient flows (Köpke & Geier, 1998/99).

Conditions for vegetable production in mixed farms can be described as follows: Sustainable soil fertility is mainly based on optimal and increased production of soil organic matter. Self reliance regarding humus production is based on the cultivation of crops producing high amounts of root- and shoot-residues and the application of farmyard manure. Calculations to quantify reproduction of soil organic matter which have been developed in the former GDR (Asmus, 1992; Kundler *et al*., 1981) and are oriented on farmyard manure as the reference can be performed by using available software (Hülsbergen & Gersonde, 1992).

Increasing the amount of soil organic matter results in higher C_t and N_t-contents of the soil. Higher or increased rates of mineralisation result in higher soil nitrate contents. The extended soil N_t-pool can increase nitrate losses when plant sinks, i.e. efficient uptake by plants, act inadequately.

Strategies to use brassica underseeds or catch crops act merely temporary. Uptake of cereals and potatoes is often limited as an effect of «untimely» plant available nitrogen and limited N sink of the shoots and the harvested organs. All strategies mentioned in Chapter 1 act therefore suboptimal if the soil nitrate pool is steadily increased. Alternatively a part of the nitrogen in the liquid phase can be bound into the solid phase via transferring for instance brassica fodder crops to farmyard manure. Farmyard manure can bind nitrogen in solid less reactive nitrogen compounds. Nevertheless also this strategy is often partly effective on the long term. Consequently, the high sink capacity of brassica catch crops can focus attention on brassica cash crops grown as vegetables acting as efficient sinks for nitrogen realising high export of nitrogen when sold. Two strategies of growing vegetables were described by Köpke (1996). First: growing vegetables integrated or apart from rotation as proposed by the investigated rotation oriented in field experiments. It is assumed that a «rotation-integrated» vegetable production is optimal for conditions were based on site and rotation the need for increased soil organic matter is high on all fields covered by the rotation of the farm. Second: For farms having conditions of high soil fertility, i.e. high nitrogen mineralisation rates, the concept of «rotation-external» production (separated vegetable production) should be studied.

Only two hits were found concerning economic perspectives in vegetable production (Lelystad and Gravenhage, The Netherlands). Without any doubt increasing consumers demand oriented on organic vegetable produce has to be responded by intensified research in organic vegetable production.

5. Breeding (7)

Site-oriented choice of cultivars plays a key role for successful Organic Agriculture. Several times suitability of modern cultivars for Organic Agriculture has been denied . Root systems of modern cultivars were regarded as less efficient under the conditions of Organic Agriculture. Selection and breeding programmes performed under condition of poor soils resulted in N-efficient cultivars of *winter wheat* available on the German seed market since 1994. Some of them show similar characteristics as defined for ideotypes well adapted to Organic Agriculture, e.g. lower tillering, higher thousand-grain-weight and single ear yield. If these N-efficient genotypes do have a root morphology better adapted to Organic Agriculture is quite unclear. Breeding of *barley* oriented on nitrogen efficiency is given by one hit (Perugia, Italy).

As mentioned in subchapter 7 (weed control) the competitiveness of a crop beside row spacing and plant density depends on the cultivar's morphology (Holt, 1995; Wicks *et al*., 1994). Proper choice of cultivars can decisively influence light competitiveness, especially under Organic Farming conditions. Higher shading ability in cereals is a function of shoot length and soil coverage during tillering and shooting, leaf inclination, leaf area index and shoot length (Köpke & Eisele, 1997; Eisele & Köpke, 1997a). Similar results were gained for *potatoes* (Korr *et al*., 1996). Here, leafy cultivars gave higher competition power compared to cultivars having a growth habit predominantly shaped by the stalks and having a lower leaf area index.

In spring *barley* shading ability was decisive until the end of tiller formation. In the latest stages of plant development importance of morphological parameters influencing shading ability depended on the site-condition. Parameters of the flag leaves were proved to be helpful for estimating shading ability during later stages of development (Müller, 1998).

Since modern breeding programs based on genetically modified organisms are omitted in Organic Agriculture and reservations do exist against breeding programs oriented on hybrid cultivars, breeding programs dedicated to Organic Agriculture only and of Organic Agriculture origin are heavily discussed. Future answers will depend on decisions made by middle-class breeders. If they consider Organic Agriculture as steadily growing, promising a bigger future seed market, they will follow classical breeding methods further. Nevertheless possibilities and limits for breeding programs oriented on site-adapted cultivars have to be found out for Organic Agriculture.

Another hit was found concerning the development of chickpea germplasm resistant to *Ascochyta* blight and *Fusarium* wilt, (Cordoba, Spain), all indicating that no intensive breeding activities primarily oriented on Organic Agriculture can be found beside mainstream breeding activities.

6. Biodynamic Preparations (6)

No equivalent exists in other systems of agriculture to the so called biodynamic preparations developed and used in biodynamic agriculture only. Experimental evidence for the effects of these preparations is meanwhile accumulated over more than 7 decades. An overview concerning research results on biodynamic preparations is given by Koepf (1981, 1993). Use of the preparations by farmers is mostly oriented on the whole farm organism. Research is focussing on the different influences, biodynamic preparations have shown on soil and plant parameters and especially product quality. More recent results derived from reviewing several results gained by different authors and at different sites have shown that biodynamic preparations can fulfil regulatory functions, balancing disorders and one-sided influences (Raupp & König, 1996). Newer hints do show higher effectiveness when applied in combination with poisonous plant extracts (Fritz, 1999).

Results from long-term experiments such as the DOK-trial in Therwil, Switzerland, showing remarkable differences in several soil and plant parameters when compared with treatments that received mineral fertilizers or fresh farmyard manure instead of aerobically composted farmyard manure. Since biodynamic preparations 502-507 are applied together with composted manure no clear *ceteris paribus* results are available.

A joined project is assigned by Louis-Bolk-Institute (The Netherlands) together with the Institute for Biodynamic Research (Darmstadt, Germany), FIBL (Frick, Switzerland) and Ludwig-Bolzmann-Institute (Vienna, Austria). Experiments were run in order to study lettuce growth affected by biodynamic preparations measuring a broad spectrum of physiological parameters under different growing conditions.

Considering the innovative potential of biodynamic preparations, urgent research needs can clearly be announced.

7. Weed-Control (48)

Compared to conventional agriculture weed species diversity is higher in Organic Agriculture (Frieben & Köpke, 1996). Higher economic damage thresholds are tolerated in Organic Agriculture. General preventive tools to regulate weed flora are the optimal design of crop rotation, clean seeds, tillage procedures, manuring, choice of variety, seeding date, seeding density and spacing. Direct control is performed by using tine harrows and howing machines. Since energy use and costs are high, thermal methods are used in vegetables, maize and valuable row crops only. Recently, machinery using air pressure have been developed but seem to have no clear future to be used as a direct control method.

Preventive control is based on increased competition of crops against weeds. Ehlers (1997) showed that lower water use efficiency in Organic Agriculture is assumed to be caused by higher unproductive water loss, especially during early plant growth. Vigorous plant growth can be enhanced via higher nutrient (N-availability) as a function of cultural intensity. Higher water use efficiency is given with higher leaf area index that can be driven by bigger seeds. Furthermore use of a tine harrow during early growth stages can disturb pore continuity and initially reduce evaporation loss. The warmer soil can mineralise higher amounts of soil-borne nitrogen, improving plant growth and leaf area index resulting in reduced unproductive water loss and a shorter period to reach maximum CGR. Some of the evaporation loss might be reduced as well by optimised spacing, narrow row distances, broadcast seeding or single grain seeding (Köpke, 1999b). This strategy distributes the relative restricted canopy in early growth stages more uniformly and is supported by using cultivars having more planophile leaves with high shading ability to suppress weeds (Eisele & Köpke, 1997a, b), which for their part can cause further unproductive loss of water but which can normally be controlled by two passes with a tine harrow after the first three leaves of cereals have emerged. Fast soil coverage is furthermore ensured by high seed quality based on healthy grains of greatest size (Piorr, 1991; Schauder *et al*., 1992; Dornbusch *et al*., 1992; Dornbusch, 1998; Derrick & Ryan, 1998)

Other investigations have shown that photocontrol of weeds resulted in 11 out of 12 field experiments in about 20 to 80 % less emergence of annual weed seedlings. Tillage during the night caused significant lower density of weed species such as *Abutilon theophrasti*, *Alopecurus myosuroides*, *Veronica hederifolia* and *Sonchus arvensis* (Gerhards *et al*., 1998). Photocontrol of weeds combined with GPS-driven machinery might have a future in Organic Agriculture when combined with spacing (reduced row distance and reduced seed density), sowing direction (east-west instead of north-south using of passive shading given by the rows) combined with cultivars showing a much more sufficient ground shading as a function of morphology, shoot length and leaf inclination (Eisele & Köpke, 1997a, b; Gooding *et al*., 1998).

Although during the last two decades knowledge to control weeds without using herbicides has made some efforts some problematic weeds can be enhanced by conditions typical for organic farming. Often docks (*Rumex* spec.) are relicts of a former high input of nitrogen in conventional farming. No clear strategy to control docks exists. The problem of controlling this geophyt is given under nearly all site conditions of grasslands in Europe. Masalles *et al*. (1997) followed the approach of non-chemical weed control via better knowledge of population dynamics in *Rumex obtusifolius* which is found in alfalfa-winter cereals crop rotations in Spain. Approaches followed in IGER, Aberystwyth, Wales are oriented on destroying the roots mechanically and burying the residues with deeper ploughing. No doubt, that further intensive research has to be performed to solve this problem.

Vicia hirsuta is one of the most problematic seed-weeds in Organic Agriculture in Central-Europe (Eisele, 1995). This plant is adapted to low nitrogen availability and low plant densities combined with a high dormancy and longer vitality of the hugged coated seed, responsible for the increase in the soil seed bank after conversion to organic farming. Successful control strategies are still required and already under development. The approach is to increase the crop competitiveness via selection of competitive cultivars, higher N-supply and seed-densities which are combined with varied soil cultivation and crop rotation. Mechanical weed control strategies were tested and investigations on seed dormancy are performed. It is expected that liquid manure in early spring can reduce growth of *Vicia hirsuta* in cereal stands but might enhance on the other side *Galium aparine*. Until now it is quite unclear, to which extend a dormancy breaking by frost can be used to reduce the soil seed bank. First results show that this tool can be used combined with reduced tillage and successful use of mechanical weed control.

One hit exists in the database indicating development of a small scale weed control technology (Juva, Finland). Effects of mechanical and thermic weed control in sugarbeets, potatoes, sunflower, rapeseed and wheat are studied in Leipzig, Germany. Population dynamics of weeds and profitability of weed control in arable crop production is studied in Wageningen, weed control by mechanical weeding on cereals (howing) in Evreux, France.

No doubt that detailed analysis of specific site conditions in Europe will show weed problems for Organic Agriculture which are still unknown yet. Beside the general well known aspects of weed control mentioned above, specific site oriented strategies have to be developed and might be performed successfully with joined research programmes consisting of local experts, farmers and members of well educated extension service supplemented with foreign experts.

III Conclusions: Outlook on future research

Research necessities:

- In order to optimise nutrient management *more knowledge concerning the rhizosphere and plant-microbial interactions is needed*.
- *More research* effort is needed *into grain legumes grown in southern Europe* covering the topics of N_2-fixation, water consumption and precrop effects.
- *More research effort* is needed *into strategies hindering gaseous losses of nitrogen* from soil, plant, farmyard or compost heaps and stables in order to optimise nutrient (nitrogen) flow within farms.
- *More research* input is needed *into crop to weed interactions, covering again rhizosphere interaction and all other aspects of system stability* (weed feeding predators, acting as hosts etc.).
- *Strip-cropping systems* as an example of polyculture have to be studied further as a cropping strategy *especially for stockless farms, for erosion control and higher product quality* (baking quality in cereals).
- *Intensive research* especially *on soil* and *soil microbial activity* in view of sustainable agriculture (organic versus conventional) has to be performed *in still existing long-term field experiments*. Important information that can be gained from these experiments especially oriented on soil physical, soil microbial and soil-biochemical parameters is feared to be lost.
- *More research effort* is needed *to describe product quality especially of vegetables* but also of potatoes better. Parameters that are able to characterise shelf-life better have to be studied more intensively. *In cereals parameters to describe high quality wheat varieties under conditions of restricted nitrogen availability* have to be investigated.
- In order to characterise product quality better further efforts should be followed in *evaluating so-called «picture-forming» methods* such as sensitive cristallization, circular chromatography and “Steigbilder” or capillary-dynamolysis.
- Compared to cereal production *research activity in vegetable production has to be urgently intensified*. Research topics were described looking on nitrogen availability, optimised use of organic manure, crop rotation and optimised positive precrop effects, questions of product quality, sensoric analysis and shelf life as a function of production strategies.
- Organic Agriculture plays a key role in *on-site preservation of endangered cultivars*. Possibilities and limits for *breeding programmes oriented on site-adapted cultivars have to be developed* for Organic Agriculture.
- *Regulatory functions of biodynamic preparations* balancing disorders and one-sided influences *are only initially understood*. *More research effort must be expanded on biodynamic preparations*, their effect on compost processes, soil and plant. Urgent research needs can clearly be announced.
- Several indirect methods to control weeds were identified. These approaches have to be studied more deeply. *Special strategies on problematic weeds* such as *Rumex* species, *Vicia hirsuta* and *Cirsium arvense* (in grassland and under dry conditions) *are urgently needed*.
- *Use of process-life-cycle-assessment in agriculture has to be deepened* and to be used in order to optimise farming procedure looking on impact categories that are typically influenced by agriculture. It is proposed to *start with analysing and compensating imbalances of nutrient and energy flows via co-operating farms*.

• *All mentioned research needs have to be oriented on site-specific solutions.* Co-operation between scientists, advisors and farmers performing *joined on-farm research by using so-called pilot farms* which can better *provide local solutions* is proposed.

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ORGANIC FARMING RESEARCH IN THE EU, TOWARDS 21ST CENTURY

ENOF WHITE BOOK

CHAPTER 4

SOIL FERTILITY IN ORGANIC FARMING

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SOIL FERTILITY IN ORGANIC FARMING

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Towards a Definition of Soil Fertility

In modern Agriculture the operational definition of Soil Fertility often emphasizes on the amount of mineral N, P and K that can be available to crops after fertilization. This is clearly an oversimplification and do not take account the intimate mechanisms by which fertilizing elements are mobilized and finally attain crops. There are many factors determining the growth and final yield of a crop (Table 1)

Table 1. Factors determining the growth and final yield of a crop

CLIMATE:	–Daylength and daily solar radiation –Temperature –Rainfall
CROP:	–Variety –Planting density –Seedling emergence –Control of pests, weeds, disease –Natural resistance of the crop
FERTILIZER:	–Application of the correct amount –Application at correct time –Nature of the fertilizer
SOIL:	–Available nutrients –Soil structure –Soil physical conditions –Soil biological activity –Soil depth –Presence of inorganic and organic toxic substances

The climate with Rainfall, Temperature and Daylengths are classical factors often cited. Obviously the crop itself with its planting density, resistance to and control of pests are of importance. The fertilizer, its correct and at time application in required composition and amounts, is often thought to be a principal determinant in crop yield. However the long trip effectued by the fertilizer through the soil to finally attain crop roots may deeply modify a predicted effect.

Soil appears in fact as the principal agent conditionning the delivery of mineral nutrients to plants.

Use and abuse of mineral fertilizers has resulted in a situation where soil is just considered by crop producers as an inert support for cropping. All factors related to soil fine structure, ecology of microbial communities and their role in the dynamic of transformation of biogenic elements, become almost ignored . However we have learned with time what can be the harmful consequences of such a reductionist attitude. For example the abuse of nitrates fertilizers provoked enhanced denitrification with consequent NOx emission in the atmosphere. Mechanical instability of soils resulted from too low organic matter content in soils only treated with inorganic fertilizers. Another consequence is the impact of agricultural practices on crop quality (e.g. pesticides residues).

Organic Farming , a branch of Ecological Agriculture is based on observations that soil organic matter, microorganisms themselves and interaction with plants, have a cardinal importance in soil fertility.

The microbial diversity

Role of microorganisms in Agriculture was perceived at the turn of the twentieth century with classical discoveries of symbiotic nitrogen fixation by Hellrigel and Willfarth in Germany (Jones & Lewis, 1993), nitrifying bacteria by Winogradski in France ((Winogradski, 1949) and microbial biodiversity by Beijerinck (La Rivière, 1995) in the Netherlands . Bacteria (including Actinomycetes), Fungi, Protozoa and eucaryotic Microalgae were found among prominent microbial species present in agricultural soils. Although sometimes comparable in size to some «big» microorganisms, nematodes, earthworms and other invertebrates of the soil microfauna, are not of unicellular nature. Interaction of the soil microfauna with microorganisms are however numerous and may condition soil fertility. Table 2 shows the relative numbers and biomass of microorganisms and microfauna.

Table 2. Relative numbers and biomass of soils microorganisms and Microfauna in a fertile Mollisol.

Organisms	Numbers (per g)	Biomass (wet kg/ha)
Bacteria	10^8-10^9	300-3000
Actinomycetes	10^7-10^8	300-3000
Fungi	10^5-10^6	500-5000
Protozoa	10^3-10^5	5-200
Microalgae	10^3-10^6	10-1500
Nematodes	10^1-10^2	1-100
Earthworms		10-1000
Arthropods, Ascari and Molluscs		1- 200

After Alexander, 1977

Bacteria and fungi may represent more than 10 tons biomass per ha of a fertile soil.

The mode of cultivation has a strong influence on the soil biomass in particular earthworms. Earthworm biomass is much higher in soils fertilized with organic manure and grass clover in the crop rotation as compared to conventional plant production (Bauchhness, 1991). Correlation between soil fertility and microbial counts were attempted in the past but failed or gave very limited results, but in extreme conditions (Pochon, 1954). In fact plate counts or dilution procedures frequently used to quantify the different physiological groups of the microflora did not gave a correct account of the real activity in soil. This is why microbial ecologists turned in the seventies to a more functional analysis of microflora. Microorganisms were considered as a soil compartment, the activity of which was estimated through respiration, metabolites (ATP, NADH,...) or enzymes production(Paul & Clark, 1989). With the advent of molecular techniques it is now possible to give a better picture of «who is doing what» in the soil (Nalin *et al*., 1998). Use of PCR procedures has for example shown that our knowledge about nitrifying species in the soil was very limited (Deni, Godden & Penninckx, unpublished). A greater diversity than previously perceived was shown and species non cultivable in the laboratory were discovered. The Microbial Ecology of the future will certainly combine molecular and functional approaches.

Microorganisms as inhabitants of the soil substructures

Microorganisms in the soil are not living as separate entities and are often associated to soil structural components and organic matter (Fig. 1)

Bacteria may live in the soil solution but are more often associated in aggregates and/or biofilms. This can protect the species from dessication, predation and assure a better management of nutrients. Water has a great importance for microbial life and in case of aridity may only be restricted to thin films. Filamentous fungi have an hyphal-mycelial structure well adapted to colonize and degrade insoluble substrates like Lignocellulose. This property is shared with some filamentous actinomycetes bacteria.

Aggregate stability as measured by the water percolation technique, indicated a much higher stability of bio-dynamic and organic cultivated soils (Mäder, 1996). Aggregate stability correlated also significantly with the earthworm biomass. Soils managed by organic farming show a remarkably reduced water erosion as compared to a neighbouring conventional farm. Organic farming increase the soil microbial biomass and activity with the consequence of polysaccharides production, which can explain the higher aggregate stability, leading to reduced water erosion.

Microbial symbiosis and some consequences

Numerous symbiosis, either beneficial or detrimental exist between microorganisms (Stotzky, 1972). For example protozoa exert a grazing effect on bacteria and this prey predator relationship may ensure a rejuvenation of the bacterial population. Microturbulency created by motile protozoa in the aqueous film around soil aggregates may improve oxygenation and nutrients supply to the bacteria embedded in the microstructures.

Generalized competition may create certain special effects like the suppressing effect of soils. In fact bacteria may create a chronic nutritional desert and perturbate fungal spore germination. Fungal spores need an external nutritional signal to germinate. If germination would be spontaneous, spores will consume their own reserves and the fungi will finally disappear. An application of this property in Organic Farming is the control of germination of phytopathogenic fungi.

Microorganisms and the N and C cycles

Figs 2 and 3 show that the Organic Matter compartment in the soil is sustained by N_2 symbiotic and non- symbiotic fixative microorganisms and also by restitution of vegetal and animal residues.

Organic Farming take particularly care from the building-up and the maintenance of soil Organic Matter . Use of green manure, animal manure and compost are of daily concern for organic farmers. It is however crucial to correctly use such fertilizers. Unappropriate use may for example result in excess NO_3^- production not consumed by crops (Fig. 2) and finally percolating in ground water or denitrified. Fresh Organic Matter is also the reservoir of the soil Humus (Fig.3).

Fertilisation and Manuring

1. Internal resources

Soil fertility in O.F. differ strongly from conventional farming due to restricted purchase of fertilisers (Köpke, 1998).

Soil fertility must be considered for the whole crops of the rotation, and can not be applied to a single crop, because of interdependance.

Crop rotations, including fertility building and nutrient demanding cash crops, are the key factor for sustainable organic farming systems (Watson *et al.*, 1997). Legume have a privilegiate situation in crop rotations. By their properties of N_2 fixation, they achieve the major N supply to OF systems (Granstedt, 1992).

Legume could take place in the rotation as pure culture (lucerne for example), associated with grasses in ley, in cereals/peas fodder associations, in rotational set-aside, or also green manure or catch crops.

In western Europe legume N_2 fixation can be estimated from 44 to more than 200 kg N/ha year (Bockman, 1997). Green manures fix the smaller amount of N_2 whereas the highest amounts were by red clover.

From a practical point of view, this signified that OF has to deal with residue management: not only crop residues but also animal manures.

Animal manures are a major resource for fertilisation.

Manure production is closely related to the nature of the producing animal.

Their composition depends principally from the animal type, dietary balance, bedding system, and secondary from animal breed and stall design.

Manure is not only produced in the stall house. Thertefore the direct recycling of nutrients during grazing must be taken into account.

One of characteristics of OF is the high utilisation of internal resources (Kristensen & Kristensen, 1997) and a strong restriction of fertilisers purchase.

Global nutrient balances are often close to zero except for N, consequence of its input by N_2 fixation (Boisdon & L'Homme, 1997; Kristensen & Kristensen, 1997).

As a consequence care must be taken to limit as much as possible the losses of nutrients.

Losses in a livestock system are numerous and started early during stall housing with ammonia volatilisation.

A better feed balance and diet composition (protein/ digestible carbohydrate) (Tomlinson *et al.*, 1996; Freuzer *et al.*, 1998) are factors reducing N excretion by animals.

A correct bedding contribute to microbial immobilisation of excreted N and a reduction in ammonia volatilisation.

Losses during storage can be important (Berner *et al.*, 1994; Dewes *et al.*, 1991, 1993; Godden, 1994; Godden & Penninckx, 1997; ...),and can be correlated with the % water content of the different manures. For evidence semi- solid manures as those coming from scrapping the feeding corridors are too moist to be stored on field and must be stored on a waterproof area with collection of the drainage fluids.

Drainage fluids have generally a high content in Potassium and may constitute the major leak of K in OF systems.

Manure composting, which result in deep biochemical biotransformation (Godden, 1986), but also in an important microbial N immobilisation and sanitation (Lopez-Real & Foster, 1985), is largely used in OF.

Biochemical change in the Lignocellulose compartiment during farmyard manure composting is summarised in Fig. ...

Manure composting is considered as a basis of fertilisation, if not the base .

For liquid manure, direct injection can reduce losses of ammonia by volatilisation. A particular attention must be given to storage capacities to permit land application at the optimal periods, for reducing losses and to increase nutrient recycling.

2. External fertiliser sources

2.1 Indirect fertiliser input

Purchase of livestock feed represent a non negligible source of nutrients. Straw allows many organic farms to maintain the K balance.

2.2 Direct fertiliser

Organic fertilisers include fresh manures, composts (manure and vegetable composts), and organic fertilisers sensu stricto.

Fresh manure are some time imported in order to compensate for a insufficient on farm production.

Commercial organic fertilisers are mainly used as boosters for a rapid N supply to satisfy a crucial crop physiological requirement.

In market gardening and horticulture, commercial compost are used in plant nurseries.

Mineral fertilisers are under insoluble form and include rock powders (basalt, calcareous algae) and natural phosphates.

Some of them are used during stalling as litter additive.

Fertility Management

Fertility management in OF differ basically from conventional agriculture.

The greatest part of nutrients is under organic form: directly applied as manure for example and indirectly for the crop residues.

The ultimate furniture of nutrients to crop depend from mineralization of organic materials by soil microorganisms.

Direct nutrient supply to crop is very limited in OF, only liquid manures have a significant mineral N content.

Another characteristic of OF is the constraint of the limited purchase of external fertilisers already mentionned above. Therefore it is crucial to optimise nutrient efficiency and to minimise losses.

The major source of N in OF is biological fixation of atmospheric N_2.

Therefore the place of legumes in the crop rotation is a factor of sustainability.

The first step in fertility management in OF is the design of a suitable crop rotation.

Crop rotations, including fertility building and nutrient consuming cash crops, are the key of successful OF systems (Watson *et al.*, 1997). The understanding of the process involved in nutrient cycling through these systems is necessary to develop crop rotations both economically viable and environmentally sustainable.

Crop rotation has to maintain and, if possible to improve soil fertility at long term, as well in term of nutrient supply than in soil structure.

In mixed and dairy farms the farmed area covered by grass-legume associations go up to 70 %. The choice of the crop rotation has to take into account the sites conditions; for example if red clover is well represented in the North West of Europe, other legume are more typical of the continental climate.

To optimise the recycling of N supplied by legumes, strategies to reduce losses must be developed. A careful choice of sowing date and the method destroying grass-clover association are therefore very important , in relation with the succeeding crop.

Care must be taken to avoid denitrification or leaching (*many ref.*). The age of the grass-legume associations influence their chemical and biochemical composition (C/N ratio, carbohydrate/ lignin content) and their degradation ability (Robin D.).

The mineralization rate of this organic materials incorporated to the soil is greatly influenced by the microbial activity and the initial inorganic N concentration in the soil (Jensen *et al.*, 1995; Recous *et al.*, 1995).

The positive effect of ley and pastures come also from their beneficial action on soil structure (Younie & Baars, 1997). The decomposition of roots increase soil cracks and is able to generate more large pores (macropores). In loamy and clay soil, small pores dominate and restrict N and C mineralization (Hassink, 1992).

The management of P and K is mainly related to manures. Losses occurred since the production (off-site losses) to the spreading to the field and after if there is some leaching (on-site losses).

As described above, of-site K losses can be important, and even consequent in sandy or coarse-textured soils; because these soils have only a low capacity to fix this mobile cation.

In such conditions care should taken on spreading liquid manures and urines to field.

During the rotation, transfer particularly of potash, from grasslands to arable cropping land were observed (Younie & Baars, 1997).

Rhizosphere effect. The role of crops in fertility

The ways in which rhizosphere microorganisms might affect the supply of plant nutrients are the following (Nye & Tinker, 1977): (1) change in the morphological or physiological properties of roots or roots systems (2) alteration of the phase equilibria of nutrients in that they are more readily transported to root surfaces and/or absorbed, e.g. change in pH or redox potential, or complex formation (3) change in the chemical composition of soil, with similar results, e.g. mineralization of organic matter, weathering of minerals (4) symbiotic processes involving direct transfer of nutrients from microbial symbiont to the host (5) by the blocking of root surfaces, or competition for nutrients.

The major likely influences of the rhizomicroflora are perceived as those listed under (2) and (3) above (Richards, 1987). In OF however (4) has a cardinal role (*Rhizobium* symbiont of legume).

The pattern of phosphate translocation is greatly modified by the rhizosphere (Bowen & Rovira, 1966) and mineralization of organic matter e.g. urea, organic phosphates and other forms of organic nitrogen (ammonification step).

As far as we know few research was systematically undertaken in order to examine the extent of such effects in OF (see for example ENOF database).

Fertility in Specific Systems

Mixed farms

Mixed farming which associate arable crops, grass-legume based ley, and livestock constitute certainly the farming type the most favourable for O.F.

They are the best structured to assure short recycling of nutrient flows, and can constitute from this point of view a sustainable functional unit, which can refereed to the notion of «organism» (Köpke, 1998).

The utilisation by livestock of the fodder crops and meadows allow large possibilities to build up optimal crop rotations in agreement with sites conditions (including soil, climate, but also market and sociological factors).

The livestock management must be adjusted on the basis of the farm's feed production capacity (Granstedt, 1992), to avoid to unbalance the farming system with excessive inputs.

Livestock farms

In Europe, we must distinguish between livestock farming in function of their «intensification», from the more intensive systems that we can find in Denmark, Netherlands, or the North of Belgium to the most extensive farms from the Uplands (Scotland, Auvergne,. . .).

In livestock farms, high stocking rates, and thereby a high import of concentrate as well of a high % of area with grass-clover (high N_2 fixation) results in high nutrients surpluses at the farm level (Halberg *et al.*, 1995; Halberg, 1992; Kristensen & Kristensen, 1997).

Nutrient surplus in mixed dairy farms in Denmark show N surplus around 124 kg N/ha year (DS 21); P surplus near 0 and K surplus around 30 kg/ha year. This lasted are related to manure import and straw import for bedding (Halberg *et al.*, 1995; Kristensen & Kristensen, 1997).

In Scotland and Ireland, P and K soil levels decrease during conversion and strategies have must set up to limit these leak (MacNaeidle, 1997; Younie & Baars, 1997).

In the extensive livestock system mainly a large part of the area is under permanent pasture, from 60 to 100 %.

The % of farmed area under rotation is low and include ley, fodder crops and if the climate permit it, cereals (Boisdon *et al.*, 1997; Bouihol *et al.*, 1996; Boisdon *et al.*, 1998). The main productions are meat (beef and sheep) and milk or cheese (from cattle and goats).

The sucker cow system represent a very extensive and very autonome system.

Nutrient management of this different livestock systems depends greatly from their intensification (stocking rate) and site conditions. Import of external feed and straw represent the major input of nutrient and at term the risk to unbalance the system.

Stockless farms

In stockless farms, it is not possible to valorise on-farm legumes for animal production.

For long-time, O.F. was associate with mixed farming.

Today there is an interest for organic stockless farming which is not rely to imported manure, in particular in regions where livestock is disappeared with agriculture evolution (Watson *et al*., 1997).

The recent change in European agriculture policy, introducing set-aside, offer a interesting opportunity to introduce legume in rotations, with a financial aid (Stopes *et al*., 1996; Clotuche *et al*., 1997).

The N accumulated under set-aside legume based, are very consequent, up to 250 to 371 kg N/ha for rotational set-aside (Stopes *et al.*, 1996; Godden *et al.*, *von Boffergeld 199X*).

The introduction of legume as catch crops is also a way to put legume in the rotation, same if the N fixed is lower. Catch crops avoid N losses by leaching.

The utilisation of this N fixed must be optimised. The choice of the subsequent crop to take off the available N is therefore very important.

At last, the development of leisure horse and their requirement for lucerne (hey or dehydrated pellets) offer a new market which stockless farms are to take advantage of.

Orchard and vineyard

The fertility management of these permanent cropping systems is very different from the other farming systems.

The nutrient applied at the plantation must assure the nutrient basis for a long period. Complementary supplies can be made as mulches or by cover cropping; but weed control and water availability determine the choice.

In some productions as vineyard, an excess of N must be avoid because it has a negative effect on fruit quality (Weinzaepflen, 1998).

Farm synergies

For many, mixed farming systems correspond the best on the rules and the philosophy of O.F.

In some countries like in the Netherlands segregation between arable and stockless farms is a fact of life. In Dutch conventional agriculture crop are produced with large input of fertilizers and pesticides even when livestock is feeded by imported concentrates.

Promoting collaboration and synergies between this two opposite farming system can contribute to relearn a mixed farm philosophy.

Such an experience is conducted in the Netherlands (Baars, 1998).

Tools for the Evaluation of Soil Fertility

Nutrients budgets

Nutrients budgets are widely used as indicator to estimate nutrient management, impact of different agricultural systems on the environment and how sustainable there are.

They can also be used to asses the nutrient efficiency. The problems comes from the fact that there is not only one method but numerous, varying in their objectives, conceptual basis and calculations.

In O.F. an additional obstacle come from the system complexity: O.F.. and especially mixed farming, is based on long crop rotations with inclusion of grazing animals; which makes difficult the determination of nutrient flows. The nutrient budget in such system is planned for long periods.

Different authors have discussed and compared the results of the available literature (Van Bol *et al.*, 1997; Watson & Stockdale, 1997, 1998; Sveinsson *et al.*, 1998).

Nutrients balance can be used at different levels: parcel, rotation, whole farm, farming system and geographic area or countries (Grandstedt, 1992, 1995, 1997; Boisdon *et al.*, 1996, Halberg *et al.*, 1995; Kloen & Vereijken, 1997; Kristensen & Kristensen, 1997; MacNaeidhe, 1997, ...).

Nutrient Availability

To know the amount of available N is from capital importance for fertility management.

Potentially available N can be determined by laboratory incubation techniques: the difficulty is to rely these laboratory results to the field situation.

A better understanding of climatic factors involved (temperature and moisture) and the development of more simple mathematic tools offer perspectives for future pratical developments (Nicolardot *et al*., 1997).

Soil microbial activity

As discussed above, microorganisms and their activity are a key factor in soil fertility, they are the «motor» of nutrient cycles.

The value of microbial measurement as indicator of soil fertility has been tested and/or used by several authors (Alvarez *et al.*, 1996; Mäder *et al.*, 1996; Fliessbach & Mäder, 1997; Trasar-Cepeda *et al.*, 1998). It was found that microbial biomass is distinctly higher in organic plots as compared to similar crop plot in conventional farming.

Global indicators

Global indicators were proposed to promote goals as to preserve soil fertility for the future, avoid pollution from agricultural practice, minimise the use of fossil energy, give farm animals good living conditions, assure to the farmers to live from their work and take in consideration values for nature and wildlife (Halberg N. 1997).

To fulfil this global objective the use of different sets of multidimensional indicators were proposed as evaluation ,management and policy decision tools (Halberg, 1997; Bockstaller *et al.*, 1997; Rossing *et al.*, 1998; Vereijken, 1997, 1998).

ENVIRONMENTAL ASPECTS

Pollution

The major risk of water pollution is related to the high proportion of legume or legume/grass associations in the crop rotations.

But the high losses of nitrate associated with ploughing of grass-clover ley are balanced by lower losses during the subsequent years of arable crops (Philipps *et al.*, 1995).

O.F. is also working with higher level of soil organic matter; this present also leaching risk associated to the mineralisation this O.M..

O.F. needs a correct management of the critical periods of intercropping , with catch crops or undersowing the subsequent crop.

Landscape, diversity

Landscape is perceived as a dynamic system in OF (Vereijken *et al.* , 1997) where fertilisation method has an impact. The EU has funded recently a research action with three objectives: (i) assessment of landscape features of farming systems in different areas. (ii) Development of methods and criteria to value landscape features of farming systems and to assess their contribution to landcape quality (iii) to develop regional guidelines in order to extend the landscape quality.

Thirty farms, half of them organic were analysed in term of their contribution to landscape identity and quality . The research has supplied arguments in the discussion on landscape quality in OF and has also given tools to farmers who want to improve the landscape quality. The goal was to formulate a set of criteria for developing sustainable agro-landscapes. Ten criteria have been pinpointed (Hendriks *et al*., 1998): (1) diversity in landscape components (2) site related character (3) coherence among landscape components (4) historical continuity (5)seasonal aspects (6) personal participation (7) particularities (8) beauty (9) environmental qualitry (10) ecological quality.

Biodiversity and landscape quality are strongly related. Plant and animal species diversity in organic and conventional fields and pastures have been compared (Frieben & Köpke, 1995).Plant species diversity is higher in organic fields compared to conventional fields. Examination of animal species diversity confirm that field boundaries are important pre-requisites for birds and arthropods. Field margins management is an important topic to be considered.

Current Research and Future Actions to be Envisaged

ENOF databank , ISI (Current contents-ABES) and the ITAB database (GEYSER to DOCEA network) were scanned for their content in projects related to Soil Fertility in Organic Farming. About 150 documents responding to the optional term Soil Fertility were deposited in the listing. These documents can be divided into ten principal topics (i) Organic matter dynamics and N-mineralization in OF systems. (ii) soil suppressivenes. (iii) Nutrients dynamics and losses (iv) mycorrhizial fungi and phosphate uptake of crops (v) Rhizobium legumes interaction (vi) studies with reference to the use of recycled residues and biodynamic preparations (vii) importance of ley and set aside (viii) diagnosis methods of soil fertility (ix) farm management in relation to soil fertility (x) Biodiversity and landscape.

A comprehensive analysis of these contributions revealed useful and already exploitable data for OF, but also the weak points to be adressed.

a– Soil fertility has to be considered in a global context (animal to crop via soil, water and the atmosphere). There are strong differences between the results obtained by considering the whole farm or only the rotation. A tendancy to extrapolate the fertility data obtained from conventional farms to organic farms ought to be avoided. The management of Soil Fertility in Organic Farming requires an in-depth knowledge of the Microbial Ecology of the agroecosystem. Only fragmentary knowledge of this topic in OF is available.

b– Regional scale is important . Better integration between organic farms of different types should be realized. Situations prevalent in Europe are diverse, spreading out along a gradient of extensiveness. Extreme situation of extensive farming is known in Auvergne in contrast to the strongly intensive situation in the Netherlands. Stockless organic farming play also an important role in certain regions, pointing to the necessity to better integrate organic farms of different obedience in a common framework. The integration of these common resource should allow the farmers not to depend from external supply, even if tolerated in certain limits in OF is unfavourable to sustainability.

c– At the farm scale, fertility must refer to the whole rotation and not on each crop taken isolate. Legume alone or in association with grass, pasture or ley, has a cardinal importance in OF. This is true as well for stockless than mixed or livestock farms. For mixed and livestock farms, the effluents are major sources of nutrients. Potassium can however be lost during storage and some nitrogen during spreading. A better quantitative estimation of nitrogen accumulation, availability and reserves is needed. Methodologies are not always adapted to OF and should deserve more comparative studies. In summary At the farm scale several objectives for nutrient balance sheet are possible: (i)minimise the difference between input and output to assure the maximum nutrient efficiency (ii) maximise such differences to increase soil fertility (iii) minimise the introduction of external inputs even of organic nature (iv) minimise the unbalance between the different nutrients. This happens for example when too much phosphorus and potassium are given to a nitrogen limited crop through manure.

Finally to be useful all the results of research in OF should be demonstrated at farm scale.

d– At the field scale which is the operative level a better nutrient management is needed. Crop demand and fertilizer supply must be more adequated. Innovative forms of nutrient management have been proposed but clearly need further in depth investigation. Crop demand and fertilizer supply should be better analysed. It has been proposed not to fulfil completely the potential of the crop, in order to rely more on soil nutrient availability and to take into consideration other limiting factors in the production. A larger attention should be given to the problems of Potassium and Phosphorus for their respective environmental impact and chronic deficiency in OF.

e– Evaluation of the environmental impact of OF needs accurate indicators. A list of indicators has been proposed: nutrient availability, energy use, soil structure and activity, creation of small biotypes, smell and noise. There is a strong need to quantify all indicators. The ultimate need is in fact the development of coherent multidimensional descriptions of the different OF systems.

General Conclusion

At the end of this century OF emerge as a valuable alternative to current devastating agricultural practices. However several big questions have still to be adressed in order to increase the credibility of this alternative:

–To what extent should mixed farms be closed systems ? What are the levels of intervention and acceptable limits ?. Shall we find sufficiently open minds in the Agricultural World to create productive interrelations between farms

–What about the decision support ?

–What about Labour availability and relation to management needs on farm ?

–What is the best role for participatory research ? Are farmers ideal contributors to farm experiments conducted in pilot farms ?

–How to achieve these needs ?

It seems obvious that interdisciplinary teams working on models, and joint optimisation of the models by each discipline (soil, Microbial Ecology, agronomy, animals, economics, politic...) are prerequisite. A system approach differing from the conventional current procedure has to be accepted by the Research Community! Participatory approach in long term research has to be developed but as stated above must find the optimal balance.

To finally conclude, a fertile soil is a soil releasing fertilizing elements at correct time and dose to the crops. This statement applied to OF needs however additionnal informations.

A certain view on agricultural systems shared by many consider the following irreversible way : fertilizer ———> crop, but ignore completely the numerous interactions between soil, crops, microorganisms, ...

A better definition should include all the actors of the cropping tragedy and surely include crops themselves. Indeed crops can also regulate nutrients fluxes through rhizosphere effect and their residues are principally restituted *in situ*..

For Organic Farmers a tentative better definition of Soil Fertility would be:

A fertile soil is a soil in sustainable harmony where all the components including microorganisms, the microfauna, organic, mineral matter and crops, interact in such a way that organic fertilization result in optimal cropping i.e. the highest crop quality compatible with the best yield.

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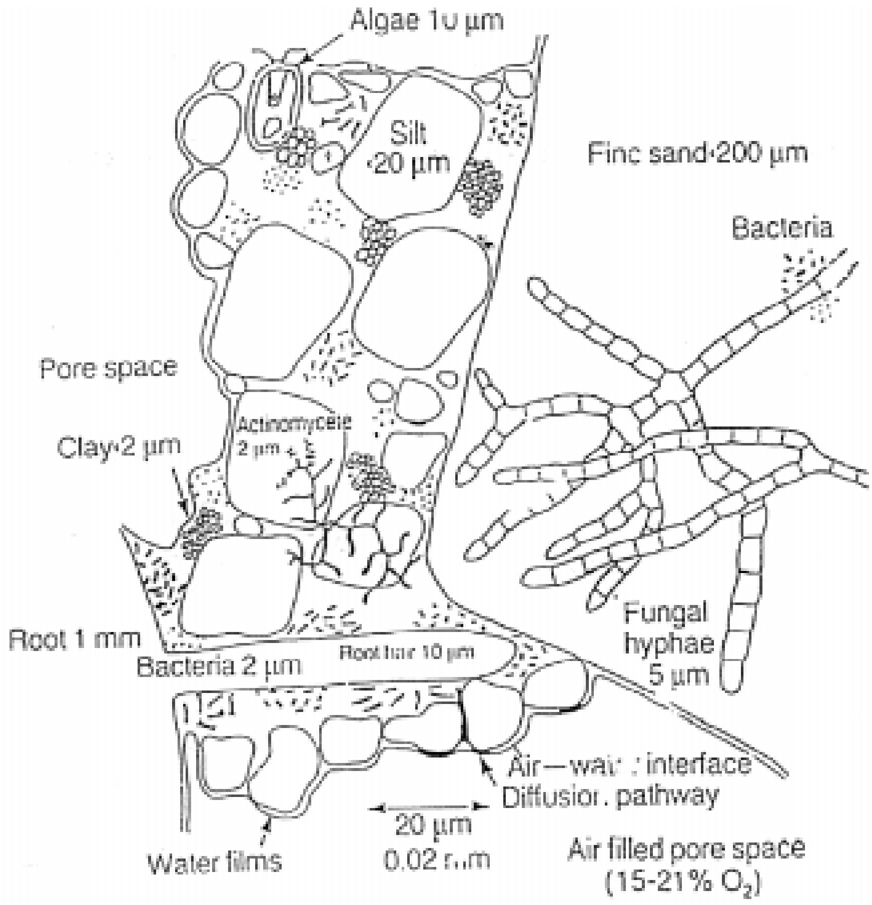

Figure 1**.** Microorganisms associated to soil components. The picture illustrates about 1 cm^3 of a highly structured microzone in the surface horizon of a grassland soil.

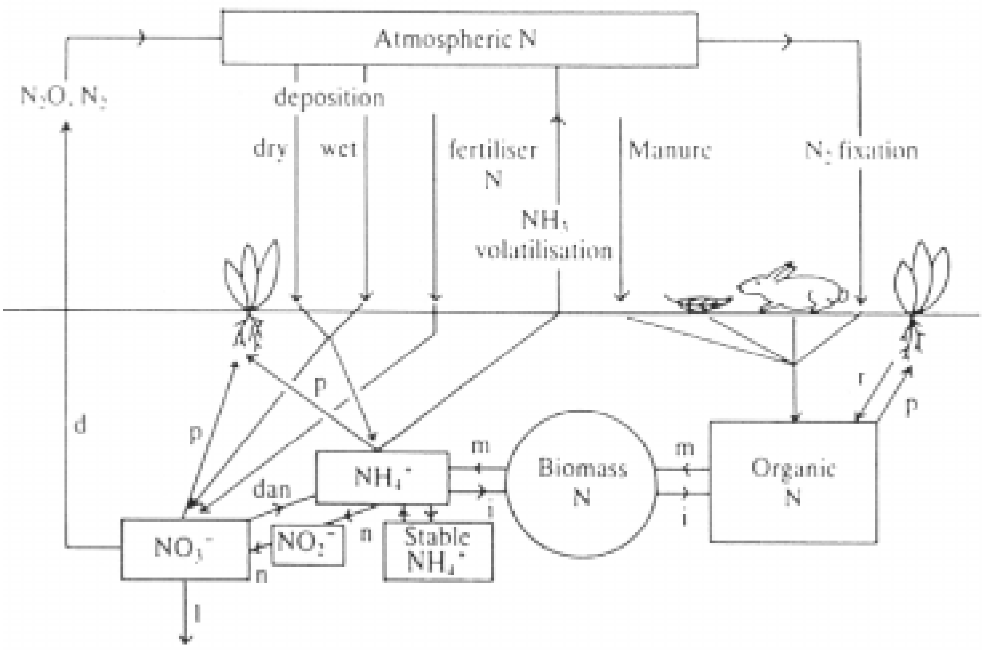

Figure 2. The soil N cycle. Adapted from KILLHAM. Abbreviations: d, denitrification; dan, dissimilatory and assimilatory nitrate reduction to ammonium; i, immobilization; m, mineralization; n, nitrification and subsequent leaching (l); p, plant uptake; r, root exudation and turnover.

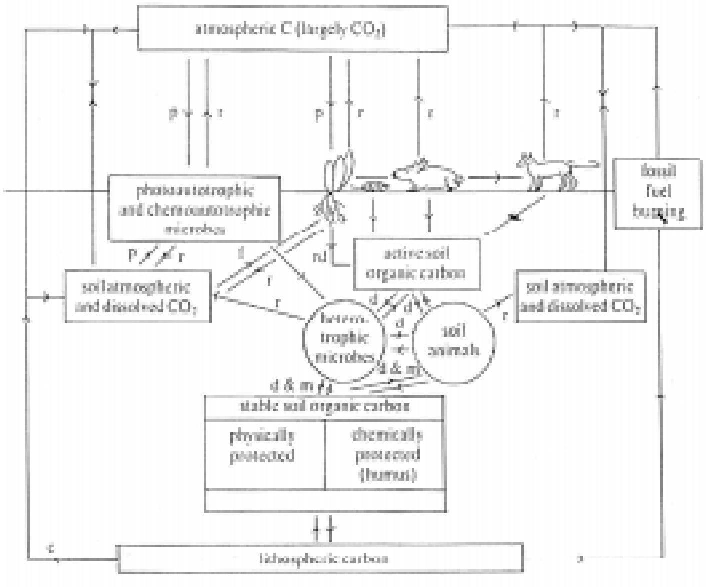

Figure 3. The soil C cycle. Adapted from KILLHAM. Abbreviations: p, photosynthesis; r, respiration; rd, rhizodeposition; f, fixation; d, decomposition; m, macromolecular synthesis; c, CO_2 from carbonates.

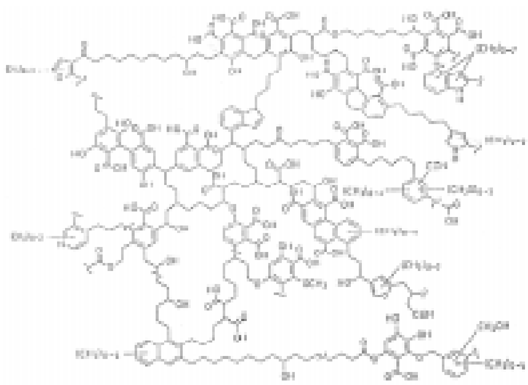

Figure 4. A current view of humic acid molecular structure. Lignin signature is recognizable, but long poly -CH_2- portions are clearly coming from another source. Adapted from Schulte (1996).

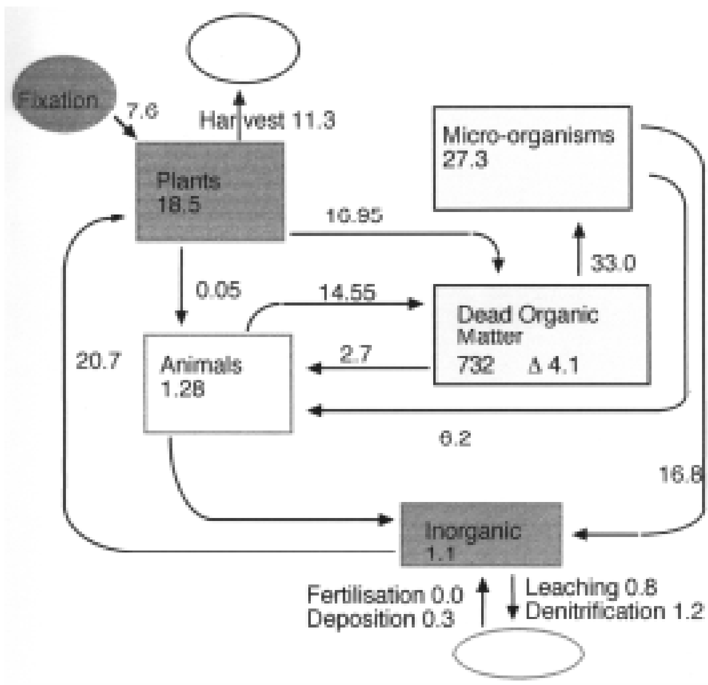

Figure 5. Lucerne Nitrogen Flows (g/m^2.year). Adapted from Rosswall & Paustian.

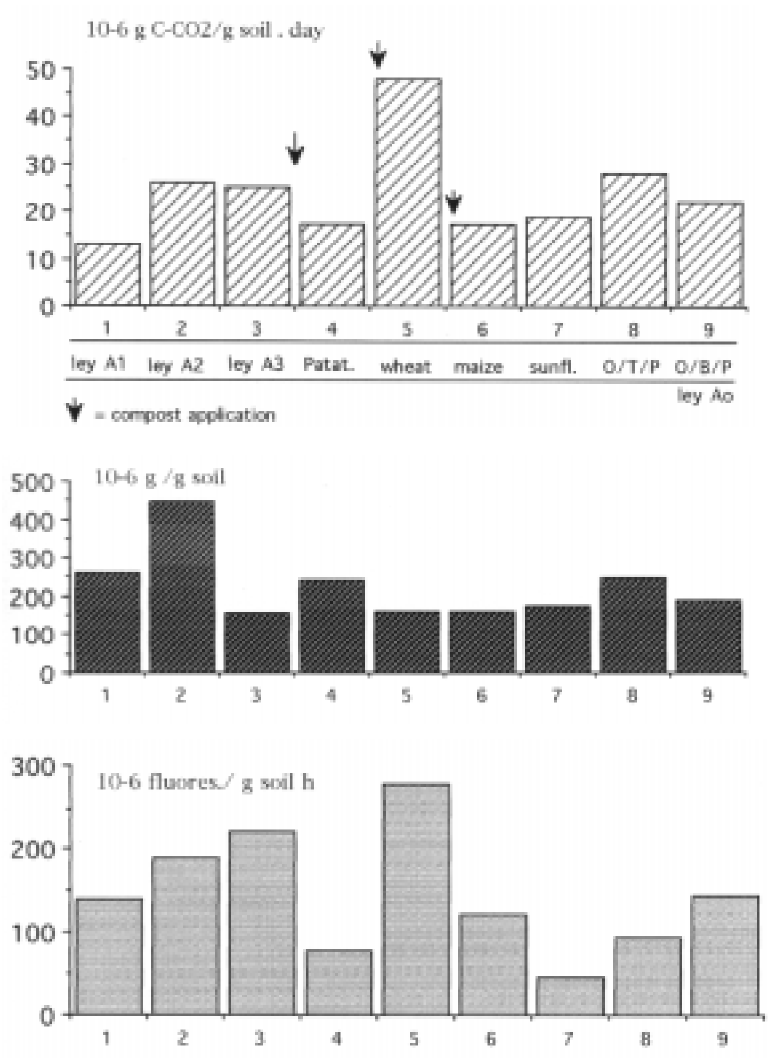

Figure 6. Microbial activity evolution during a crop rotation of a typical organic farm.

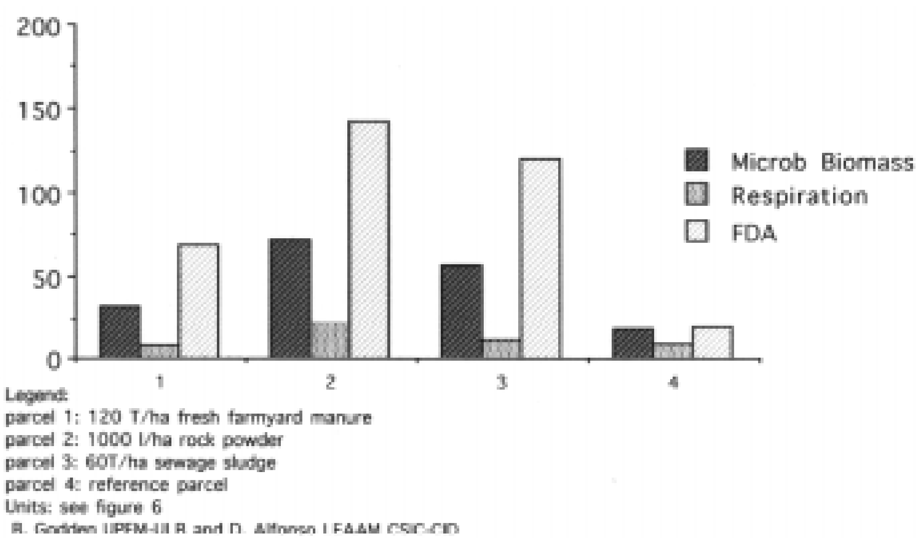

Figure 7. Effect of Manuring on Soil Microbial.

ORGANIC FARMING RESEARCH IN THE EU, TOWARDS 21ST CENTURY

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CHAPTER 5

REVIEW OF ANIMAL HEALTH AND WELFARE

T. Baars

REVIEW OF ANIMAL HEALTH AND WELFARE

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INTRODUCTION

Database survey

A search of the ENOF database was made to find projects in the EU. Several key words were used in the search: animal welfare, animal production, animal health, pig, chicken, dairy, beef. There were only a limited number of hits, mainly projects in the Netherlands, England, Ireland, Germany and Scotland. Because of my professional contacts with several research stations in Europe, I knew that the result of the database search was all but comprehensive. There are many more projects currently being carried out on this topic; a lot of information is missing (mainly from Scandinavia, France and southern Europe). Because of the small number of hits in the database, this article only gives a general description of research in this field. Research topics were defined on the basis of discussions during several ENOF meetings.

The role of livestock in organic farming systems

The main reason for keeping livestock is that they are a source of food: the animals convert plants, which cannot be eaten by people due to their high fibre content, into food for human consumption (mostly dairy and beef). Livestock can therefore graze in areas not suitable for growing plants for human consumption. The animals increase the biological value of the plants they eat. In this way, animals play an important role in nutrient management and nutrient cycles. They can also contribute to fertility in an organic farming system. The long tradition of livestock farming has altered the landscape and social life of rural areas. Today, the animals are seen as a key to maintaining the biodiversity and livability of rural areas.

With respect to the latter, livestock farming is considered crucial in many rural European regions to stop rural depopulation. Livestock farming shapes the landscape and is part of the landscape, standing in close connection with the environment. General objectives for organic livestock production are:

–to produce health and welfare next to products as milk and meat

–to provide high-quality products

–to use scarce resources in an efficient manner (environmentally friendly production)

–to maintain genetic biodiversity (nature and landscape values)

Specialisation versus integration of livestock systems

From a farmer's point of view, there are several benefits to a having a single specialisation per single farmer. More skills are available, time can be used more efficiently, and product quality may be enhanced. However, in view of nutrient management and health management, collaborations between specialised organic dairy farms and arable farms, so-called partner farms, are desirable as they may provide the same benefits of mixed farming systems (Baars, 1998).

Some negative effects of specialisation and intensification are:

–difficulty to control parasites and micro-organisms (health risk)

–loss of biodiversity due to intensification

–regional concentrations of animals and minerals (pollution risk and welfare risk)

–economic risks

–loss of man-animal relationship

Prevention strategies for animal health problems

An important issue with regard to organic animal health is the development of prevention strategies (Boehncke, 1997; Baars & Barkema, 1997). The goal of any prevention strategy is to maintain animal health in the long term through a combination of management tools. This does not mean that organically kept animals are never ill. But long-term efforts should be focused on eradicating herd problems and reducing the intensity and duration of diseases.

There are different interpretations of prevention. For example, dry cow therapy with antibiotics is a prevention strategy in conventional dairy farming. The goal of this treatment is to prevent recurring mastitis in the next lactation. This style of prevention clashes with organic principles because of the synthetic drugs involved and the symptomatic approach. In organic farming, a farmer tries to develop a combination of management factors which effectively keeps livestock in good health on that farm. These management factors may be related to grassland production and quality, grazing management, animal feeding, housing and animal breeding.

This approach demands a certain attitude from the farmer towards his animals. The farmer must be willing to learn more about the natural behaviour and needs of his livestock. Secondly, he must also know how to improve animals' resistance to disease.

Clearly, the symptomatic regulation of diseases has no place in this approach. Failures in the farming system (deficiencies in soil and feed, inappropriate housing) should be avoided. Diseases should be regarded as a symptom of shortcomings in farm management. There is no point in suppressing these symptoms.

Solutions for problems must be distinguished in short term, medium term and long term solutions (Spranger, 1995). Solutions should be sought in all aspects of farm management:

–feed (amount of roughage, equilibrium of energy and protein in the rumen; minerals, trace elements and vitamins) and grazing. Monitoring for deficiencies is vital, but surpluses –particularly in protein– should also be avoided

–housing (ranging area, quantity of straw for bedding, ventilation, technology). Housing materials and construction should meet the animals' needs and enable them to display their natural behaviour. Sufficient possibilities for movement and a dry area to bed down are essential, and these play an important role in any prevention strategy

–closed farming system (buying feed and animals; intake of diseases). There is no need to realise a closed, sterile system, which is the new standard for intensive, industrially managed meat production farms. But farmers should realise that newly-bought animals may introduce several new problems to their farms

–handling the animals (man-animal relationship, stress, quiet, attention). An important aspect of prevention is a farmer's quick response to deviant behaviour. A farmer should try to put himself in the animal's position to find out which measures reduce stress and which measures only aggravate the situation

–animal breeding (other goals than milk and meat; line breeding). A major theme in organic breeding is potential longevity or life-time production (Postler, 1989; Haiger *et al*., 1988). A lot of animal suffering can be avoided if animals are the system are tuned to each other so that the animals can reach old age in the system with few age-related problems. In the long term, a higher mean herd age will be obtained, which has a lot of advantages in an organic system (fodder intake, stability in horned herds)

A system of line breeding or family breeding (Baars, 1990) also includes interactions between genotype and environment. With this method of breeding, specific farm circumstances can be adjusted to animal needs.

Primary approaches to disease control

In conventional farming, disease prevention is strongly focused on combatting pathogens; in fact, there are so many hygiene and disinfection measures that one might think one is dealing with a hospital rather than a farm. The result of this strategy is now becoming apparent: pathogens are becoming increasingly resistant to commonly used drugs, particularly antibiotics and antihelminthics. In time, this may pose a severe threat to human health (see New Farmer & Grower, 1998, issue 58).

On organic farms, prevention means finding a healthy balance between animals and their environment. Measures are directed at promoting health and creating a healthy, balanced environment with minimal stressors to animals' passive and active immune systems, under normal hygienic conditions.

Boosting animal health with a view to effective prevention is entirely in keeping with the principles of organic agriculture. In the organic view, finding the right mix of interactive management measures is crucial in disease control. Farmers need to have considerable skills in detecting and addressing health problems. Therefore, a system approach is probably most suitable for the implementation of an organic prevention strategy.

In Table 1, we have given a summary of different classes of livestock diseases and organic prevention approaches.

Primary infections catch a farm unawares, so to speak, and it is probably difficult or impossible to prevent them by means of management measures (foot and mouth disease, pig fever). Vaccination is widely used to combat this category of disease –in organic practice, too, although its use is under discussion. Multi-factorial diseases are caused by pathogens which are endemic to the farm, but which only cause disease under the right environmental conditions.Technopathies are the result of technical failures or shortcomings, particularly with regard to housing. These failures may cause injury, or mental or physical distress to animals.

How animal welfare may enhance natural behaviour

Farm animals' intrinsic value (Grommers *et al*., 1995; Verhoog, 1997) should always be considered in matters concerning animal welfare in organic farming systems. Intrinsic value, the value of an animal as a living being in its own right, is the opposite of instrumental value, which is a reflection of

Table 1. An overview of diseases and disorders, suggestions for prevention and control, and intervention areas.

disease classification	pathogen	goal: to promote health by changes in	goal: to enhance natural behaviour by changes in	primary approaches to control	intervention area
primary disease	microbe (extraneous)			eradication; avoid infection	vaccination; isolate outbreaks
secondary or multi-factorial disease	microbe (endemic and/or extraneous)	general environmental conditions		regulation; management; finding an ecological balance	management; stockmanship
technopathy		echnical environment; housing		prevention; adapt housing	maintenance; housing quality
behavioural disorder		environment; housing; treatment of the animal	character-environment relationship	avoid mental distress	farmer's stockmanship; man-animal relationship

the animal's use to man. Intrinsic value is incorporated in the definition of animal welfare and in the definition of integrity. Respect for an animal's integrity is an ethical principle. Grommers et al. (1995) defined this principle as three complementary elements:

–respect for an animal's wholeness, not mutilating the animal (individual animal)

–respect for a species' unique ecological balance (animal in relation to its environment)

–respect for the animal's ability to survive independently in a species-specific environment (animal as a species)

This definition of integrity is one of the principles of OF. In consequence, dehorning, tail-docking, debeaking, extracting teeth, or inserting genes from other species are not allowed in organic farming. Current practices in poultry, pig and cattle breeding should be critically assessed for compliance with the integrity principle. One-dimensional breeding goals have spawned farm animals which would never be able to survive as individuals or as a species without repeated human intervention in the processes of birth, reproduction and growth.

Animal welfare is often formulated in terms of things to avoid (stress and anxiety, health problems, atypical behaviours, injuries). For example, the Farm Animal Welfare Council lists five basic rules to avoid animal suffering (FAWC, 1997). These rules are based on the assumption that if there are no behavioural or physiological disorders, there is no animal welfare problem. It is harder to define animal welfare in positive terms. Some positive expressions of animal welfare are: opportunities for exploration of the environment, playing behaviour, grooming, but also specific sounds and (tail) movements (Fölsch & Hörning, 1996; Ganzevoort, 1994). In addition, (potential) longevity is seen as a positive indication of animal welfare (see also the chapter on breeding).

Fraser *et al.* (1997) incorporates the intrinsic value of farm animals in his definition of animal welfare. He lists three overlapping concerns of animal welfare:

–«Anatural living» concerns: animals should be able to lead natural lives according to their natural adaptations and capabilities (in German: *Artgemässe Haltung)*

–«Afeelings-based» concerns: negative affective experiences (hunger, pain, stress) for the animal should be avoided and animals should be able to experience normal pleasures (comfort, satisfaction)

–«Afunctioning-based» concerns: the animal's biological systems should be able to function «Anormally» or «Asatisfactorily».

It is vital that animals' natural needs are considered in livestock housing, feeding strategies and farm management. From an organic point of view, large-scale and highly specialised farming systems pose a number of problems with respect to animal welfare. On large farms, the greater number of animals per caretaker and automated feeding and milking systems inevitably alter the nature of the relationship between man and animals. Herd size itself may also affect animal welfare. In recent years, herds have become bigger in response to the pressure on farmers to intensify; the question is whether herds can also become too big.

The relationship between animal welfare and animal health is obvious, but there is also a strong relationship between welfare and breeding. Animal health can be regarded as a resultant of animal welfare, but at the same time, an animal's health is dependent on environmental circumstances and certain innate qualities of the animal. Thus, potential longevity might be a strong determinant of animal welfare. Although breeding is also closely linked to animal welfare, we will not go into breeding strategies, goals and reproduction techniques for organic breeding programmes in this article. This is an extremely complex issue which warrants a separate discussion.

The Animal Welfare Index is an indirect measure of welfare at farm level (developed in Germany as the *Tiergerechtheitsindex* = TGI) (Sundrum *et al*., 1994; Bartussek, 1995a, b; Bartussek, 1996 a, b). Welfare scores are based on the housing situation and specific aspects of farm management. The index evaluates several aspects of animal behaviour (movement, eating, social interaction, resting, etc). It is not easy to describe the interaction between livestock and real-life management aspects; the man-animal relationship is excluded from the index, even though it is a key factor in animal welfare. As with all indices, the weights and limitations attributed to the different factors are subjective. The index has been criticised because the effects of extreme scores on housing system are toned down, that is, the mean welfare score may be satisfactory even though the animals' housing scores poorly on several specific aspects (Darwinkel and Tjalkes, 1997; Varekamp and Boons, 1998). Nevertheless, organic farmers in Austria and Germany are required to make an evaluation of housing conditions following the animal welfare concept.

Development of livestock systems

Several countries boast experimental organic farms at research stations, sometimes in conjunction with a conventional system for comparison. Depending on the possibilities, specific technical issues are tested in experimental trials. The profitability of the systems is always measured. Currently, the following systems have been developed at research stations:

–beef and sheep production (UK)

–dairy (NL, Finland, D)

–suckler cows (UK, Ireland, D)

–pork production (Denmark)

Sometimes data collected from commercial organic farms are integrated in system development. These commercial farms are used for the interpretation of results and provide a link to real problems encountered in daily farm practice. Experimental systems may also be examined with respect to the relation between farm management and environmental and wildlife values. These values can only be evaluated by taking the farm system as a whole and considering the attitudes of the farmers concerned towards the environment (DK).

Next to the farm units at research stations, prototyping projects are being carried out on groups of pilot farms. These projects may be aimed at the complete system or at specific issues. Pilot groups are formed to examine specific problems (how to reduce of mineral losses or improve efficiency, feeding strategy, animal health), or farming developments in general. The methods implemented in these projects usually consists of data collection and interviews during farm visits, followed by an identification of problems (epidemiological approach). This can be followed up by farm research trials.

Models and simulations of farming systems are being developed in several countries. Programmes may be developed specifically for organic farming systems, or conventional programmes may be adapted to organic farming (NL, UK, DK).

Breeding programmes

As yet, there is no specific interest in breeding. In Switzerland (FIBL, Frick) a research project was launched following an evaluation of conventional breeding goals (see also NENOF-7). Research groups in the German-speaking countries are specifically interested in life time production in dairy cows.

The ENOF database gave one hit for a query about economic evaluation of breeds in organic farms in Northern Italy (Bologna, (I)).

However, there is increasing concern in several countries about the impact of breeding technologies (embryo transfer, ovum pick up) in relation to animal welfare. Discussion groups have already been formed to look at genetic engineering in plants and animals (EFRC (UK), LBI (Netherlands) and FIBL (Switzerland).

Research on Animal Health

1. The development of prevention strategies from an organic point of view and the need for decision support systems for farm managers. Goal is to control all kind of infections through a mix of «natural» management factors. Important multi-factorial diseases in organic beef and sheep populations are: internal parasites (gastro-intestinal nematodes, lungworms, liver fluke) and mastitis (organic dairy cows).

The database gave only two hits for mastitis (Reading & Driebergen). However, research programmes are being carried out in Denmark (Copenhagen, Foulum) and Germany (Witzenhausen), too. Intestinal parasites (lambs and calves are being studied in Aberdeen).

Two main aspects of animal health need to be improved in organic farming, namely (A) animals' natural resistance and (B) knowledge about the epidemiology of parasites and microbes and specific risk factors in organic systems. In addition, the relationship between animal health and breeding goals warrants closer examination.

A. More knowledge is needed about, for example, the relationship between animal resistance and dietary imbalances (energy, protein) and deficiencies (minerals, trace elements, vitamins). Little is known about the influence of more natural remedies (leaf hay, herbal treatment, etc) or homeopathic remedies on resistance to diseases.

B. More knowledge is needed about the ecology of pests and pathogens (bacteria, parasites, etc) in relation to farm management. (MacNaiedhe, 1998; Gray, 1998).

The database listed projects in Ireland and Scotland.

2. Evaluation of alternative therapies. Alternative therapies include: homeopathy, biological control, vaccination, alternative forage species and herbs.

3. Evaluation of the rise in immunisation programmes.

4. Nutrition:

–alternative feed sources, adapted to organic situations, must be found

–we need more knowledge about several aspects of soil fertility, the use of specific plants and plant communities in relation to animal health. More attention should be paid to the specific relationship between the soil, plants and animals, particularly with respect to minerals and trace elements

–diets must be well-balanced, special attention should be given to protein content, and to the supply and uptake of trace elements and vitamins

In pig farming, attention should be paid to the quantity of forage in the daily diet. Protein quality is also of some concern in both pig and poultry production.

In dairy farming, the focus should be on ensuring a balanced diet during the grazing season. Too much protein is ingested in the second half of the growing season, which has been linked to health problems and nitrogen losses.

According to the database, there is an organic pig production project in Foulum (system development).

5. Specialisation versus integration:

Research must be carried out into the potential of collaboration between specialised farming systems. However, collaborating farmers cannot fully achieve specific integration within a mixed system. Examples are: mixed grazing of cattle and sheep; parasite control in poultry in grazing systems; efficient use of building up soil fertility in mixed systems.

Recomended Research in Animal Welfare in Organic Farming Systems

A new network was recently set up (1999) to discuss issues concerning organic animal health and welfare (Concerted Action (PL98-4405): Network For Animal Health And Welfare In Organic Agriculture’ NAHWOA). The two main objectives of research and development are:

1. To create a joint platform for organisations and institutions involved in organic livestock production, particularly in animal health and welfare research, to enable the sharing of information and ideas along with the development of new research priorities, and to analyse conventional research methodologies and their suitability for organic livestock research.

2. To create a forum for on-going discussion on animal production and welfare, and their interrelationship in the framework of organic livestock production, in order to contribute to the development of organic regulations.

In the next three years, the issue of welfare and health will be discussed in greater depth during a series of workshops and in four thematic publications from the theme workshops.

In general, research is desperately need in the following areas:

–new methodologies to assess welfare

–the development of systems and practices to avoid mutilation, starting with de-beaking and dehorning

–an examination of the part of human-animal interaction in animal welfare

With respect to animal housing:

–methods to evaluate housing systems. Attention should be paid to compensating factors within each housing system

–an inventory of the consequences of the implementation of EU-regulations for the farming traditions of different countries

–more insight into optimum group size of housed animals with respect to welfare

More specific issues in organic farming are:

dairy and beef production

1. the development of the lay-out of tied barns for dairy cows
2. the development of group housing (bull(s), cows, heifers plus young stock), taking into account herd structure and horned dairy animals
3. the part of (daily) movement of animals
4. the part of the farm manager in rearing youngstock
5. in beef and mutton production, research is needed about livestock systems without any housing

Pig production

1. the development of indoor housing facilities as a satisfactory alternative to free range pigs
2. more insight into to the optimum length of the weaning period in relation sow welfare
3. piglet mortality in loose housing

Poultry

1. factors influencing cannibalism in beaked chickens (breeding, rearing and housing factors, flock size and the role of cocks and older hens)
2. development of longevity
3. artificial versus natural rearing (hen plus chickens) methods in relation to cannibalism

Breeding

–specific organic breeding goals (including quality parameters and outdoor hardiness) and the evaluation of specific breeding programmes. Due consideration should be given to the increased use of technology in breeding programmes (embryo transfer, ovum pick up)

–breeding for disease and parasite resistance

–evaluation of locally adapted breeds

In highly specialised systems like the produce of table poultry, an alternative must be developed for the unadapted conventional breeds.

Economics and policy

–cost/benefit assessment of measures to improve welfare, closed systems, high food quality, etc (the quality of organic produce and systems in general)

–cost of converting specialised intensive conventional livestock systems to organic systems

Technology

–evaluation of the consequences of new technologies for all aspects of the production system (ie. automated feeding, milk robot)

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CHAPTER 6

REVIEW OF GRASSLAND AND FODDER PRODUCTION

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INTRODUCTION

Survey from the database

A search of the ENOF database was made to find projects currently running in the EU. Several key words were used in the search: grass, grassland, clover, legumes, fodder crops and weeds. There were only a limited number of hits, mainly projects in the Netherlands, Ireland, Germany and Scotland. Because of my professional contacts with several research stations in Europe, I knew that the result of the database search was all but comprehensive. There are many more projects currently being carried out on this topic; a lot of information is missing (mainly from Scandinavia, France and southern Europe).

Several issues are related to this topic, like mineral cycles and losses, crop rotation, feed value, set-aside, alternative fodder crops. Because of the small number of hits in the database, this article only gives a general description of research in this field. Research topics were defined on the basis of discussions during several ENOF meetings.

The role of grassland in OF

Initially, organic farming systems were mixed farming systems as a matter of principle. Mixed systems integrate different farming functions in one location. Today, however, simple-structured grass based systems are much more prevalent, particularly in Western Europe (Brittany, Belgium, Netherlands, UK and Scandinavia), mostly as a result of agricultural intensification and specialisation and climate conditions. In a mixed, more self-sufficient farming system, soil quality (fertility, moisture) and production goals determine the area for fodder crops and the area for vegetable crops for direct human consumption. Thus, mixed systems in sandy soil areas only have fodder production in a rotation of grass-clover, fodder maize and cereals, such as whole crop silage or corn, for concentrates. Mixed systems on more fertile clayey soils also produce vegetable and arable crops for human consumption (cereals, potatoes, vegetables). In general, the lower the soil fertility, the more grass/clover and other nitrogen fixing crops must be grown.

Mixed organic farming systems have declined because of the open regulation provisions in EU legislation and the different standards set by individual countries (Baars & Van Ham, 1996). However new, more stringent regulations about the use of organically produced farmyard manure have renewed the need for mixed systems. Modern mixed systems may be realised through the partner farm concept, encompassing the close collaboration of specialised arable and livestock farms (Baars, 1998; Köpke & Geier, 1998).

Younie & Baars (1996) explained the role of grassland in the organic system. Later, they studied grassland with respect to sustainability concerns (Baars & Younie, 1998). In organic farming, grassland has always been regarded as the most important way to raise soil nutrient status, particularly nitrogen (N), and improve soil structure, which also enhances nitrogen supply by improving N mineralisation. In a mixed ley/arable system, therefore, grassland can be seen as the central bank in the farm nutrient economy, building up reserves which can be utilised elsewhere in the system. In addition to nutrient resources, however, grassland and its management can influence the botanical and amenity resources on the farm and can also influence the wider environment (aquatic and atmospheric).

Interest in grass/clover systems is growing because of environmental issues. However, the total amount of N cycling in the system seems to be the most important factor determining the level of potential losses, rather than whether the N source is biological or artificial. Clover-based grassland is relatively energy efficient, principally as a result of the non-use of N fertiliser.

Reseeded pastures are very poor in species diversity. Permanent pastures have the greatest potential for biodiversity, but in organic pastures as well as conventional pastures there is a negative correlation between utilisation intensity and white clover content on the one hand, and biodiversity on the other hand. The greatest biodiversity is found in permanent natural pastures in combination with a high watertable and little or no fertiliser dressings. However, it is difficult to base an intensive dairy system on such pastures because of their low energy and protein yield. The agronomic value of these pastures lies in their high herb content, which is potentially valuable in terms of animal health. Nevertheless, potential opportunities for segregation or integration of production and nature are possible at landscape level, farm level and field level.

The database search yielded several projects on the development of farming systems and the role of legumes. There are projects for dairy farming (Witzenhausen, Lelystad/Driebergen, Foulum), beef production (Aberdeen), suckler cows (Wexford) and sheep (UK). Projects concerning cereal and red/white clover intercropping techniques, stripseeding cereals in white clover, and weed control are especially interesting in this respect. System development hits were found concerning prototyping (Louvain la Neuve, Lelystad/Driebergen, Foulum).

Maintaining soil fertility

Nutrients are a key resource in all farming systems, but the control of nutrient dynamics is especially important in organic farming where external inputs are restricted. Considerable importance is placed on the biological processes involved in mobilisation and uptake of soil nutrients by crop plants, in the recycling of nutrients within the farm system, in minimising the loss of nutrients and the need for replacement with nutrients brought in from outside the system.

Maintaining a satisfactory P status in the soil is important for the maintenance of herbage yield and clover content, and also the P content of herbage, which influences animal health (e.g. cow fertility) (Nguyen *et al.*, 1995). Newton & Stopes (1995) reported that, in a survey of herbage production on organic farms, soil P status was the best predictor of herbage production. It is known that low P supply inhibits nodulation and N-fixation by clover, thus limiting N supply and herbage production (Haynes, 1980).

As with P, clovers are poor competitors for soil K compared to grass, and low soil K may restrict the input of atmospherically fixed N in the system. The reductions in K content in a sandy soil caused a significant loss of clover from the swards (Baars & Younie, 1998).

It is essential, therefore, that, in a largely self-contained system such as organic farming, with minimal import of nutrients, grass-clover swards intended for conservation be given high priority in the distribution of manures (Younie, 1998).

Because of the labile nature of K_2O in manure and in soils, the risk of loss during the nutrient cycling process itself is substantial. Berner (1986) estimated losses of 50-60 % of total K from farmyard manure heaps on commercial organic farms. Nolte & Werner (1994) estimated that 78 % of whole-farm K losses were lost during the internal nutrient cycling process, and suggested that the K balance could be improved substantially by improving manure handling and storage procedures.

An informal group of researchers in the UK has been studying the issue of nutrients in organic agriculture since 1997 (NOAG-newsletter). The group meets once in a year (contact person Christine Watson, SAC, Aberdeen).

The database gave only a handful of projects on this matter. These concerned: phosphate uptake and the role of mycorrhizal fungi (Wageningen, Aberdeen), reducing potassium losses (Aberdeen), effects of organic manure (Driebergen).

Grass/white clover, permanent grassland and biodiversity

Management of a grass/clover sward in relation to the long term maintenance of white clover is an old issue. Research programmes on grass/white clover are running in several EU countries. Frankow-Linberg & Frame (1997) recently gave a progress report on white clover research. They concluded that rapid progress has been made in many aspects in the past decade. Thanks to breeding activities, improved cultivars are available that have greater tolerance to stress factors. We now have a better understanding of grazed grass/white clover swards, and how nitrogen fixation and transfer work. There has been less attention for breeding and the ecology of pests and diseases.

In general, conventional grass clover systems and organic ones are managed in the same way. In Europe, increasing our knowledge of the ecology of white clover is an important topic of research. Research is coordinated by the FAO lowland pasture group and meetings take place every second year.

A general problem in organic grass based systems is how to improve the quantity of home grown fodder and the balance between energy and protein in the daily ration.

Three different sward types need to be differentiated in discussions on biodiversity in grassland: (a) short term leys, (b) permanent swards with a production goal and (c) permanent swards managed specifically for their nature conservation value (floral and faunal diversity objectives). Evidence for a division of permanent grassland into the two categories listed above can be seen in the survey of 91 organic grassland sites in Schleswig-Holstein by Worner & Taube (1995) who found that the index of stand value (for agriculture) was closely related to the presence of perennial ryegrass and white clover. The percentage of legume in the sward increased with intensity of utilisation, and the content of *T. repens* tended to be negatively correlated with species diversity. Similarly, Younie & Armstrong (1996) found relatively little species diversity in an intensively managed and highly productive organic sward over a period of nine years from sowing. Over 95 % of ground cover in this sward comprised *L. perenne* and *T. repens*.

Resown pastures, whether organic or conventional, are very poor in species diversity, but have a major advantage in terms of yield and quality. Resown pastures have a higher clover yield and a higher N yield than old swards. The total yield and protein content of natural pastures is lower still. This herbage could not be used as the main fodder for high yielding dairy cows, mainly because of the low protein content (Baars & Younie, 1998).

Many of the unsown plants in these grasslands are deep-rooting and have a better mineral status than sown species, and therefore potentially contribute to the health resource of farm animals and to an enhanced nutrient cycle within the farm.

Several trace elements (selenium, zinc and copper) play an important role in immune response (Van den Brug, 1996). Baars & Opdam (1998) found a relationship between trace element supplementation and somatic cell counts in organic dairy heifers who were fed a grass/red clover diet. The role of sown herb mixtures, leaf hay and young branches from hedges, but also species rich old pastures, should be further investigated in relation to animal health and fertility (Boehncke, 1997).

Forage herbs have considerable agronomic and nutritional potential but have largely been overlooked by forage agronomists and breeders (Foster, 1988). This is changing to some extent, at least in New Zealand and Australia, where breeding effort has led to the commercial release of varieties of *Cichorium intybus* and *Plantago lanceolata* (Moloney & Milne, 1993; Rumball, 1986). One of the main reasons for the limited use of forage herbs is their relatively poor establishment and persistence. There is a need for more research to identify optimal management regimes for the more promising herb species. The more upright and less well tillered *Phleum pratense* may be a less competitive and therefore more suitable companion than *L. perenne* to *C. intybus* and *P. lanceolata* (Younie & Umrani, 1997).

An FAO lowland pasture group on white clover has been meeting every second year for the last eight years to discuss all the agronomic aspects of white clover. The group is coordinated by Sweden.

Recently, an EU demonstration project, EFFECT (an acronym for the European Commission funded project (CT97-3819) European Farms For Effective Clover Technology) was launched to demonstrate the introduction of white clover in grass based systems. This exciting demonstration project will run for 4 years from 1998 to 2002, during which time a package of new technologies will be implemented to tackle persistency problems associated with white clover in permanent pasture. The project is coordinated by Northern-Ireland.

One project was found in the database (Foulum) concerning the relation between organic farming and nature development. A scientist at SAC Aberdeen wrote a PhD thesis on the growth and mixtures of forage herbs.

Weed control

The search for projects concerning annual weeds yielded studies on control after reseeding old grassland or oversowing white clover. In general, annual weeds disappear after one or two cuts, depending on the nitrogen level of the soil (*Stellaria media, Poa annua).*

The control of perennial weeds in pastures is poorly understood. Recently Humphreys (Teagasc, Ireland) completed his Ph.D.Thesis on the ecology, control and spread of docks (*Rumex obtusifolius*). Dock spread is negatively affected by high potassium levels in soil, cutting and bare patches (urine) in the sward. Docks need an open sward structure to germinate and therefore reseeding grassland is an effective key to increase the number of docks. Dock seeds are spread over the farm through haymaking. Seed can be killed by ensiling (see Humphreys *et al*., 1997).

No hits were found for the control of perennial weeds in OF.

Research is needed on: *Cirsium arvense, Rumex obtusifolius, Elytrigia repens*.

Grass/red clover

Red clover is used in mixtures as a short term ley in crop rotation or as a starter of a resown grass/ white clover. The most important advantages of using grass/red clover rather than grass/white clover are greater herbage production and perennial weed control.

Research questions mainly focus on mixtures' species content, clover varieties as well as grass species.

In several countries (France, Switzerland, Germany), grass/red clover is part of a conventional farming system. This means that a lot of basic knowledge can be used for organic farming as well.

In the database only one project was found about mixtures and cultivars (Bonn, D). Current projects in the Netherlands (Driebergen) concern mixtures in relation to crop rotation.

Lucerne

No information was available. In one of the NENOF newsletters, Van der Schans (1997) describes research on lucerne. The main issue is how to improve herbage quality in relation to long term persistency and weed control. An issue for research is the predictable values of fodder quality in terms of digestible energy and protein (Netherlands). In France and Germany lucerne is an important fodder crop in conventional systems.

Other forage legumes

The database listed several alternative fodder crops like Galega, Lotus and Medicago. Trials with these crops are aimed at developing an economically efficient production system for Northern EU countries based on the use of ensiled forage legumes.

Nutritional value and uptake of grass/clover

There is an imbalance in the protein/energy ratio of grass/clover during the growing season. The more clover in the sward, the more protein ingested by livestock and subsequently excreted as N in urine and milk. The time of year during which herbage N content increases depends on the rate of N mineralisation in spring and the use of additional manure. In mixed systems with a low manure input in the Netherlands, herbage N-content does not increase until after early July (from about 25-30 gm N/kg DM to 40-45 gm N/kg DM) (Van der Meer & Baan Hofman, 1989; Baars & Younie, 1998). Van Eekeren (1999) showed differences in milk urea levels during the growing season in 42 organic dairy herds.

Mineral cycling, N-fixation

No projects were found in the database. However, research is being carried out on N-cycling in white clover in several European countries (France, UK, Denmark).

The use of organic manure and fertilisers in OF systems (the potential of household waste, nature areas, rocks and mining) warrants more research.

Rations with little or no concentrates; fodder based diets

No hits.

Other fodder crops

No hits found on maize silage and whole crop silage.

Research Needs in this Area

Specific areas in the field of grassland and fodder crop research need further attention:

–maintenance of soil fertility (especially on soils with a lower soil fertility), mineral uptake, obtaining a healthy, organic soil. Research should focus on basic chemical fertility and acceptable input from fertilisers (mainly P, K and Ca), but also on the relation with bioregulators (bacteria, mycorrhiza, earthworms, biodynamic treatments and micro-organisms). We need to increase our knowledge of the relationship between soil pH and mineral uptake. As a matter of principle, manure should be transported from livestock divisions to arable division. Research is also needed on how soil fertility can be maintained (level of suppletion, improvement of uptake). Trials should be carried out with nutrient accounting, the distribution of manure over different fields (MacNaeidhe, 1997; Watson & Atkinson, 1998)

–breeding and selection of clover varieties under different organic circumstances instead of conventional research situations. COST-project Aberherald versus Huia is one approach. Main topics from an organic point of view are resistance against pests and diseases (slugs, fungi), adaptation to several management and climate aspects, grass production next to clover (nitrogen fluxes from grass to clover), year-round and in spring (winter damage)

–mixtures of grasses and clover; extending the growing season in spring; the role of the grass component

–improving mixtures with herbs; the role of herbs in pastures and mixtures in animal health (minerals and trace elements) and uptake of minerals from deeper soil layers. In this respect, more attention should be paid to old, permanent organic swards

–nature development; the role of permanent pastures in relation to production level, quality, species diversity (plants, birds, insects, butterflies)

–the effects of finely adapted machinery on the uptake of soil minerals and soil compaction

–ecology and control of perennial weeds

–development of site adapted systems based on the soil quality and climate conditions

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ORGANIC FARMING RESEARCH IN THE EU, TOWARDS 21ST CENTURY

ENOF WHITE BOOK

CHAPTER 7

LEGAL AND ECONOMICAL ASPECTS

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1 Survey from the ENOF database of organic research

From reviewing the projects currently listed in the database using «economic», «market», «policy», «legislation» as keywords in the search engine, only a limites number of hits can be found. Indeed, the database is far from being complete, due to the fact that researchers tend to be overloaded with questionnaires and similar, and tend to react very slowly and only if they see some real benefit in it. Most of the people found much more benefits in making the co-ordinator and sub-coordinators aware of their existence (in order e.g. to be invited to a workshop or receive the proceedings ore NENOF), than in registering in the database. Nevertheless, some conclusions may be drawn:

a. most projects are farm-level performance studies of organic farming systems compared to conventional systems;

b. the largest research effort (measured by numbers of projects) was found in the Netherlands, Germany, UK and Italy. This is probably due to the fact that some projects derive from the AGREP databases. Besides the sub-coordinator for legal & economic aspects is Italian where a network of researchers (mainly economists) exist in organic farming.

c. in any case, as already mentioned, the database is not completely representative: only around 50 projects are listed in the economic & policy studies.

This review will now focus on and discuss the main areas of research in the economics and policy of organic farming at the EU level. The discussion which follows is partly based on the thorough survey by Zanoli (1998), presented in the last ENOF workshop. For more details and references, the reader is kindly invited to refer to it.

2 An overview of main research results

2.1 Farm –level studies of the conversion process

This type of studies have been particularly abundant in Northern European literature, and methodology used range from case-study or cross-sectional to modelling approaches making use of partial budgeting and optimisation techniques. Experimental farms data has been used in some studies but this approach is much less used in economic research compared to what happens in agricultural sciences. Due to the systemic nature of organic farming systems, experimental results are not particularly reliable due to the large differences existing between experimental and real-world farms in terms of management and technical abilities as well as input availability and site/geographic representativeness. Conversion studies have been and are mainly useful for advice and extension, due to the fact that they tend to reduce economic and financial risk and uncertainties for new adopters. This are, indeed, the conclusions of the second ENOF workshop held in Barcellona, specifically devoted to conversion. Many studies have pointed out the increased importance of the economic factor in the motivations of farmers to convert, especially after the CAP reform of 1992 has reduced the relative advantages of conventional farming in terms of global economic performance in most areas. Therefore, specific demand of research exists in the field of conversion planning, where traditional budgeting techniques should be improved by making use of expert systems and programming methods.

2.2 Farm-level performance studies of organic farming systems, including comparisons to conventional systems

Studies related to this area of research exist in most European countries. A FAIR project «Organic farming and the CAP» (CT 1996-1794) is presently making a very thorough overview of the studies existing in this area of research; but it is already quite clear that the analyses of established organic farms and their comparison with conventional ones are not limited in number. The differences in the methodological approaches used are the main limiting factor in comparing and adding up results of the existing studies: some studies are limited to gross margins calculations of some organic enterprises, while whole farm-studies are often more difficult to compare in those countries/regions where staged or part farm conversion is possible. Differences in accounting standards and definitions is also a limiting factor in comparing and assessing research results; these problems, coupled with the fact that no real accounting systems is compulsory for farmers in most EU countries, results often in difficulties in collecting reliable data. Cross-sectional surveys of farms appear to be the most reliable method of collecting data, but, due to high cost of data collection, many studies refer to case-studies or, in general, non-representative samples of farms. After the EU Reg. 2092/91 a lot of information is asked to farmers for certification purposes; with few adjustments such information could become much more useful for statistical purposes too. Another controversial methodological issue relates to whether and how comparisons between farming systems should be made. Although established organic farmers are probably more interested in assessing their relative efficiency compared to that of other organic farmers, conventional producers need comparisons of the two systems in order to make sound decisions concerning conversion. To a certain extent, therefore, comparative studies provide useful data for advice and conversion planning. At the same time, comparative studies are an important area of policy-oriented research, and provide basic data for regional/national models of the impact of widespread conversion to organic farming. The design of comparative studies is, by no means, clearly standardised in existing literature; indeed, «the comparison of farming systems is an area of research which is problematic even in situation where the results are not likely to be controversial» (Lampkin, 1994a). Studies differs according to time and geographical scope of the comparisons, performance measures used, sample selection and representativeness, *ceteris paribus* assumptions and how structural and latent factors such as size, location, enterprise structure, farmer's ability, etc. are taken into account when making the comparisons.

Related to this area of studies is the availability of *standard data collections* specific for organic farming; these collections are highly demanded by advisors and training services, although at the moment no collection exists for Mediterranean farming systems, where weather and soil conditions are quite different and very site-specific. These collections are quite useful for model building and simulation, and help in conversion planning, too. Specific research efforts to provide organic standard data for all regions/countries are, therefore, highly welcomed.

2.3 Market studies and other sector surveys

This group of studies are more widespread, but often very different in terms of depth of the analysis and quality/quantity of data available. General overviews of the organic sector exist now for most of the European countries, and a recent German publication was dedicated to a country-by-country synopsis of the organic farming sector in Europe (Willer, 1998). Nevertheless, the availability of trustworthy data on organic farm numbers and land area –as well as data on farmers re-converting to conventional farming– is still an open issue in some countries, while the average enterprise structure of organic farms is still almost unknown in most regions/countries. Seven years after EU Reg. 2092/91 in many European countries no official statistics exist about variables such as: gross output, yields, farm-gate prices, final market prices, imports, export of organic products. For what concerns more specifically the demand side, market studies exist for most countries, but vary in terms of geographical scope, sampling and interviewing methodology as well as in credibility of results. Definition of an organic product is not always clearly understood by consumers, therefore answers to direct surveys are often biased due to linguistic/conceptual distortions and misunderstanding of respondents. At the same time, surveys carried out show that:

1. «healthiness» of food is the most important quality attribute in consumers perceptions and an increasingly relevant factor in explaining buyers behaviour

2. «food scares» such as that induced by BSE, salmonella, listeria, etc. are another important factor in explaining the search for «more genuine» food products

3. general environmental concerns and «green consumerism» are probably more important in Northern European countries than in the Mediterranean, but the negative impact of conventional agricultural systems on the countryside is a general perception

4. consumers are willing to pay premium prices to buy organic products; surveys generally underestimate the real amount of these premiums due to the respondents free-riding behaviour. In real market, final consumers often pay up to 300 % premiums for organic purchases

More in general, the demand for organic products has increased more slowly than expected and forecasted; some studies have shown that public information and promotion is an important factor in increasing final demand and establishing a higher level of confidence among consumers (Hamm, 1997; Hamm-Michelsen, 1996). The organisation and qualification of quality assurance systems in organic farming and processing is also a variable that plays an important role in explaining market development. Few studies exist that investigate the organic market and industry structure, either vertically (Santucci, 1997) or horizontally (EFRC, 1988) .

In general this area is quite an important one, but marketing research and market studies of the organic sector are hardly publicly available.

2.4 Modelling the impact of widespread conversion to organic farming

Another group of studies concern the modelling of more or less widespread conversion to organic farming. Few studies have been implemented at a national/regional basis only in Northern European countries. Other studies refer to the impact of EU Reg. 2078/92 on the uptake of organic farming . In general, the results of these studies show that there is a substantial decrease in output of cereals as a consequence of reduced intensity and area cropped, while forage crops increase, as a consequence of different rotations patterns and green manuring in organic farming.

An ex-post study just completed as part of the already mentioned FAIR project «Organic farming and the CAP» (Zanoli-Gambelli, 1999), has shown that «when considering single countries, two main groups may be identified, one showing relatively high impacts of organic farming on output, and the other one showing lower impacts. AT, DE, FI and CH belong to the first group (…) DK, FR, GB, GR, IT, NL, SE, NO and CZ belong to the second group». Besides, even if the analysis is limited to only some EU countries due to the lack of data, the study shows that 46 % of the financial support for organic farming is covered by savings derived from output structure modifications due to the adoption of organic farming. This is an underestimate, given that this result does not take into account the wide range of positive environmental externalities and environmental cost reductions deriving from organic farming.

As already noted by Midmore & Lampkin (1994), the major weakness of the above mentioned models is «the absence of any direct assessment of the impact of changing levels of output on prices for agricultural produce, and the influence which these changes in turn might have on the structure of land use». Even the most recent studies have not overcome this problem. A reason of this may be found, at least partially, in the lack of econometric studies on the demand of organic products and in the consequent lack of information on price elasticities in the organic market. Methodologies used in these studies vary.

On the other hand, at present there is no model or set of models available which can handle a quantitative assessment of organic farming at the EU-level. These type of studies are quite relevant for policy analysis and decision-making, therefore they will very likely expand in the near future. Their feasibility and usefulness is constrained by data availability; therefore, a reasonable supply of consistent farm-level and regional-level data on organic farms is, again, a pre-requisite for the development of any economic research.

Scenario-type studies are also relevant; they can be both quantitative or qualitative. No study exist at the EU level insofar, but it is one of the aim of the already mentioned FAIR project «Organic farming and the CAP» to provide one on a mid-term perspective (Zanoli, 1998).

2.5 Econometric and sociological studies on the adoption of organic farming techniques

The fifth area of economic research is that of regional/national econometric and sociological studies on the adoption of organic farming techniques. Very few econometric studies exist at the moment in Europe on the determinants of the decision to adopt organic production techniques, while sociological studies are relatively more abundant. The first sub-group of studies generally use logit and probit models to a cross-sectional sample of organic and conventional farms, in order to explain adoption decisions in terms of different characteristics of farmers and farms; some authors use duration analysis too, in to model uptake as a dynamic process.

Problems in this area of research originate from the fact that, in order to be able to apply qualitative response models and to draw meaningful results, it is necessary at least to use comparable samples of organic and conventional farms. This is an important issue in any organic vs. conventional farming comparison, and should not be overlooked when using econometric techniques that refer to the probability of adoption. It is not only a matter of sample representativeness, but a question or whether or not the surveyed farms are consistently comparable. The question of sample representativeness, and therefore of generalizability of results, is also an open issue and is strictly related to the quality of existing farm-survey data. In sociological studies the focus is more or less the same but the approach is more qualitative and the analyses are generally based on *case-studies* and less frequently on surveys.

Results show that adoption has different motivations: ethical, economic and institutional. The last motivation has increased its importance in EU especially after 1991-1992, because economic incentives exist and the political situation is favourable. Profit-maximisation is becoming an increasingly important goal of organic farmers and particularly of more recent adopters, due to decreasing profitability of conventional agriculture. Ethical considerations appear to be the basis of many decision to adopt, although increasingly in combination with more prosaic motivations.

2.6 Policy analyses

The last group of studies is that related to policy analysis. These studies can be divided in two main sub-groups:

a. studies on the consequences of policy support to organic farming or, more generally, on the impact of agricultural policy on the organic sector (positive studies)

b. studies on new policy instruments to support organic farming (normative studies)

The literature concerning the first sub-group of studies is, by far and large, the most important in term of size and distribution. Studies exist in all countries, and a full account is here impossible. The first report of the already mentioned FAIR project «Organic farming and the CAP» is specifically devoted to policy for organic farming in Europe and we ask the interested reader to refer to it (Lampkin *et al*., 1998). In terms of goals, a vast majority of the studies belonging to the first sub-group that have been published after 1992 tend to analyse organic farming support under agri-environmental and extensification measures, particularly EU Reg. 2078/92. The focus is on the effectiveness and efficiency of support, as well as on distortions in supply originated by the current support scheme. In fact, in present rules and regulations organic farming is a matter of degree rather than kind. In some countries only whole farms can be converted, while in other countries partial conversion is accepted (as in EU Reg. 2092/91). Also, although organic farming originally was almost synonymous of mixed farming, this is no longer true, especially in Mediterranean conditions. These considerations show that there are different approaches (if not different definitions) to organic farming practices, and sometimes they hardly cohabit under the EU Reg. 2092/91 umbrella definition. The differences between approaches to organic animal farming in Northern European and Mediterranean conditions are among the causes explaining the long gestation of the long-awaited livestock regulation. In future research these contrasting approaches should be adequately recognised and accounted for, while matched with the implications of the proposed USDA organic standards in the framework of the WTO agreement; all these issues, in the near future, may well hinder if not jeopardise the development of the organic farming sector in Europe.

Normative studies relating to organic policy support are much less numerous, especially recently. As noted by Zanoli (1997) resource use and sustainability issues are very relevant in order to assess present regulations (especially all organic aids schemes, EU Reg. 2078/92 *in primis*) and to devise new methods of policy support to organic farming. Special attention should be given to the *goals* of any support scheme, and more attention should be given to the distortions that subsidies can cause in the adoption pattern. Subsidies are important at this stage, but more financial effort should be put in the development of the market: this could be beneficial for it could reduce the importance of subsidies in the medium-long run, reduce agricultural over-production, environmental impact and health hazards. Members states should increase their effort in promoting organic products to the consumers and a massive European campaign should be launched. For analogous reasons, organic farming should become a compulsory priority for more general agro-food regulations (such as EU Reg. 866/91) and a combined application of EU Reg. 2079/92 and 2328/90 should be implemented to favour new generations of organic farmers. Therefore, more research efforts are needed in the formulation and ex ante assessment of new policy instruments to support organic farming in Europe, with particular reference to the opportunity of reform brought upon under the general framework of «Agenda 2000».

3 Perspectives for future research

Zanoli (1998) discusses in detail the issues concerning theoretical and methodological improvements in the field of the economics and policy of organic farming.

The recognition of «the special needs of organic farming research, i.e. whole farm system experiments and above all an holistic, interdisciplinary experimental design requiring in-depth horizontal collaboration and special methods», has been a major point raised at the Expert Roundtable Discussion on Biological Farming Research in Europe held in Braunschweig on the 28 July 1997 and sponsored by the FAO Regional Office for Europe (REU). «Since the holistic and interdisciplinary approach and particularly the former, include a larger human element of interpretation of research results, i.e. different perceptions from different scientists, a uniform, agreed methodology takes on a more important role» (Krell, 1997). On these grounds, FAO-REU has organised a first workshop on "Research methodologies in organic farming" in Frick (Switzerland), co-sponsored by the Swiss development agency. After the workshop, a sub-network on the same topic has been established under the SREN-ESCORENA umbrella network. Almost 60 researchers of all Europe participated to the workshop, including many participants from CEE countries. On-farm research and other novel methods have particularly been under discussion during the meeting; on this aspects the next workshop to be held in Bari will focus. We think that a link between EU (through ENOF) and FAO –apart from that represented by the fact that the co-ordinator of the FAO network is one of the ENOF sub-coordinators– would be useful, in order to establish a permanent network of researchers interested in organic farming. FAO financial resources, though, seem very limited.

Apart from this, in the field of legal and economic studies priority should be given to the following research topics:

a. Market studies seem to be crucial in order to better understand the need of consumers and orient the supply. Also, new promotion and communication tools need to be devised, given the peculiar characteristics of organic products. Although often simply labelled as «quality products», they are somewhat more than just so and in a more subtle way. Some issued has been discussed by Zanoli (1995); in any case, consumers need to recognise that the quality of an organic product is not only intrinsic but related to the global environment.

b. Most studied are limited by data availability. This represent a severe problem in socio-economical studies. An effort should be made in order to devise the level of detail and the procedures to collect relevant data with standardized procedures at the EU level. The peculiarity of the organic farming production systems advocate for new set of variables and new methods of collection to be used. Specific research is probably needed also for what concerns statistical methodologies and sampling techniques particularly suited to the organic sector.

c. Interdisciplinary and holistic research should also be supported. Most economic studies can benefit from results coming from other disciplines, particularly in the field of the economic valuation of the overall benefits of organic farming as well as of countryside amenity in organic farming systems.

d. Still in the field of market studies, new insights should be taken in trade issues, especially for what concerns emerging phenomena as fair-trade and related channels, box-schemes and community supported agriculture (CSA). Organic producers and consumers may well meet in ordinary markets via ordinary sales channels, but alternative forms of market organisation should be explored, to see if they are globally more efficient, i.e. taking into account latent, non-monetary factors and equity.

e. Modelling and standard data collections relevant for modelling should also be a target of socio-economic research in organic farming. This field can also be useful in order to fine-tune future agro-environmental policies, in order to achieve results which are coherent with the predetermined goals. Some distortions which resulted from the application of EU Reg. 2078/92 in some regions, could have probably been avoided if better predictive models and consistent scenarios where available. Again, here is a case for interdisciplinarity, especially in the field of environmental impact evaluation of the various policy tools.

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ORGANIC FARMING RESEARCH IN THE EU, TOWARDS 21ST CENTURY

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CHAPTER 8

REVIEW OF CROP PROTECTION

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REVIEW OF CROP PROTECTION

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INTRODUCTION

According to EEC Council Regulation 2092/91, very few direct pest-control agents are permitted in organic agriculture: preparations involving natural pyrethrum, *Quassia, Ryania, Bacillus thuringiensis*, granulosis virus and a few others. These preparations may be applied «only in cases of immediate threat to the crop»; as a consequence, pests in organic agriculture «have to be fought by the holistic application of the following measures: choice of appropriate species and varieties, appropriate rotation programme, ...protection of natural enemies of pests through provisions favourable to them (e.g. hedges, nesting sites, release of predators)...». Consequently, pest control in organic agriculture has to rely, very largely, on mixed control strategies based on preventative measures (Kromp & Meindl, 1997).

Crop Protection research in organic farming in the EU will be reviewed by referring firstly to the ENOF Database of Organic Research. Following the drawing of some initial conclusions regarding the projects entered in the Database, three active areas of research will be discussed. Final conclusions will then highlight those areas of research which in the opinion of this reviewer require further effort.

ENOF DATABASE OF ORGANIC RESEARCH

The following conclusions may be drawn from reviewing the Crop Protection projects currently listed in the Database, viz.

(i) many more projects on pests than on diseases

(ii) the largest research effort (measured by numbers of projects) was found in Germany followed by the Netherlands and UK (equal numbers of projects) and then by France and Spain (also equal numbers of projects)[the non-EU country, Switzerland, had the same number of projects as France and Spain] i.e. most research effort is to be found in northern European countries

(iii) slightly more numbers of projects were experiment-based than survey-based; and

(iv) the largest effort by area of research was in polyculture (measured by numbers of projects), followed by host plant resistance and botanical insecticides (with equal numbers of projects)

This review will now focus on and discuss the three areas of research highlighted in the ENOF Database of Organic Research: host plant resistance, botanical insecticides and polyculture. The discussion which follows on these three areas of research is based on McKinlay & McCreath (1995).

Host Plant Resistance

Plant resistance has been successfully used for the management of soilborne pests. Potato varieties, for instance, resistant to the cyst nematode, *Globodera rostochiensis*, reduced nematode population densities more than susceptible varieties treated with nematicides (Gurr, 1987). The resistance of the variety Maris Piper to *G. rostochiensis* arises from a single major gene, H1, which results in an inhibition of the growth and development of the invading nematodes. One problem which has arisen from the use of H1 gene varieties is, simultaneous with the elimination of *G. rostochienis* (Evans, 1994), selection for populations of the cyst nematode, *G. pallida* (Whitehead, 1986). The problem of selection must always be borne in mind when using resistant plants, particularly those with single major gene resistance. Polygenic resistant varieties of potatoes are available for the management of *G. pallida* but as the degree of resistance is partial only, they have to be used in conventional agriculture in conjunction with nematicides (Spaull, 1991).

Plant resistance can also be used to manage airborne pests, but the degree of resistance tends to be partial only. For example, Ellis *et al.* (1987) reported the partial resistance of the carrot cultivar, Sytan, to the carrot fly, *Psila rosae.* Plants with incomplete resistance may be supported by other forms of management such as chemicals. McKinlay & Birch (1992) found that insecticides applied to *Brassica napus* for root fly control could be reduced by 50 % on varieties having partial resistance. Conversely, partial resistance may not be compatible with biological control, e.g., wheat varieties with resistance to the grain aphid, *Sitobion avenae*, had detrimental effects on the biology of the parasitoid, *Aphidius rhopalosiphi* (Gowling, 1988). Van Emden (1991) makes a plea for pest resistant cultivars to be tested for extrinsic resistance characteristics such as mortality response of the pest to insecticide, survival and fecundity of natural enemies or attractiveness to parasitoids and predators; otherwise host plant resistance could contribute to pest mis-management.

In practice, the market dictates whether resistant crop plants will be adopted. If growers are unable to market resistant varieties, as with partially resistant varieties of *Brassica napus* in the UK, these varieties will not be accepted (McKinlay & Birch, 1992). Research should therefore attempt to identify the resistance factors with a view to isolating the genes responsible and incorporating them into varieties which are preferred by the market.

Resistant crop varieties offer an inexpensive, long-lasting and environmentally-acceptable method of plant protection but are not yet available across all types of crop plants e.g., sugar beet.

Botanical Insecticides

Of the 59 plant families shown by Simmonds *et al.* (1992) to have potent anti-insect activity, the Meliaceae have received most attention, particularly the neem tree, *Azadirachta indica*. Its active constituent, azadirachtin, is a limonoid with antifeedant, growth regulatory and reproductive effects (Mordue & Blackwell, 1993). Recent research at the Scottish Agricultural College (Mordue [Luntz] *et al*, 1995) has shown that pure azadirachtin and a commercial neem preparation, NeemAzal-F, gave reasonable protection of brassicas from *Plutella xylostella* (diamond-back moth), *Pieris rapae* (small cabbage white butterfly) and *Mamestra brassicae* (cabbage moth) caterpillars in the field. Similarly Osman and Port (1990) found that neem seed powder and aqueous preparations applied to the soil reduced damage by *Pieris brassicae* (large cabbage white butterfly) on cabbage. While azadirachtin may not be as effective as synthetic insecticides, it could be used in organic agriculture where it may be less harmful on beneficial insects. Verkerk & Wright (1993), for example, found little or no activity of azadirachtin on the ichneumonid, *Diadegma semiclausum*, a parasitoid of *Plutella xylostella.* Commercialisation of natural products has, however, been deterred because their complex chemical structures make them difficult to synthesise. Perhaps the recent synthesis of azadirachtin by Ley *et al.* (1993) will promote its development.

POLYCULTURE

The simultaneous cultivation of two or more plant species has been called intercropping (two crop plant species), weedy culture (a crop and a weed) or cover cropping, living mulches, etc. (a crop and a beneficial noncrop). All these mixtures are known collectively as polycultures to distinguish them from monocultures which are fields growing bare-ground, sole crops.

Ecologically speaking, the theory of polyculture is encompassed by the «diversity - stability hypothesis» (Andow, 1991) which states that the greater the biological diversity of a community of organisms, the greater will be the stability of that community. Further subsidiary hypotheses describe the role of plants and the behaviour of arthropods in a polyculture: the role of plants is described by the associational resistance hypothesis («one plant species growing simultaneously with another plant species will suffer less herbivore attack than either plant species growing alone») and the host plant quality hypothesis («a changed physiological fitness of the host plant for the arthropod pest due to mutual influence of other plant species»); and the behaviour of arthropods in a polyculture is described by the natural enemies hypothesis («both generalist and specialist natural enemies will be more abundant in polycultures than in monocultures and, as a consequence, herbivore population densities will be suppressed more in polycultures than in monocultures») and the resource concentration hypothesis («many herbivores, especially those with a narrow host range, are more likely to locate and remain on host plants that are growing as monocultures»).

Because there are greater experimental problems associated with testing the resource concentration hypothesis, the natural enemies hypothesis has been tested more often. Larger numbers of epigeal polyphagous predators, such as carabid beetles, have been found in polycultures than in monocultures. The effect of polyculture on specialist natural enemies such as parasitoids is less clear: Helenius (1990) found that polyculture did not affect the incidence of parasitised bird-cherry aphids (*Rhopalosiphum padi)* on oats; by contrast, Theunissen *et al.* (1992) found that parasitoid activity was increased by undersowing cabbages with white clover or subterranean clover.

The natural enemies hypothesis states that herbivore population densities will be suppressed more in polycultures than monocultures as a consequence of the greater abundance and activity of natural enemies. Uvah & Coaker (1984) showed, for example, a reduced attack of carrot fly on carrots growing with onions than on carrots growing alone, and McKinlay (1985) showed that under-sowing potatoes with perennial ryegrass reduced numbers of potato and peach-potato aphids (*Macrosiphum euphorbiae* and *Myzus persicae* respectively) compared with potatoes alone.

Reduced oviposition by the cabbage root fly (*Delia radicum*) on cabbages grown with French beans (Hofsvang, 1991) and with white clover or subterranean clover (Theunissen *et al.*, 1992) have also been reported. Numbers of cabbage aphid (*Brevicoryne brassicae*) and cabbage moth (*Mamestra brassicae*) were also reduced on cabbages growing with either white clover or French bean (Wiech & Wnuk, 1991). The weak link in all these studies is an unequivocal demonstration of increasing natural enemy activity causing decreasing herbivore population densities.

Polyculture has potential for herbivore pest management in temperate, low-input farming systems (Coaker, 1990) as, if for no other reason, the activity of epigeal predators appears generally to be increased (McKinlay, 1994). In the case of airborne pests, where crop arrangement in space is more important than crop arrangement in time (i.e., rotation), spatial diversity can be achieved by polyculture (Speight, 1993). The spatial diversity of polyculture does not always lead, however, to reductions in herbivore population densities. Helenius (1990) found that peak densities of bird-cherry aphids (*Rhopalosiphum padi*) were between 30% and 85% higher on oats growing with *Vicia faba* beans than on monoculture oats.

Conclusions

Research input already exists which can benefit organic agriculture e.g. studies on insect pheromones and sampling methods; within-field/within-farm diversification studies such as beetle banks, flowering strips, etc. The following conclusions emphasise those areas of research which require more effort, viz.

1. More research effort is needed by experiment rather than by survey i.e., more innovative experimentation in organic farming is to be preferred to comparison of different farming systems (including organic farming) by survey of various agronomic and environmental indices.

2. More research effort is needed into disease management; one useful area of research would be to investigate the potential of natural populations of phylloplane microbes to be antagonists of disease-causing pathogens; a similar study of the naturally-occurring populations of microbes in the soil would perhaps suggest ways of managing their numbers and activity to the detriment of soil-borne plant pathogens.

3. More research effort is needed into microbial agents for pest and disease management.

4. Host plant resistance offers an inexpensive, long-lasting and environmentally acceptable method of plant protection in organic agriculture. Because of (i) relatively small size of organic agriculture market; and (ii) current emphasis in plant breeding on the use of genetic engineering techniques which are not acceptable to organic farmers, it seems unlikely that major sources of funds will flow into a plant breeding programme dedicated to organic agriculture.

5. The small amount of current European research effort into botanical insecticides should be increased as they show promise for pest management in organic agriculture.

6. Further studies on polyculture - a very promising technique for pest and possibly also disease management in organic agriculture - should concentrate on demonstrating unequivocally increasing natural enemy activity causing decreasing herbivore population densities.

7. Continuing effort must be expended on infochemical studies of insect herbivore-insect parasitoid/predator and insect herbivore-host plant interactions.

8. Research into plant defence systems against pest and pathogen attack should be increased e.g. systemic acquired resistance (SAR) and its association with nitrogen fertilisation.

Crop Protection involves two basic approaches: control and prevention. The greatest effort by the agricultural industry has been put into the control approach, typically through the use of pesticides. Much less effort has been expended by the industry –for reasons that are not discussed in this review– on the prevention approach which is so important to organic agriculture. For prevention to be successful in the field requires an in-depth knowledge of the ecology of the agroecosystem i.e. research is needed on the fundamental biological processes involved in the ecology of pests and pathogens on the range of crops grown across Europe. To this end, strong international collaboration must be maintained by means of information networks and joint projects.

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CHAPTER 9

CONCLUSIONS. RECOMMENDATIONS FOR FUTURE RESEARCH IN ORGANIC FARMING

J. Isart & J. J. Llerena

CONCLUSIONS. RECOMMENDATIONS FOR FUTURE RESEARCH IN ORGANIC FARMING

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On the 17th and 18th of September 1992, in Louvain-la-Neuve (BE) a workshop was held entitled: «Potential and Limits of Organic Farming». In its conclusions and recommendations it stated:

«*The workshop concluded that organic farming offers a more sustainable model for agriculture in the EC, can increase rural employment, contribute to the preservation of the countryside, increase the diversity and stability of agro-ecosystems and improve public health through better food quality*». (MACNAEIDHE, 1992)

Later it went on to recommend the establishment of research programmes which will facilitate the development of organic farming in Europe. This programme should have the following characteristics, among others, which we can qualify as aims:

1- HOLISTIC APPROACH TO RESEARCH

A Holistic approach, linking all the components of an agro-system, and not just studying them out of context.

2- SOCIAL AND RURAL RESEARCH

Studies of the market and organic farming economies are needed.

3- SYSTEMS RESEARCH

Systems and Technological Research. Research should be carried out within agricultural systems using pilot schemes, in which farmers are directly involved, so as to facilitate an interchange of experiences and results.

ENOF has its origins in the conclusion of the Workshop at Louvain-la-Neuve. It was proposed that those attending who were interested should meet to found a European Network for Organic Farming Research. Within the AIR Programme, in 1994, the constitution of ENOF was proposed to the EU and approved in January 1995, as a Concerted Action.

The three aims highlighted above can be detected throughout the previous chapters and should be taken into account when planning any type of research into organic farming (naturally, within the obvious limits of each individual project).

So as to make this last point even clearer, the recommendations mentioned above are shown here in a synoptic Table. We believe it is not worth re-stating the arguments that led to these conclusions, it would merely be a redundant duplication of them.

Crop Production and Weed Control

rhizosphere and plant-microbial interactions
grain legumes grown in southern Europe
gaseous losses of nitrogen
crop to weed interactions
strip-cropping systems
soil and soil microbial activity
description of product quality especially of vegetables
vegetable production
breeding programmes oriented on site-adapted cultivars
biodynamic preparations
special strategies on problematic weeds

Soil fertility and Environmental Aspects

research must consider soil fertility in a global context
regional scale is important
fertility must refer to the whole rotation and not on each crop taken isolate
nutrient balance sheet at farm level
environmental impact and availability of Potassium and Phosphorus
accurate indicators of environmental impact of OF

Animal Husbandry

creation of a joint platform for organisations and institutions involved in organic livestock
new methodologies to assess welfare
the development of systems and practices to avoid mutilation
the examination of the part of human - animal interaction in animal welfare
methods to evaluate housing systems
inventory of the consequences of the implementation of EU-regulations for the farming traditions of different countries
optimum group size of housed animals with respect to welfare
cost/benefit assessment of measures to improve welfare
cost of converting to organic livestock systems
evaluation of the consequences of new technologies (ie. automated feeding, milk robot)

Grasslands and Fodder Production

maintenance of soil fertility
breeding and selection of clover varieties under different organic circumstances
mixtures of grasses and clover

improving mixtures with herbs
the role of permanent pastures in relation to production level, quality, species diversity
the effects of finely adapted machinery on the uptake of soil minerals and soil compaction
ecology and control of perennial weeds
development of site adapted systems based on the soil quality and climate conditions

Economic and Legal Aspects

new methodologies must be developed
market studies to better understand the need of consumers and orient the supply
to devise the level of detail and the procedures to collect relevant data with standardized procedures at the EU level
to adapt statistical methodologies and sampling techniques to organic farming caracteristics
interdisciplinary and holistic research should also be supported
alternative forms of market organisation should be explored

Crop Protection

innovative experimentation in organic farming is to be preferred to comparison
evaluation of agronomic and environmental indices
better disease management
study of natural populations of microbes as antagonists of pathogens
host plant resistance
botanical insecticides
studies on polyculture as a factor to increase natural enemy of pathogens
infochemical studies of insect herbivore-insect parasitoid/predator and insect herbivore-host plant interactions.
Research into plant defence systems against pest and pathogen attack

BY WAY OF A CONCLUSIONS AND A FUTURES PERSPECTIVE

Beyond the needs of research already outlined, and as can be easily deduced from the previous box, a change in mentality is needed when drawing up and evaluating organic farming projects. Methodological change, the object of an organised network by the FAO, is a necessity given the special characteristics of organic farming.

In order to carry this out, one of the most important steps must be to have available a network of farms directed by research centres, or by regional, or national governments with agricultural skills, to provide scientists with sufficient data so they will be able to take into account the internal functioning of the organic farming systems. The farms should have sufficient scientific and technical staff who will be familiar with the nutrient cycle, control the development of crops and adjacent flora, study the food chain, relationships with flora present, the economy within the farm and outside of it and the relationship between the farm and the outside world, whether conventional or organic.

These farms should be established in all European regions and should be given sufficient funds to carry out the necessary studies. They should also depend, administratively, on the European Commission. This proposal, which would at first seem to clash with the principle of subsidiarity, is justified by the global character of the study. This network of «model farms» will not lead to detailed solutions to specific problems, but rather will form the base for comprehending the working of the farms and contribute data which will allow comparisons to be made between different systems throughout the European Union.

Local problems will be solved by setting up «pilot farms», in other words, real farms run by farmers receiving local, regional or national government subsidies and co-operating with scientists and technicians. This way, local solutions to local problems can be found (solutions that may have a more general application given that the same problem will probably have surfaced somewhere else in the Community and the solution may only require a change of focus to apply to local conditions).

The European Co-ordination network for Scientific Research into Organic Farming should continue, at least, to make good use of the work done by ENOF. However, it should also maintain permanent contact between European researchers, facilitating readily available information about organic farming production systems and disseminating this information as well as holding regular meetings with the intention of spreading the latest results of research.