Research on organic agriculture in the Netherlands

Organisation, methodology and results

Wageningen UR & Louis Bolk Institute

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W. Sukkel & M. Hommes (editors)

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In the Netherlands most research on organic agriculture and food takes place within the scope of comprehensive research programmes. These programmes are mainly financed by the Ministry of Agriculture, Nature and Food Quality. Bioconnect, the knowledge network for organic agriculture and food, directs the research programmes. Wageningen University and Research Centre and Louis Bolk Institute carry out the majority of the research activities. All results are available to Dutch farmers and other stakeholders through the website www.biokennis.nl.

Preface

The Dutch agricultural sector as a whole is very innovative, but this is especially true of the organic sector. The Dutch Ministry of Agriculture, Nature and Food Quality supports the development of more sustainable and innovative agriculture and considers organic agriculture to be a prime example of how a sustainable sector can be achieved.
Research is an important pillar of the current Dutch policy on organic farming because it contributes to sustainability and generates new ideas. This research is highly cooperative, involving the agricultural sector, universities, research institutes and the Ministry. The Dutch government currently allocates 10 per cent of the total agricultural research budget to organic farming.
Closed cycles, resilience in animals and crops, animal welfare and food quality are important research topics that deal directly with producing good food while taking account of the environment and the wishes of society. This research also contributes to a commercially healthy sector that can compete on the international market. The results of the research on these topics are not only important to the Netherlands, but can hopefully find an international audience as well. This book can contribute to an international exchange of ideas and enhance cooperation between researchers and their international partners, which will benefit all those involved in organic farming.

Annette Wijering, *Head of the Agricultural Production and Fisheries Division*
Department of Knowledge and Innovation, Ministry of Agriculture, Nature and Food Quality

The Netherlands has a long tradition in research on organic agriculture. This research takes place at Wageningen University and Research centre and the Louis Bolk Institute. Each has developed its own approaches and methodologies, addressing the potential for development of the organic sector. In recent years the relationship with the organic sector, which has always been strong, was taken to an even more professional level. This was done through interaction with Bioconnect, the knowledge network for the organic sector. At the same time, all research sponsored by the government was brought together in the so-called 'Cluster Organic Agriculture'. The financial support of the Dutch government enables a substantial, ambitious and very diverse research effort. So far, most research has focused on national issues. In the years to come we would like to gradually open up our expertise and experience to the rest of the world. This book is an important step in that process. It presents for the first time the full spectrum of research in organic agriculture in the Netherlands. We hope you will enjoy reading *Research on organic agriculture in the Netherlands*. Please feel free to contact us for an exchange of experience and knowledge. We look forward to talking to you!

Frank Wijnands, *Program manager and Research coordinator Cluster Organic Agriculture*

Dutch farmers are very involved in the research carried out for organic agriculture. Not only do they participate in setting the research agenda, they also partake in the research projects. Organic farmers are often de facto researchers, as we face many challenges whilst pioneering in this branch of agriculture. There is still much to gain in terms of, for instance, product quality, sustainability and the economic viability of organic agriculture. We are therefore happy to cooperate with researchers to innovate our farming practice. Putting together the craftsmanship of farmers and the theoretic knowledge of researchers clearly creates an added value. The results and research examples you will find in this book are also farmers' results and farmers' research.
We would also like to draw your attention to another new initiative for sharing knowledge. The Dutch organic farming sector organises an international farmers' fair called BioVak (www.biovak.nl). The fair displays the developments in the organic sector to all primary producers who want to know more about sustainable production. We would be very happy to meet our international colleagues during the next BioVak.
We hope you will enjoy reading about our experiences and perhaps take inspiration from them for your own work.

Kees van Zelderen, *Vice president Organic farmers association*

Introduction

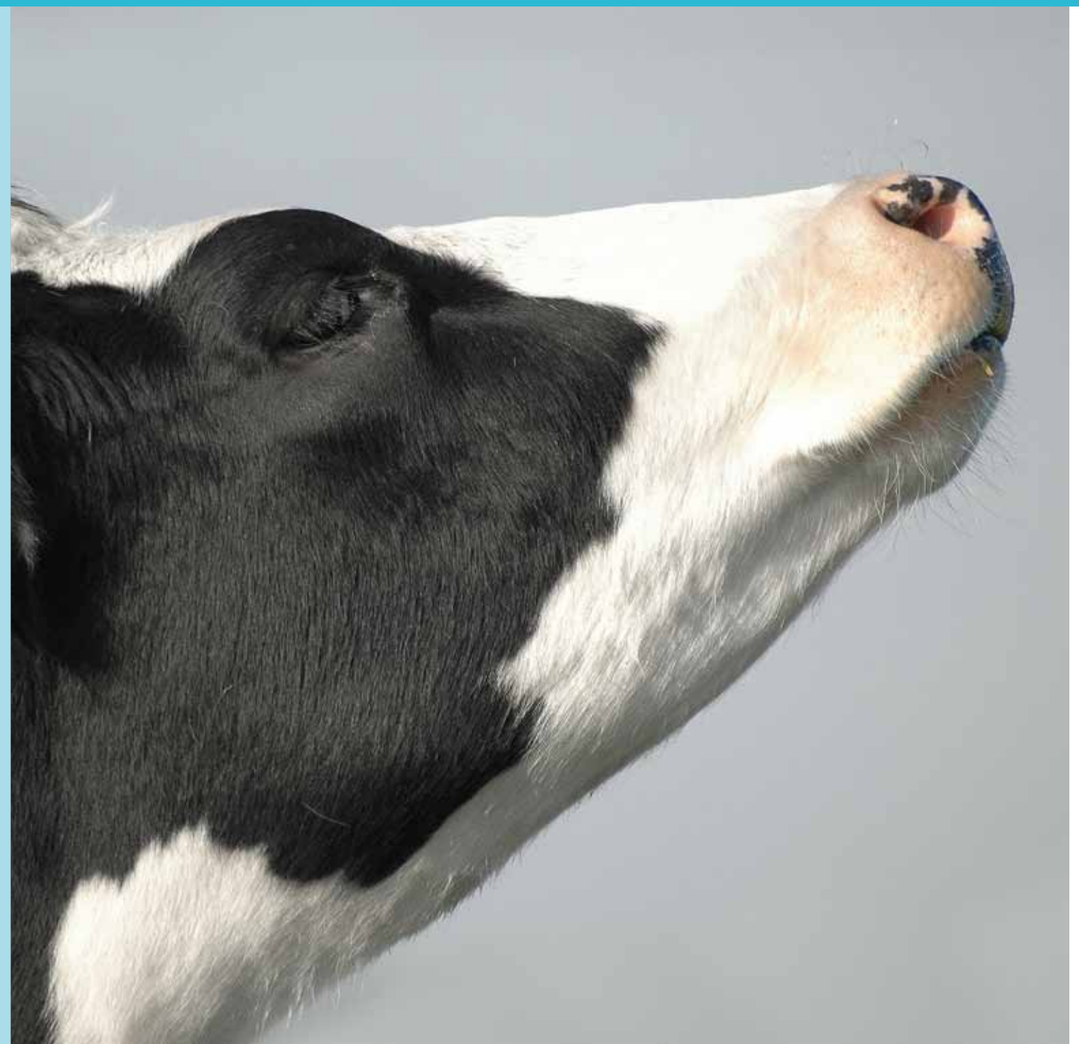
This book aims to present a comprehensive and up-to-date overview of the results of research and innovation in organic agriculture in the Netherlands. Not only will you read about the fields of research and the research results, the researchers involved will also share their approaches and views in this book. Moving beyond scientific results, this book will present examples of how the findings are brought into practice in close cooperation with farmers and other stakeholders. *Research on organic agriculture in the Netherlands* also provides an introduction into the unique structure and management of the cooperation between the organic sector, government and research organisations.

In the Netherlands, policy makers focus on developing knowledge and markets for organic agriculture. The budget available for research into all aspects of organic agriculture is one of the highest in Europe. All government-funded research on organic agriculture is brought together in a comprehensive research cluster in which Wageningen UR and the Louis Bolk Institute are the main partners.

Research on organic agriculture in the Netherlands covers a wide range of topics. From basic production factors such as soil and seeds, to food quality, health, animal welfare and economy. The organic sector in the Netherlands is, through the Bioconnect network, actively involved in setting the agenda for research and directing scientific projects.

Organic agriculture holds a myriad of possibilities for a sustainable and vibrant future. Research on organic agriculture raises questions that are relevant to all agriculture and can be a driving force for innovations. Dutch policy makers explicitly want research on organic agriculture to take a leading role. To show all agriculture a way to greener food production and a healthier living environment.

We hope this book may serve as an inspiration and invitation for everyone involved in agriculture and agricultural research all over the world. If you have questions, suggestions or would like to cooperate, don't hesitate contact us through the website www.OrganicHolland.com. For specific research topics you may also contact individual researchers whose references are mentioned in the book. Together we can achieve a sustainable and healthy future for agriculture.



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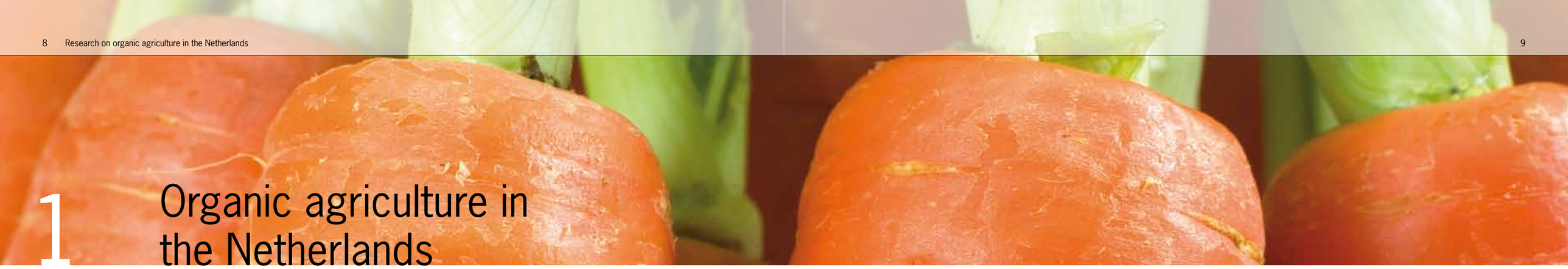


1 Organic agriculture in the Netherlands

Dutch organic agriculture has unique characteristics and peculiarities. It is still a relatively small sector compared to conventional agriculture in the Netherlands. However, its market share is growing and organic agriculture leads the way in terms of sustainability and innovations.

With a total surface area of about 4.15 million hectares, the Netherlands ranks among the smaller countries in Western Europe. With a population of 16.5 million in the year 2007, it is one of the most densely populated countries in the world.
The limited land area puts almost permanent pressure on rural areas, as these have to provide opportunities for economic production and transportation. At the same time, valuable nature areas and unique landscapes must be safeguarded for future generations.
Agriculture is an important sector in the Netherlands. Of the 3.4 million hectares of land surface, 1.9 million hectares is dedicated to agriculture. Costs for land and labour are high and therefore high productivity and good mechanisation are needed for farmers to be able to earn a living.

Organic acreage and plant production

Organic agriculture occupies a relatively small part of the total agricultural acreage in the Netherlands. With a share of 2.61 % (see Table 1), Dutch organic agriculture is below average compared to other EU countries. However, almost all organic acreage is highly productive.
High-value crops have a relatively large share in the crop rotations (see Table 2).
A large part of the organic area is grassland that is used mainly for dairy production. Feed crops are also grown mainly for dairy production. The dominant feed crop is silage maize. Cereals are used mainly because of their positive role in crop rotation and have a relatively low share in the farmers' incomes. Important cereals are wheat and barley. These are grown partly for human consumption and partly for animal feed.
Vegetable crops and potatoes are the most important cash crops in organic plant production. Principal vegetable crops are carrots, onions and cabbage species. A large part of the yield of these crops is exported to neighbouring countries. Greenhouse production is a very specific branch of organic vegetable production, and although it is very small in terms of area (70 ha), it has a very high economic value. Tomato, sweet pepper and cucumber are important organic greenhouse crops.
The main Dutch fruit crops are apples and pears. Scab-resistant apple varieties such as Santana and Evita are important organic fruit crops. Besides apples and pears, berries and wine grapes are grown.
In addition to these main branches of plant production, many other crops are grown organically, for example, ornamentals, flowers, bulbs and mushrooms.

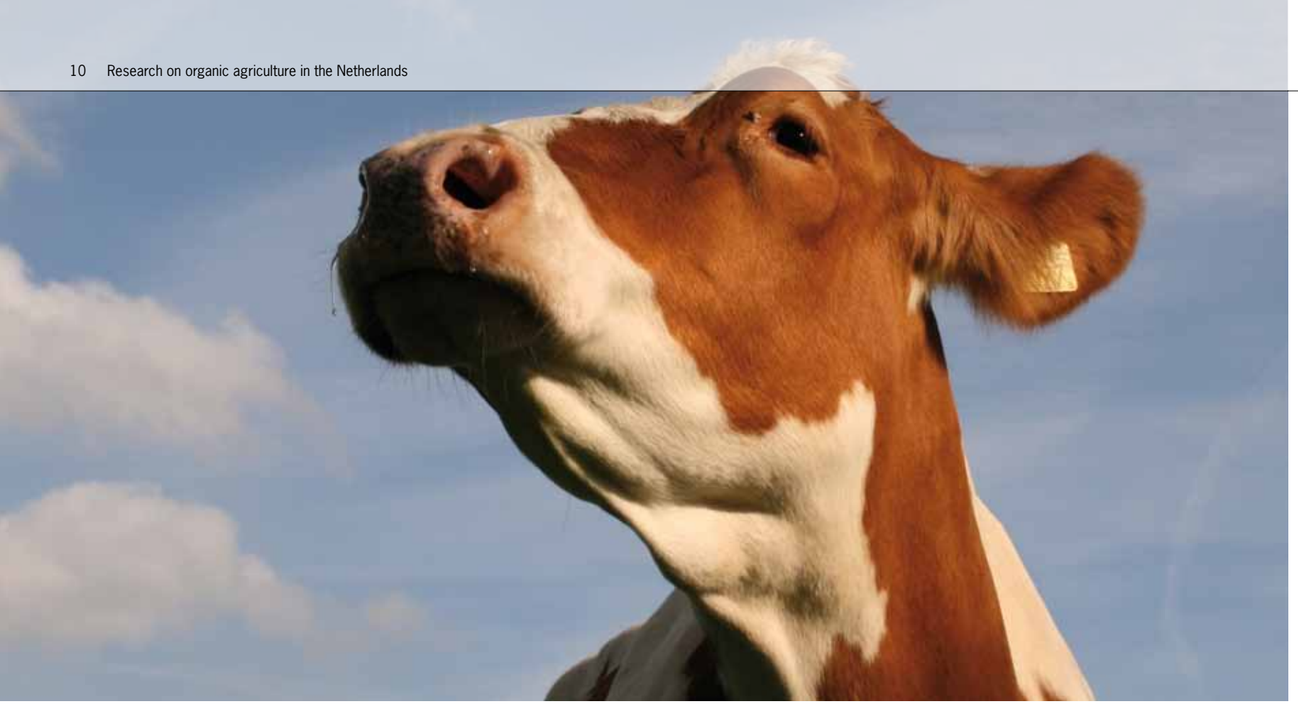
Table 1. Land area and number of organic farms in the Netherlands (2008)

Total agricultural area	1,929,274 ha
Organic agriculture	50,435 ha
Organic share of total agricultural area	2.61%
Number of certified organic farms	1,395

Table 2. Land use in organic agriculture (2007)

Total area organic agriculture	50,435 ha
Grassland	36,029
Cereals	5,092
Vegetables	4,200
Feed crops	1,305
Potatoes	1,270
Fruit	5464
Non productive*	737
Various	1,256

* The non-productive land is either fallow or cultivated with crops primarily grown for soil improvement



Animal production

Dutch people consume a lot of dairy products, and organic dairy has enjoyed increasing popularity. Most of the consumed dairy products come from dairy cattle. In the Netherlands there are approximately 16,000 organic dairy cows on 305 farms, with an average cow density of 1.77 per hectare. Moreover, there are about 60 organic goat dairy farms and 15 organic sheep dairy farms. Their produce is mainly exported.

About 170 farms produce organic beef. Dutch organic beef production is in steady decline, similar to conventional beef production. Consumer demand for organic beef, however, has shown steady growth. A large part of the organic beef that is sold in the Netherlands is therefore imported.

The number of organic pig farms has increased slowly in recent years, as has the number of pigs per farm. Currently there are approximately 65 organic pig farms in the Netherlands.

The number of organic laying hens in the Netherlands has increased strongly over the last few years, from about 405,000 in 2004, to almost 1 million in 2007. However, this still amounts to only 4 per cent of all laying hens in the country. Three-quarters of all organic eggs are exported to Germany.

Organic poultry meat is produced on only 10 Dutch farms, which together house about 55,000 birds.

Area remains constant with rising demand

Consumer demand for organic products has risen steadily over the last 10 years. In 2008, consumer spending on organic produce amounted to €583 million, a market share of 2.1 per cent. The product groups fruit, potatoes and vegetables, and dairy and eggs enjoy the highest market shares of 3.8 and 4.3,per cent respectively. The main sales channels for organic produce are supermarkets and specialised organic or natural food stores, with respective shares of 45 and 42 per cent of total sales.

Upcoming sales channels are the internet and the catering market. Sales of organic produce in the catering market have almost doubled from €23.4 million in 2007, to €46.1 million in 2008. A typical sales channel for organic produce is the so-called 'box scheme'. The latter entails a subscription plan where the consumer receives a box or bag containing an assortment of freshly harvested vegetables and fruit every week, for a fixed price.

Over the last decade, consumer spending on organic produce has grown 8.5 per cent annually on average. International sales of organic produce are also still increasing. However, since 2004, the number of organic farms has declined and the total organic acreage has almost stabilised. This development has caused a shortage in the supply of organic produce in recent years. Dutch conventional farmers are currently reluctant to convert to organic agriculture. An active campaign is now taking place to try to influence the views and attitudes of these farmers. Organic production needs to be considered more as an economically viable option for farm development.

Ambitions for sustainable development

The organic sector in the Netherlands is dedicated to the continuing sustainability of organic agriculture. The sector supports a long-term vision in which a top performance in sustainability is the goal. Based on this vision, ambitions have been formulated, which in many cases go much further than the current standards for certified organic production as described in EU regulations. Priority issues in sustainability are the following: animal welfare, a clean environment, climate-neutral production, on-farm nature and biodiversity, close connection with society and consumers, healthy, flavourful and safe food, 100% organic inputs and no depletion of resources. Following the recommendations of the organic sector, a substantial part of the agenda for research and knowledge circulation is dedicated to these ambitions.

Multifunctionality and connecting to society

Due to the dense population and competing claims for land in the Netherlands, there are opportunities for multifunctional land use and multifunctional agriculture. The organic sector in the Netherlands contains a very high number of multifunctional farms. Sixty per cent of all organic farms have activities in addition to primary production. This is three times higher than in conventional agriculture. Nature conservation is the most common side-activity, with 40 per cent of farms involved. Direct sales (30%), recreation (20%) and healthcare (12%) are other significant activities.

It is striking that organic farms are often specifically involved in activities that foster a closer connection between society and production. On organic farms, the general public is much more personally involved in the farm and in food production than on conventional farms.

Ambitious policy

Dutch policy actively supports the development of organic agriculture. The motivation for this support is the sector's strong performance with regard to sustainability, multifunctionality and social connections. A precondition is that organic agriculture connects with forerunners in sustainability in mainstream agriculture, and in this way promotes the exchange of knowledge. The government also challenges the sector to strengthen its connection with society.
The organic sector must continue with its own development. In the years to come, the Dutch organic sector should develop into a robust and independent sector, with a market share that increases by 10 per cent annually. Additionally, organic acreage should grow by 5 per cent annually. Knowledge and market development are considered to be the main driving forces for the growth of organic agriculture. Therefore, financial support from the government is focused on these aspects instead of direct financial support for organic farmers.
Market development is facilitated by the Taskforce Market Development for Organic Agriculture. An important objective of the Taskforce is to increase the sales of organic produce. This Taskforce organises consumer campaigns, supports retailers in their marketing efforts and promotes export and import of organic produce. Moreover, the organisation has a role in balancing supply and demand considering the current shortage in the supply of organic produce.
Another important way to encourage market development in organic agriculture, is effective cooperation between the parties in the chain. This cooperation is outlined in a formal agreement between chain parties. Chain management is a key element in the approach taken through this formal agreement. Acting as impartial discussion partners for all links in the chain, chain managers are encouraging greater efforts from businesses towards both consumers and other links in the chain.
Knowledge development is strongly directed at strengthening the innovative power of the sector. There is also ample attention to knowledge exchange and use of knowledge. The organic sector is, through the Bioconnect network, specifically involved in setting the agenda for knowledge development and exchange (see Chapter 3). To support knowledge development and exchange, there is a standard allocation to the organic sector of 10% of the budget for policy support research and statutory research tasks in agriculture.

Literature

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2 Dutch research on organic agriculture: approaches and characteristics

Dutch research on organic agriculture began in the late 1970s. Key characteristics of this research were the systems approach and the strong participation of farmers and stakeholders. The ambitions for a fully sustainable organic agriculture as formulated by the Dutch organic sector set the research agenda.

A short history

Dutch research on organic agriculture began in the late 1970s with the establishment of a national experimental farm to evaluate the potential of organic agricultural systems (the DFS in Nagele). During the same period, the Louis Bolk Institute in Driebergen (see Box) established a department for organic agriculture. Both initiatives were in response to the growing interest in organic agriculture as an alternative to conventional farming.

On the 72-hectare experimental farm 'Development of Farming Systems' (DFS), three farming systems – on a semi-commercial scale – were developed, implemented and compared from 1977 until 2002. The three systems were a bio-dynamic mixed system, an integrated system and a conventional arable farming system.

In the 1980s, virtually the only government-sponsored research on organic agriculture in the Netherlands took place on the DFS farm. In the 1990s, however, research on organic and integrated farming systems expanded into other regions and other sectors, such as nursery trees, vegetables, flower bulbs, fruit and dairy farming. Almost simultaneously, the interest in more thematic or disciplinary research into aspects of organic farming increased. These types of research were mostly carried out in the context of systems research or in cooperation with commercial farms. The Louis Bolk Institute expanded its work on organic farming, mainly in close cooperation with commercial farms, based on a participatory research approach.

At the end of the 1990s, national pilot farm networks were established in arable farming, vegetable farming and dairy farming. In these networks, commercial farms worked closely with advisors and researchers on the development of their farming systems. These efforts led to networks in other sectors, such as nursery trees, fruit, flower bulbs, poultry and pigs. Since that time, the network approach has become a much appreciated key element in Dutch research and development for organic agriculture.

Clustering research for organic agriculture

Since 2004, all public-funded research activities for organic agriculture in the Netherlands have been brought together in the so-called 'Cluster Organic Agriculture'. In this cluster, partners such as Wageningen UR and the Louis Bolk Institute work together on different research themes.
This makes the most efficient use of all available manpower and research facilities. This cooperative approach also brings together specialists in integrated research, even if they work for different organisations.

The agricultural-horticultural activities that characterise the Netherlands are very diversified and cover the entire spectrum of plant and animal production, including glasshouse production of flowers and vegetables, the production of seed and propagation materials (flower bulbs, seed potatoes, seeds, etc) and a whole range of nursery products. Dutch research on organic farming addresses all these primary production areas. It also addresses questions and issues related to the chain, from farm to consumer. Thematic areas for research are defined in consultation with the organic sector.

At present, the cluster comprises research programmes in the following areas:

- **Organic animal production**
- **Organic plant production (outdoors): arable crops, vegetables, fruit, wine, flower bulbs and nursery trees**
- **Organic greenhouse production: vegetables and cut flowers**
- **Aquaculture**
- **Robust organic propagation material and organic breeding**
- **Market and production chains**
- **Energy, climate and carbon sequestration**
- **Soil fertility**
- **Nature/landscape and multifunctional agriculture**
- **Policy-related issues**

The cluster coordinates the research and facilitates, initiates and fosters activities relevant to all themes. These activities include documentation and communication, scientific publications, international network participation and development, and cooperation with the conventional sectors. The communication is coordinated and supported centrally. One of the strengths of the cluster is its central website, which gives access to all research results from the cluster (www.biokennis.nl)

Wageningen UR

'To explore the potential of nature, to improve the quality of life'. This is the mission of Wageningen University and Research Centre (Wageningen UR). Wageningen UR has 6,300 employees and 10,000 students from more than 100 countries. Wageningen UR specialises in the field of 'healthy food and living environment' and works around the globe doing research for government agencies and the private sector.

The domain of 'healthy food and living environment' comprises three related core areas:

- **Food and food production**
  This concerns sustainable agriculture/horticulture and fisheries/aquaculture, international food chains and networks, health aspects of food and the use of biomass within the scope of a bio-based economy.
- **Living environment**
  This includes nature, landscape, land usage, adaptation to climate change, water and ocean management, and the various competing claims on space, along with biodiversity and the sustainability of management and production.
- **Health, lifestyle and livelihood**
  This has to do with the influence of people's behavioural choices regarding health, food and living environment, including the behaviour of consumers and citizens, their attitudes towards risk and uncertainty, their perception of quality and safety, and the relationship between food safety and poverty, particularly in developing countries.

Issues within this domain are almost never exclusively natural, technical or social in nature. There are always multiple approaches and possible solutions, often synergetic ones. Wageningen UR therefore fosters the unique interaction between the natural and social sciences. When formulating the research agenda, Wageningen UR cooperates closely with public authorities, the private sector, special interest groups, citizens and other universities and research institutes in the Netherlands and abroad.

Beginning in 2000, public-funded research was organised in a limited number of coherent programmes that were later combined to create what is now called the 'Cluster Organic Agriculture' (see Box). At the same time, the organic sector became structurally involved in governing the research of the cluster (see Chapter 3). The Louis Bolk Institute (see Box) and Wageningen University and Research Centre (see Box) work closely together within the framework of the cluster.

Louis Bolk Institute

The Louis Bolk Institute is a private organisation which offers research, advice and development in the field of organic and sustainable agriculture, nutrition and health care. It operates as a not-for-profit foundation, and derives all its income from contract research, project subsidies and donations. The Institute links social issues with pioneering research, and bridges the gap between scientific objectivity and personal involvement. Its strength lies in bringing different disciplines together, as exemplified by its broad range of researchers, including soil, plant and animal scientists as well as physicians.

Research at the Institute follows a participatory approach that is both practical and holistic. Experiential knowledge is used, and questions are considered within a wider context. The Institute collaborates with practitioners in the field, as well as with many institutes and universities at home and abroad. By considering social, economic and environmental factors, the Louis Bolk Institute contributes to a healthier future for soils, plants, animals and people. The Institute operates in the Netherlands, Europe, Africa and the Middle East. Its headquarters are in the Netherlands.

The Louis Bolk Institute is the natural source of knowledge for encouraging scientific research and providing new insight into organic and sustainable agriculture, nutrition and health care. Its researchers have been pioneers in this area since 1976. In December 2008, the advisory organisation Agro Eco became part of the Institute. By combining research and advice, the new Institute not only provides research, but also directs new knowledge towards practical solutions and applications.

The value of 'naturalness' in organic agriculture

Producers, traders and consumers of organic food regularly use the concept of 'natural' to characterise organic agriculture or organic food. Critics sometimes argue that this concept lacks any rational scientific basis and only refers to sentiment. The Louis Bolk Institute carried out research in 2001 to better understand the content and use of the concepts of 'nature' and 'natural' in organic agriculture. This research aimed to reconstruct the value basis underlying the use of the concept of 'natural' in organic agriculture and to understand the implications for agricultural practice and policy. A literature study and the authors' own experiences were used to produce a discussion document with concrete statements about the meaning of 'natural' in different areas of organic agriculture. These statements were validated by means of qualitative interviews with stakeholders. The concepts of nature or natural appear to be value-laden. The value basis is a normative reconstruction that cannot be derived only from the use of the word 'natural' by organic stakeholders. For this reconstructed concept, the term 'naturalness' is used. Naturalness thus becomes an ethical value for organic agriculture, an inspirational guide for organic stakeholders. The value of naturalness refers to basic respect for the intrinsic value of nature, meaning the value of nature is independent of the benefits it may provide for humans. This manifests itself in three ways: (1) the use of natural substances, (2) respecting the self-regulation of living organisms and ecosystems, and (3) respecting the characteristic and species-specific nature of living organisms. If organic stakeholders limit themselves to using natural substances, this is called the no-chemicals approach. If they also respect the self-organisation of living organisms, the authors call this the agro-ecological approach. If the normative element of naturalness is also included, this is called the integrity approach. Only when all three approaches are included can the full strength of organic agriculture manifest itself.

Developing organic farming: concepts, visions and system approaches

Dutch research has always been led more by the intentions and values of the organic sector than by formal rules, such as certification guidelines and government regulations. Organic farming has always been regarded as 'agriculture in development'. Striving to develop the full potential of the sector is a goal that Dutch organic farming research has set for itself.
The International Federation of Organic Agricultural Movements (IFOAM) formulated four leading principles to inspire the organic movement: health, ecology, care and fairness. These principles guide the IFOAM's development of positions, programmes and standards. In the Netherlands, a somewhat different set of concepts characterises the ambitions of organic agriculture: sustainability; environmentally-friendly; animal welfare; products that are natural, healthy and safe, and the connections to society, consumers and citizens. The concept of naturalness was studied in depth and made operational in a study commissioned by the Louis Bolk Institute (see Box and Chapter 6 for an example from plant breeding).

A second defining characteristic of Dutch organic farming research is the system approach (see also Chapter 4). This approach reflects the awareness that farm performance depends strongly on the interactions and interdependencies of various farming methods and various aspects of these methods. To fulfil multiple objectives in different domains, such as the environment, ecology and the economy, an integral approach towards the whole farming system is needed. The different methods have to be carefully geared to each other and the interactions optimised.
The Dutch research approach has always had an eye for designing, testing and improving farming systems. Simultaneous attention is given to the development of concepts and visions, as well as to the concrete development of feasible and effective strategies, methods and techniques. For crop rotation, for instance, the basic strategy including its practical implications, potential and challenges, was described and documented by Wijnands (1999).

The ambitions of the Dutch organic sector do not stop at the farm gate. Aspects such as climate change, biodiversity, nature, landscape and sustainable food production clearly transcend the farm's boundaries. Research therefore focuses on various system levels and on the entire food chain. Examples include the cooperation between various regional farms regarding the exchange of feed and manure, and the total food-chain approach for a better performance on fossil energy use and greenhouse gas emissions (see Chapter 4).

Participatory research, on-farm research and networks

A third essential element in the Dutch research approach is its strong cooperation with farmers. There are several reasons for this cooperation. The first is that farmers (especially the pioneers in organic farming) are considered important experts in this new farming approach. Their tacit knowledge is considered to be equally important as more formal knowledge. Tacit knowledge (in dealing with natural processes) comprises the farmer's complete set of practical experiences with the complex and local organic farming system. The confrontation between tacit and formal knowledge often leads to valuable new insights. A second reason is that private commercial farms provide excellent opportunities for on-farm experimental research.

The cooperation with organic farmers includes a great diversity of approaches. Forms of cooperation range from research on a single commercial farm concerning an isolated factor in the system (such as cultivar choice, fertilisation, weed control method etc), to complex innovations where multiple farmers, various stakeholders and researchers work together. Research projects often involve farmers and stakeholders in order to take advantage of the available expertise and experience or to consult with them on challenges and possible solutions. This often forms the basis for well-focused research efforts.

The network is a prevalent form of participation in Dutch organic farming research, where researchers and farmers work together – sometimes with other stakeholders – on well-defined challenges, such as antibiotic-free dairy production, soil fertility improvement, or developing niche products. Bioconnect is the network organisation for the organic sector (see Chapter 3). In this network, entrepreneurs in organic food and farming systematically participate in research project teams. This gives them the opportunity to take part in the governance of the projects.

Co-innovation is a specific type of participatory research. In co-innovation projects, entrepreneurs from the organic food chain work together with research organisations to realise new innovations (see Chapter 12). The entrepreneurs invest their own resources in these projects to match the public funding from the research institutes.

In these projects, the role of the researcher is determined by what is needed in terms of content and process. The researcher's role therefore varies between expert, researcher and facilitator. The role of facilitator includes bringing together the relevant partners and attending to their questions and needs. It also means facilitating interaction and cooperation by creating the optimal conditions necessary for a joint search for possible solutions to complex problems.

Research approaches: a methodological overview

In organic agriculture research, different approaches and methodologies are often used simultaneously or sequentially. Baars (2002) developed a coherent model that clarifies and positions various research approaches in their mutual relationships, against the background of concepts from science and philosophy. The basis is a four-quadrant figure developed by Miller (1985) and further adapted by Bawden (1997) and Röling (2000).

Descriptions per quadrant

1 In quadrant 1, traditional causal-analytical research into isolated elements or aspects of systems is dominant. The researcher has a neutral and detached 'modus operandi' using verifiable and falsifiable research techniques. Regular mono-factorial research fits here. This is very useful for unravelling mechanisms.

2 In quadrant 2, the object of study is the whole system. Research approaches that deal with the system level fall into this quadrant. Farming systems research (prototyping) and agro-ecological approaches are examples. Systems in their context are at the centre of attention, the relationship between the constituting parts and the properties of the system as a whole are studied at each level. The approach is that of 'hard systems' research. In many cases the same methods are used as in quadrant 1. The researcher has more or less the same 'modus operandi'.

3 In quadrant 3, the system level in its context is still the focal point. In this quadrant, however, we deal with the way in which people create, interpret and maintain systems in interaction with others. Reality is multilayered and open to different interpretations. It is a social construction: people play a role in the interpretation of the world, people are involved. This quadrant deals

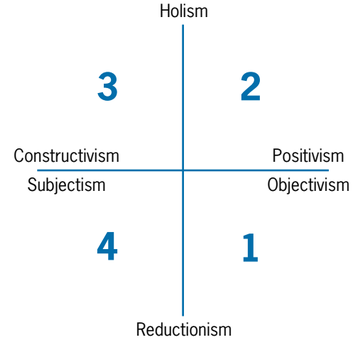

Figure 1.
Different scientific paradigms as a basis for the distinction between different research approaches (Baars, 2002)

with human behaviour, the values involved, learning and negotiation processes. In this quadrant, predominantly 'soft' system approaches are used and connections are made between natural and social sciences. The research process itself is often also the object of study. In this case, the researcher is part of the research process.

4 In the fourth quadrant, personally-inspired participation in the surrounding world is what it's all about: situational behaviour based on local knowledge (which was gained in the real world) and an understanding of the best possible action. Baars introduced the term 'experiential-science' (also known as action research). The attitude of the researcher strongly affects the choice of the topics to be studied and the framework of interpretation that will be used. The researcher takes co-responsibility for the actions taken. This quadrant deals with elements of the system in the action as well as in the reflection.

In Dutch research on organic agriculture, research quadrants 2 and 3 are strongly represented. Quadrant 1 research will always be needed to unravel mechanisms, to study system components, to design new routines, to determine causal relations and so on. However, elements or components of systems that were studied in isolation have to be fitted into a system. This requires systems research. The system context, with it multi-objectives, will often reveal new problems in the interaction with other system components. Adaptations to these components are frequently needed. Consequently, organic farming research continually shifts back and forth between the different approaches and between holism and reductionism. It involves constant commuting between analysis and synthesis, on both the component and system levels.
The attitude of the researcher also has to shift between positivism and constructivism. When the system is part of society and the search for solutions is conducted with a number of partners, the researcher also gets involved on a more personal level. This means the researcher will also shift back and forth between detachment (observing) and involvement (participating), and between tacit and formal knowledge.

Developing relevant knowledge in cooperation with farmers and other stakeholders

In organic farming, the linear model of knowledge development was never really embraced. In the linear model, knowledge is developed by research institutes and subsequently disseminated by the extension service, leading to the adoption of new techniques by farmers (for example, the conventional agriculture 'miracle model' of the period following World War II). In contrast, most organic research takes an approach where cooperation with farmers is a crucial element, as was described earlier. This approach enables different perceptions of problems and solutions and different types of knowledge and expertise to confront one another and to interact, thus creating knowledge circulation. This confrontation optimises the chances for innovation. Additionally, it ensures that the developed solutions or innovations are sufficiently feasible and effective in the context of the practitioners. Knowledge development is increasingly tailored to the specific needs of stakeholders. In the context of the future application, knowledge is co-created together with the relevant stakeholders.

Inspiration for increasing sustainability in agriculture

Organic agriculture is developing in response to its self-chosen ambitions and the differing views of stakeholders in the sector. In practice, the search for new and innovative approaches continues to strengthen the economic, technical, social and ecological performance of organic enterprises and chains. As described in this book, research organisations are working closely together with the organic sector on the continuing development of organic farming.
The innovations realised by organic agriculture do not stand alone. In conventional agriculture, the need to become more sustainable is also becoming apparent. In many ways, stakeholders and farmers are looking for new approaches, methods, concepts and markets. As a result, conventional and organic farming have more and more challenges in common. New approaches from organic farming can be very useful in conventional farming, and vice versa. The Dutch government is very keen to foster this cooperation. Sustainability concerns us all. It is not solely the domain of organic farming. But since organic farming has already made the choice for sustainability, its 'personality' will continue to inspire people.

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3 Dutch knowledge infrastructure for organic agriculture

Stakeholders in Dutch organic agriculture have a very strong voice in determining the research and knowledge agenda. An innovation network called Bioconnect has been established to act as an intermediary between research and the knowledge demand of the organic sector. Through Bioconnect, the government has delegated decision-making about research-projects to the end-users of the research. The positive interaction between all parties in the network leads to successful and fast innovation.

Let the users decide which knowledge is needed! This is the main idea behind a unique network for research and development governance in organic agriculture in the Netherlands. This network, called Bioconnect, functions as an instrument to improve the effectiveness and relevance of research by creating full participation of industry and farmers in projects. Bioconnect facilitates the planning, funding, monitoring and user participation in Dutch research and knowledge transfer for organic agriculture. In addition, it serves as a platform for discussion, a sounding board for opinions, a link between commercial agro-food chains and policymakers, and as a social network.

Although Bioconnect has only been in existence for a few years, notable results have already been achieved. Research is increasingly tailored to the needs of the organic sector. The overwhelming enthusiasm with which this new approach to research governance has been received is a strong incentive for the further development of this type of cooperation for innovation. The main organic processors and approximately 50% of the farmers are involved and connected in one way or another.

Supportive government policy

The Dutch government has clear objectives with respect to agriculture in general, and to organic agriculture in particular. Its policy is directed toward sustainability, and the organic agricultural sector is presented as a 'best practice' and source of inspiration. The Dutch government's objective for the entire organic sector is a 10% annual increase in consumer spending and a 5% annual increase in the area under cultivation. To support knowledge development and exchange, there is a standard allocation to the organic sector of 10% of the budget for policy support research and statutory research tasks, which amounted to a total annual budget of €9.6 million in 2008.

To achieve greater input, involvement and ownership from the users themselves, a new type of governance for research, knowledge development and transfer was introduced in 2005. This change was proposed by Biologica, the organisation which represents the interests of the organic sector in the Netherlands. From 2005 onwards, the government delegated the responsibility of setting the research agenda for organic agriculture to the stakeholders. The government thereby established the framework and, as much as possible, left implementation to the network of stakeholders, which is called Bioconnect. The government is involved as a participant in this network and is the initiator of strategic research for policy aims. The network is being financed through public funding until it is capable of standing alone in 2011. The government considers Bioconnect to be a pilot project. Does this type of delegation of research governance to networks work? Ultimately the same type of networks could be created for other areas of public-funded applied agricultural research.

Framework of Bioconnect

The heart of the innovation network is formed by the Thematic Working Groups (TWGs) or Product Working Groups (PWGs). These groups are organised according to different market sub-sectors (such as dairy production, arable farming, glasshouse horticulture), or according to important themes (such as plant breeding and seeds, multifunctional agriculture, market and chain). Farmers, suppliers, processing companies and manufacturers in the agro-food chain are all represented in these working groups. Representatives from research, consultancy and the government also take part in these groups in an advisory capacity.
Within specific themes (each earmarked with a certain budget), the TWGs and PWGs can decide which particular topics they want researched. Their representatives from farming and industry are expected to propose topics based on a broadly shared demand from their grassroots. Each working group has set their ambitions, and subsequently their activities, for the long term to achieve their goals.
Every TWG and PWG reports their suggested package for research and knowledge transfer to the Bioconnect Knowledge Committee. This committee, which is made up of representatives similar to

the various actors involved in the TWG or PWG, coordinates and balances the total research package. The Committee checks compliance of prioritised research proposals with long-term programmes and budgetary requirements. The Knowledge Committee advises the financier (the Ministry of Agriculture, Nature and Food Quality) about the total research package that is to be carried out.

Each research project is directed by a project team in which representatives of the relevant stakeholders take part. In this way, a participative approach is guaranteed. For every PWG or TWG, a knowledge manager takes the role of facilitator. This knowledge manager streamlines the information flows and mediates between the different groups of actors involved.
In addition to their role in research and knowledge transfer, the Bioconnect working groups have developed a long-term vision about the future of organic agriculture in the Netherlands. Ambitious targets have been set for a wide range of topics, including improving animal welfare, improving biodiversity on every farm and climate-neutral production. Based on this long-term vision, the TWGs and PWGs are not only capable of setting the research agenda, but also the agenda for improving legislation and implementing market strategies. Moreover, this long-term vision prevents them from focusing only on short-term bottlenecks.
Because of their expertise and status, the Bioconnect working groups also operate as a sounding board and advisory board for various matters concerning organic agriculture. By request or on their own initiative, the Bioconnect working groups give advice on topics such as market strategies, policy regarding organic agriculture and legislation. Discussions focus specifically on regulations involving the certification of organic production. Although the Bioconnect working groups have no formal role in these themes, their opinion is taken seriously because of the network's expertise and status.

Knowledge circulation

Bioconnect also takes responsibility for the dissemination of knowledge concerning organic agriculture. This involves knowledge transfer to farmers and chain partners, as well as to the agricultural education system. In knowledge circulation among farmers, an important role is played by farmer networks. These are mostly regional networks which are organised according to a sub-sector or theme. In these farmer networks, farmers meet on a regular basis and exchange knowledge and experience. They organise farm visits, excursions and on-site knowledge exchange. The groups are facilitated by a professional advisor, and there is regular input from researchers. The farmer networks are also a source of information for the TWGs and PWGs about current bottlenecks, new developments in farming practice or common opinions held by a large group of organic farmers.

The backbone of knowledge transfer is the communication service called BioKennis. The website www.biokennis.nl provides access to all publications and news items relevant to Dutch organic agriculture. For the international exchange of information, the website www.organicholland.com has been set up. BioKennis utilises various forms of media that were developed according to the wishes of the end users. Its products are news bulletins, e-newsletters and brochures containing practical information about various topics. These knowledge products are tailor made and adapted to the information needs of the users.

Bioconnect: the facts

Bioconnect is a network of actors in organic agriculture. Its primary task is to govern research, development and knowledge circulation in organic agriculture. The formal commissioner and financier of the agricultural research initiated by Bioconnect is the Dutch Ministry of Agriculture, Nature and Food Quality. This governmental body has delegated the tasks of research governance and knowledge circulation to Bioconnect, but is still the financier and remains intensively involved as a participant in the network.

Thematic and Product Working Groups

The Thematic and Product Working Groups are the heart of the Bioconnect network. A Product Working Group focuses on a group of products (such as beef, dairy or fruit), and a Thematic Working Group focuses on a certain theme (such as soil fertility). Bioconnect currently has fourteen product and thematic working groups. These groups are composed of representatives of the various actor groups in the organic food chain: farmers, chain partners, advisers, researchers and the government. A thematic or product working group gives advice on the research and knowledge transfer needed for their topic.

Knowledge Committee

The Bioconnect Knowledge Committee coordinates and balances the total research package of the various product and thematic working groups. It advises the Ministry of Agriculture, Nature and Food Quality about the desired research package, about new topics and about the allocation of funds between research themes.

Knowledge manager

The administrative and coordination processes for every working group are supported by knowledge managers who are facilitated by Biologica. They are the secretaries of the working groups and act as information brokers between research contractors/service providers and users to stimulate dissemination and uptake of research results. Moreover, they play an important role in matching the activities in the short term with the long-term ambitions of the working groups.

Farmer networks

Farmer networks are the 'roots' of Bioconnect in the day-to-day entrepreneurial activities and are an integral part of the total network. These groups of farmers –mostly regional – are an important tool in knowledge circulation. They act as platforms for the exchange of practical knowledge and experience and for the dissemination of research results. Experiences, research questions and bottlenecks are reported to the product or thematic working groups.

Submission of ideas

Ideas for research and other activities are submitted to the working groups by farmers and the other network partners. With regard to research projects, the working group commissions researchers to develop the relevant proposals, and then decides which proposals are eligible for implementation.

Rapid exchange of knowledge and experiences

The Bioconnect network links organisations in various ways and at all levels. All of these organisations make use of Bioconnect to test ideas, learn from others' experiences, distribute knowledge and express opinions. The network offers a way to rapidly exchange knowledge and experiences.

List of Product and Thematic Working Groups

Product Working Group	Knowledge Manager	Contact
Arable crops and field-grown vegetables	Marian Blom	blom@biologica.nl
Greenhouse vegetables and mushrooms	Mari Marinussen	marinussen@biologica.nl
Flowers and flower bulbs	Mari Marinussen	marinussen@biologica.nl
Trees and ornamentals	Maaike Raaijmakers	raaijmakers@biologica.nl
Fruit and wine	Marian Blom	blom@biologica.nl
Dairy and beef	Clemens Oude Groeniger	oude.groeniger@biologica.nl
Pork	Clemens Oude Groeniger	oude.groeniger@biologica.nl
Poultry and eggs	Clemens Oude Groeniger	oude.groeniger@biologica.nl
Aquaculture	Mari Marinussen	marinussen@biologica.nl
Thematic Working Groups		
Soil fertility	Sjors Willems	willems@biologica.nl
Propagation material and plant breeding	Maaike Raaijmakers	raaijmakers@biologica.nl
Energy and greenhouse gasses	Mari Marinussen	marinussen@biologica.nl
Biodiversity and landscape	Sjors Willems	willems@biologica.nl
Multifunctional agriculture and direct sales	Sjors Willems	willems@biologica.nl
Markets and chains	Arjan Monteny	monteny@biologica.nl

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4 Sustainable systems

To put sustainable agriculture into practice, the organic food chain should be considered in its entirety. Such is the vision of the Dutch organic sector. By emphasizing this holistic view, organic farmers can make a significant contribution to increasing the sustainability of agriculture. Through systems research, scientists are analysing environmental performance and trying to find system solutions for the challenges faced by Dutch organic agriculture.

Organic agriculture has many objectives besides producing food and providing an income for the farmer. It also aims to prevent the depletion of scarce resources, minimise losses to the environment and has social and ethic objectives. Organic agriculture strives towards a sustainable food production system. To realise all - apparently conflicting – objectives, the food production system needs to be considered as a whole. Dutch research in organic agriculture therefore studies the food production system on various integration levels such as geographic scale (region, country, world). Also, the total food chain from the farm inputs to the consumer, is considered.

The level of the entire farm is a system level that has been studied intensively in the Netherlands. “Making organic farming systems resilient and sustainable is an important goal of our research”, says Wijnand Sukkel. He coordinates the research themes ’System Innovation’ and ’Climate Change’. The holistic approach is an integral part of Dutch research in organic agriculture. Scientists have a number of organic experimental farms and farming systems at their disposal; from animal husbandry to plant production.
Farming systems and methods are also tested and improved on working farms. Groups of organic farms in a region are considered together when the life cycles for feed, manure, nutrients or organic matter need to be closed. The objective is not only a closed cycle, with a minimum of undesired losses, but also a balanced cycle where no accumulation or depletion in certain stages of the cycle takes place. The phosphorus cycle, for example, is a cycle that tends to be unbalanced.

Climate change in relation to agriculture is a typical topic that has to be studied in a total system approach. The use of fossil energy, the emission of carbon dioxide, nitrous gas and methane, the amount of organic matter in the soil and adaptation to climate change are all linked closely together. When looking more specifically at greenhouse gas emissions, the whole food chain has to be considered. Not only the primary production counts. Transport, processing, retailing and consumer behaviour also play an important role. By calculating the carbon footprint or carrying out a Life Cycle Analysis (LCA) for several organic product chains, insight is gained in the strong and weak points of organic production.

Wijnand Sukkel

“Making organic farming systems resilient and sustainable is an important goal of our research”

Wijnand Sukkel

Taste of tomorrow

In the 'Taste of tomorrow' project researchers are experimenting with arable farming systems that are based on sustainable crop protection and in line with expectations for Dutch agriculture in 2030. By then, farms in rural areas are expected to still be production-oriented, while farms in urban peripheries will engage more in experience-oriented agriculture. Experiments with both integrated and organic systems now take place. They contribute to optimal 'cross-pollination' between the two cultivation systems. The timeline for design, testing and improvement of these systems is 5 to 10 years. The research focuses on: (bio)diversity in time and space, controlling weeds, pests and diseases, soil management and high-tech agriculture. High-tech applications involve combinations of ICT, sensory techniques and GPS. These techniques are for example used for recognition and control of weeds, pests and diseases and for so-called Controlled Traffic Systems. The main objective has been to prove the principles; economic feasibility has not been a high priority thus far. In the context of this project, researchers are also working with the city of Almere, the fastest-growing city in the Netherlands. Together they aim to find new forms of sustainable urban agriculture that involve urban residents more closely with food production.

Farming systems

Right from the start, Dutch research in organic agriculture has placed much emphasis on the development of farming systems. For the past 30 years, since 1978, various systems on the experimental farm in Nagele have been tested. DFS Nagele is known internationally for its multiyear comparative research into three arable farming systems: integrated, organic and bio-dynamic. Improving farming systems entails fitting together various pieces of the puzzle and adjusting the farming system in order to achieve multiple objectives. Aspects such as the improvement and maintenance of soil fertility, the use of manure, prevention of mineral leaching, control of pests and diseases, the quality of the products and the economic results are considered together. This means investing in healthy soil, crop rotation, biodiversity and all kinds of other measures to stimulate a sustainable and high quality production. The individual aspects do not stand alone, but have to be mutually supportive and thoroughly integrated in the farming system.

In looking for more long-term answers at arable system level, experimental farming systems are being tested. In the project 'Taste of tomorrow' (see Box), two systems are tested, one focused on (functional) biodiversity and consumer-producer relationships and the other on the combination of organic agriculture and high-tech applications. High-tech tools can be very useful to organic agriculture in helping to reduce costs or raise yields. This usefulness explains the current research emphasis on high-tech tools such as GPS systems, Controlled Traffic Systems and weeding robots with image recognition.
Another experimental system called 'Nutrients Waterproof' (see Box) focuses on soil health and nutrient emissions. Additionally, experiments with so-called multifunctional agriculture have been set up. These involve encouraging agrobiodiversity and combining agriculture with landscape maintenance and social functions.

Nutrients Waterproof

The 'Nutrients Waterproof' project is looking at developing, among other things, organic farming systems that release a minimal amount of nutrients (nitrogen and phosphate) to ground and surface water. The project follows the European Nitrate and Water Framework Directives. Nutrient leaching is a serious problem in open field cultivation, and it is difficult even on organic farms to satisfy the current and projected norms for water quality. This means that nutrient losses in organic open field cultivation have to be reduced. Conditions that have to be met in developing these systems include safe-guarding high-quality production, use of organic fertilizer (manure or biodegradable refuse), and maximal closure of cycles. Increasing nutrient efficiency per product unit is especially important in the organic sector. Since the problems being studied are complex, a systems approach focusing on the medium term of ten years was chosen. Four farming systems, including one organic system, were set up in 2004 at the experimental location Vredepeel (on sandy soil in Northern Limburg). The project's focal points are: cleaning drain water with natural filters, optimal management of organic matter; composting or co-fermentation of crop residues and industrial waste; and guided fertilisation systems and location-specific fertilisation within plots. So far, only the organic system has satisfied the leaching norm.

Environmental performance

Dutch farmers are faced with relatively high costs of land and labour. This means they need a high added value to make farming economically viable. Surprisingly organic agriculture in the Netherlands performs better on most environmental aspects than conventional agriculture, even though Dutch farming systems have a relatively high intensity of production. Based on many studies, a large volume of detailed farm registries and measurements taken on farms, the environmental performance of Dutch organic and conventional agriculture was evaluated. The environmental impact of pesticides is almost nil on organic farms. Dutch farmers use organic pesticides only incidentally. On average, organic farms also emit a lower amount of nutrients into the environment and create a higher biodiversity compared to conventional farms. The variation between individual organic farms is nevertheless very high. The challenge for the organic sector is to improve the performance level of the 'worst cases'.
The state of the art of Dutch organic farming with regards to climate change has also been studied (see Box 'Energy use and greenhouse gas emissions'). In this respect Dutch organic agriculture performs better than or as well as conventional farming systems.
The study provided insight in the strong and weak points of the organic sector with respect to fossil energy use and climate change. Researchers and farmers now work together on developing, testing and implementing measures to further reduce fossil energy use and emission of greenhouse gasses.
Another positive environmental effect of organic production is that it adds a relatively high amount of organic matter to the soil (see Box 'Carbon sequestration'). The sequestration of organic matter in the soil helps preserve soil quality and improves resilience to extreme weather conditions.

Energy use and greenhouse gas emissions

In most cases, the organic agricultural sector in the Netherlands performs better than the conventional sector when it comes to energy use and greenhouse gas emissions per hectare. To quantify this difference, a comparative study was conducted in 2007. The study looked at a number of model farms involved in dairy farming and open field crop cultivation. The model farms were chosen specifically to reflect the Dutch organic farming practice, and the study inputs were based on a large set of registries of commercial farms. The situation for dairy farming is the most straightforward. The organic farms have lower greenhouse gas emissions, both when calculated per hectare and per ton of milk. The organic dairy farms' emissions of greenhouse gasses expressed in CO_2 equivalents are 40 per cent lower per hectare than those of conventional farms. This is largely due to the more extensive production, but expressed per product unit, the difference is still 10 per cent. In open field cultivation, the emission of greenhouse gas per hectare is also lower on organic farms. The results vary considerably between crops. Leek has a relatively high emission, while that of carrots is relatively low. Organic plant production emits as many or a little more greenhouse gas per kilogram of product, compared to products from conventional farms. This is largely due to the 20 to 30 per cent lower yield, which in the Netherlands is caused mostly by pests and diseases.

100 per cent organic

"Current organic practice in Europe is not yet completely in line with the ambition of organic agriculture to be a locally or regionally based sector without inputs from conventional agriculture", suggests Udo Prins, researcher of organic systems and feed production. In this context a study has been done on close cooperation between different production sectors in organic agriculture. This study provides an inventory of possible ways to make the Dutch organic sector self-sufficient in the use of inputs such as manure, feed and straw. At present, Dutch organic agriculture is still partly dependant on conventional inputs. An important reason for this is the high degree of specialisation of organic agriculture in the Netherlands. This is caused in part by the agricultural limitations of certain regions. Peaty lowlands, for example, are not well suited to crop cultivation and are therefore traditionally dominated by livestock farms. Moreover, most farms were already highly specialised before switching to organic production and, within the boundaries of the legal guidelines for organic production, partly remained so afterwards. Specialisation can also be an advantage because of the high level of expertise that is needed to accomplish an economically viable organic production. Thus we find several cases in which there are two entrepreneurs on one farm: one who focuses on animal production and one who specialises in arable farming.

The Dutch organic sector believes it is important, to gradually phase out the use of conventional manure and straw. In addition, raw materials for concentrates should come from the livestock farmer's own farm or the immediate area rather than from some other part of the world. Therefore, the organic sector encourages research into the development of more closed cycles and a higher degree of self-sufficiency.

Carbon sequestration

Organic arable and vegetable cultivation add more organic matter to the soil than their conventional equivalents. This was revealed through analysis of large sets of registered farm management data from the Dutch organic and conventional farmers' networks. Carbon sequestration in agriculture is a relevant factor in climate change. Organic farms in the Netherlands annually add 400 kilograms more organic matter per hectare than conventional farms. According to model calculations, however, this is still insufficient to compensate for the decreasing carbon content of the soil. Calculations suggest that the carbon content of organically farmed soil will decrease in 25 years by 7.5 tons per hectare. In conventionally farmed soil it will decrease by as much as 11.7 tons per hectare. Better soil management and an increase in the use of green manures are needed. Especially in winter, too many fallow periods occur. Researchers are focusing on how this problem could be handled. One direction scientists have taken is to make use of knowledge and experiences from conservation agriculture. Reduced tillage, ridge tillage and direct seeding are all currently under investigation.

Eventually, decreasing dependence on conventional agriculture for manure, feed and straw and on foreign imports for feed would lead to shortages in the mineral balances of several sectors. The minerals found in products that go from farm to market, are lost to the farm's nutrient cycle. This 'mineral leak' is not compensated for at the moment.
"We have to think about which external sources are appropriate for organic agriculture and sufficient to compensate for this loss" says Udo Prins. Feasibility studies now look into ways to return residuals from society and the food chain, such as composts and human waste.
In the short term, improved cooperation between organic field crop and livestock farmers, coupled with optimisation of operations within these cooperative efforts, would already do a lot to improve the situation.
To further optimise alliances or linking enterprises between field crop and livestock farmers, scientists have been cooperating with a range of working farms since 1998. By cooperating with each other and exchanging products, specialised farms can start functioning as linked but separate units which together make up a mixed farming system.

The food chain

Research into sustainable systems also includes the entire food chain. Approximately one third of the chain's energy use, for example, can be attributed to primary production. The remainder is used further up the chain during processing, transport and consumption. Product spoilage alone can already cause a considerable increase in energy use and greenhouse emissions per kilogram of product. Together with chain actors scientists are therefore looking at the carbon footprint of products. This research provides chain partners with possible measures to curb greenhouse emissions and energy use. The transport phase is not only responsible for the use of fossil energy but also for the emission of particulate matter, claims for space, traffic accidents and noise. Transport of food by consumers is an important factor in the transport distance per unit of product. A well-designed total distribution system should therefore also take the consumers' kilometres into account. Alternative ways to organise the food distribution system are currently being studied. One example is an internet system through which products can be ordered straight from the farm and home-delivered or transported to distribution centres close to the buyer's home.
Also, opportunities exist to make better use of by-products and food residuals. Vegetable by-products can either be used again for human consumption (see Chapter 13) or for cattle feed. In case the quality of the by-products is too low, they can be composted or fermented, and this can be done at the firm or regionally. Current research is also looking into these options. Much can still be gained at this stage of the product cycle.

Regional approach: 'Echt Overijssel!'

**In close cooperation with social partners, researchers and farmers are working on a project called 'Echt Overijssel!' ('Truly Overijssel!', Overijssel being a province of The Netherlands). The project focuses on profitable organic chains with cycles closed on a regional level. The project also strives for far-reaching integration of agricultural production with social objectives related to nature and landscape. By working towards greater biodiversity in existing agro-ecosystems, a contribution is made to the preservation or restoration of landscapes with a high cultural or historic value and to the protection of rare and endangered native animal and plant populations.
In addition to striving for 100 per cent organic feed and manure, the organic agricultural sector is looking to develop regional supplies of these inputs. This could help improve the local mineral balance and lower energy use. To make sure that the contributions to agro-biodiversity and the closing of regional cycles are also economically profitable, the project is following three lines of research. First, efforts are being made together with a regional marketing organisation, the Dianthus Foundation, to develop and market products with added value in short chains. Together with Natuurmonumenten, one of the largest managers of nature areas in the Netherlands, efforts are also being made to combine sufficient-quality agrarian production with sponsored nature and landscape management. New strategic cooperative alliances are also being sought.**

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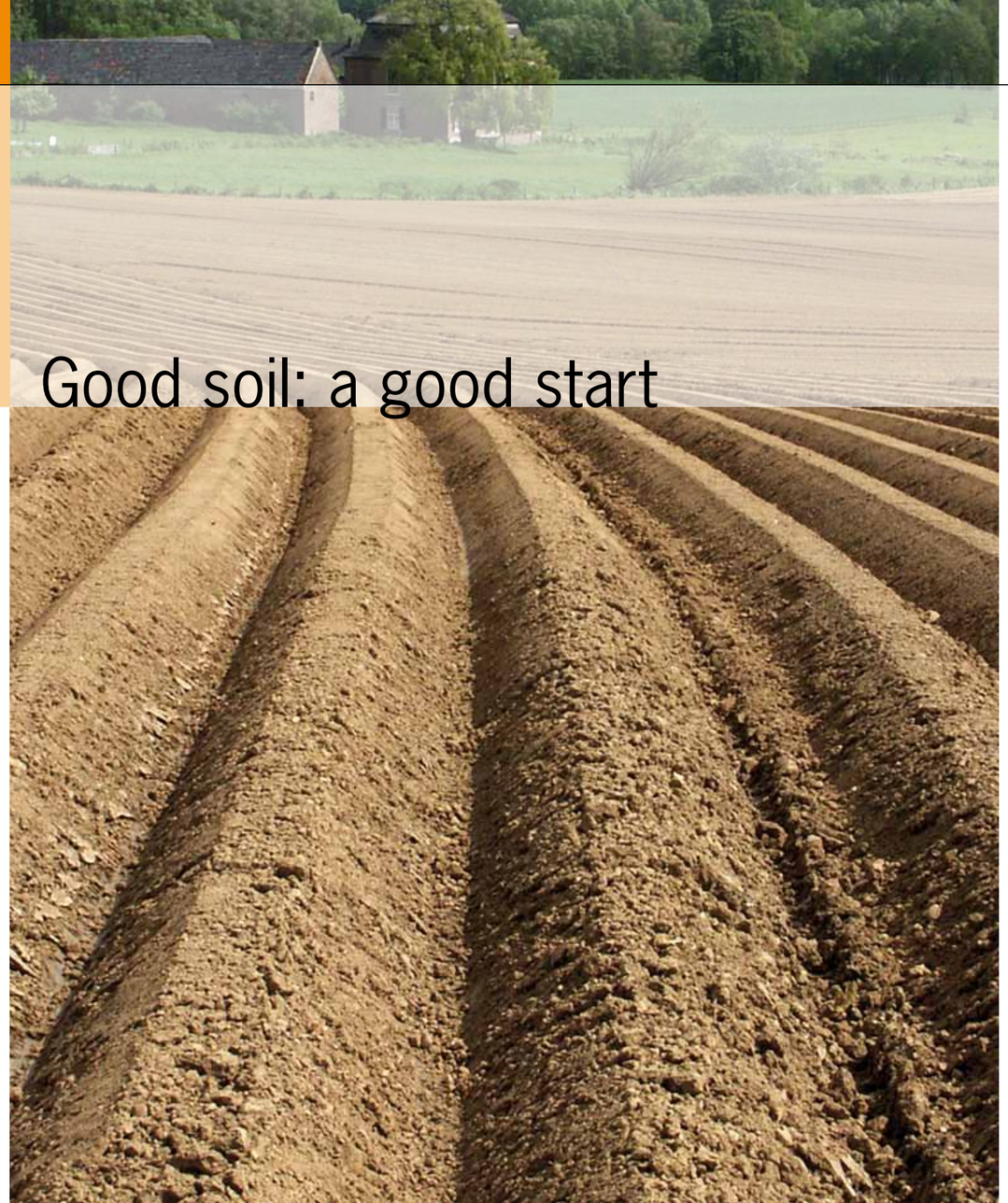
5

Good soil: a good start



Soil plays a central role in plant production and the environment. Organic growers depend on the soil's natural richness and resistance to disease. In order to foster these essential qualities, farmers and researchers are looking at ways to stimulate soil life, optimise soil structure and close nutrient cycles.

Henk van Reuler

Agriculture in the Netherlands commonly takes place on wet clay soils, sensitive to structural degradation, and on poor sandy soils. Root crops make up an important part of Dutch crop rotations, even though the heavy mechanisation required for these crops can harm the soil structure. Since the soil represents organic farmers' greatest asset, they have to practice extremely careful soil management.

To a large extent, the environmental impact of agricultural production involves processes that take place in the soil. Soil plays an important role in the loss of nutrients, storage of carbon in organic matter, emission of greenhouse gases and accumulation of undesirable substances. A sufficiently high level of organic matter in the soil, minimisation of nutrient losses to the air and water, and preservation of good soil structure are therefore important and strongly interrelated objectives of organic farmers. These objectives are based on the organic principles but also on the EU and national policy for the minimisation of nutrient losses to the environment. Achieving them requires a precise combination of crop rotation, fertilisation and mechanical soil management. Farmers and researchers work closely together to develop an integrated system for sustainable soil management.

Soil fertility

Current research on soil fertility focuses on fertilisation, organic matter management and closing of mineral cycles. An important aspect of closing the mineral cycles is minimising nutrient losses to the environment. "Organic agriculture is directed toward sustainable soil management and the long-term preservation of soil fertility", explains Sjef Staps, coordinator of the research on soil fertility. Research is being conducted to help farmers realise these ambitions.

"Increasing organic matter in soil has a positive effect on disease suppression"

Henk van Reuler

The right combination and timing of fertilizers, legumes, cash crops and green manures is crucial for sustainable nutrient management. This is a rather complex equation and a big puzzle for farmers. To help them, researchers have developed user-friendly software called NDICEA. This program gives farmers detailed insight into nutrient management on their plots or farms (see Box 'Planning fertilisation by computer').

Planning fertilisation by computer

Crop yield depends to a large extent on the amount of nitrogen that becomes available to the crop. In organic cultivation it is hard to predict this availability. Nitrogen becomes available from the organic carbon stock in the soil, which is built up by the compost, manure, crop residues and green manure that was added to it in previous years. To help predict nitrogen availability, a computer program called NDICEA (Nitrogen Dynamics in Crop Rotations in Ecological Agriculture) has been developed for farmers. The program gives organic farmers insight into the nitrogen dynamics of their soils. The NDICEA nitrogen planner has been extensively tested and used by farmers for the last ten years. The user-friendly program gives a very reliable indication of the level of nitrogen and organic matter present in the soil. Different scenarios for crop rotation and fertilisation can be tested. The program indicates whether crops have sufficient nitrogen available and calculates potential nitrogen losses, nutrient balances and organic matter balances. Regional weather data are gathered every two weeks from the internet. The program's default setting is for the Netherlands and Flanders. Users can choose between Dutch or English as the language of operation, but other languages can easily be added. The model can also be adapted for use in other countries (with different soils, crops, manures and weather) by changing the databases within the model and linking it via the World Wide Web to other weather station data.

"Organic agriculture aims at the long-term preservation of soil fertility"

Sjef Staps

Organic matter in the soil is an important source of nutrients for plants. The short- and long-term behaviour of organic matter in the soil is therefore being studied in various projects. Research is also testing the effect of different fertilisation strategies or applications. Their long-term effects on soil fertility, but also on the short-term availability of nutrients are being assessed. To gain insight into the long-term effects of organic fertilisation strategies, long-term experiments have been set up (see Box 'Long-term effects of manure and compost').
Another aspect is the testing of new types of fertilizers that have recently become available. One such fertilizer, digestate, is the residue of anaerobic fermentation of organic matter, a process used for energy production. Digestate is a valuable, nitrogen-rich product that is very well suited for top fertilisation.

Another concept being tested is the use of a farm's own nitrogen source, legume crops, for fertilisation during the growing season. Mulches of alfalfa or clover are used as fertilizers for crops with a high nitrogen demand.

Minimising nitrogen losses is important from both the environmental and plant nutrition points of view. Experiments with strategies for organic fertilisation and optimisation of organic nutrient management have shown that organic agriculture is very capable of complying with the EU nitrate directive without suffering yield losses.

Soil health

A fertile soil not only promotes the growth of crops, but also protects plants against soil-borne diseases or plagues. In organic agriculture, the farmer has to depend on the natural disease suppression of the soil. If problems do arise, the farmer can turn to organic forms of soil disinfection as a last resort (see Box 'Organic soil disinfection').

Soils contain countless soil organisms that can keep soil pathogens under control. An active and varied soil life thus has a positive effect on disease suppression. Part of current research is therefore directed at increasing soil health by stimulating soil life. The assumption is that a high organic content in the soil will stimulate soil life. "Organic matter is the food for soil life", explains researcher Henk van Reuler. Through experiments he has shown that the number of harmful nematodes in sandy soils decreases if there is more organic matter in the soil. "We thus have definitively demonstrated that increasing the organic matter in the soil has a positive effect on the disease suppression effect of soils."

However, ensuring a sufficient level of organic matter is not enough. Crop rotation and the choice of green manure crops are also powerful instruments in trying to avoid yield losses caused by infestation with soil pathogens. Plant-parasitic nematodes are an important threat to soil health in organic agriculture on sandy soils. Researchers are still trying to find the best strategies for controlling them. They test the sensitivity of crop varieties to nematodes and look at the ways different crops affect the nematode's population density.

Specific attention is given to organic cultivation of flower bulbs and ornamentals. The Netherlands is unique with respect to its highly developed flower and tree production sectors. Rotation is a common practice with many crops, but not yet with bulbs and perennials. Research is looking at ways to rotate these crops that could decrease the risk of soil-borne pests and diseases. Tests have shown that bulbs and ornamental shrubs form a good combination for rotation. Bulbs are sensitive to certain fungi that do not bother ornamental shrubs. By planting these shrubs after a period with bulbs, the fungi disappear from the system and the next bulbs can be planted on clean soil again (See Chapter 10).

Long-term effects of manure and compost

Farmyard manure, compost and the combination of organic waste and slurry are the best inputs for a healthy soil and have the least negative effects on the environment. This conclusion was reached after eight years of measuring the effects of commonly used organic fertilizers and soil improvers on the experimental field.
The research project, called 'Mest als Kans' (the MAC trial), was carried out near Lelystad. Since 1999, thirteen different fertilisation strategies have been compared in order to gain insight into the long-term effects of various fertilizers and types of compost. The researchers have been looking at various aspects of soil quality and the influence of fertilisation on yield and product quality. The experiment has been carried out on the crop rotations of a vegetable farm on light, loamy soil. Each plot was fertilised with a certain combination of animal manure, vegetable compost and slurry, which provided 100 kg of active nitrogen (N) per hectare and a maximum of 80 kg of phosphate (P_2O_5) per hectare per year. The objective of the ongoing experiment is to better understand the short- and long-term effects of organic fertilisation, and to strive for a balanced fertilisation strategy. So far, none of the tested variations have fulfilled the 2015 policy objectives for balanced phosphorus fertilisation.

Organic soil disinfection

Organic soil disinfection kills a number of harmful organisms, but does not harm most of the beneficial ones. This was demonstrated by tests of this technique carried out on sandy soils sensitive to soil-borne diseases. For organic soil disinfection, fresh organic material is incorporated into the topsoil during the summer. A good amount of grass cuttings will suffice. The soil is then covered with plastic, which is left in place for six to eight weeks. The organic matter is broken down by fungi and bacteria. In this way oxygen is extracted from the soil. Since the plastic does not allow oxygen to pass through, anaerobic conditions are created in which a large group of soil-borne plant pathogens cannot survive. Harmful fungi and bacteria, insect larvae, root knot nematodes, cyst eelworms and other nematodes die off. Many beneficial organisms are able to survive this treatment. Most pathogens will not return for another two to three years. Organic soil disinfection thus gives better results than chemical treatment, after which the population of plant pathogens often redevelops rapidly. An additional advantage of organic disinfection is that it adds organic matter to the soil. A disadvantage is that the method is relatively expensive and can only be applied during a fallow period.

Controlled traffic farming is characterised by the use of fixed traffic lanes

Controlled traffic harvesting

If farmers could use fixed traffic lanes for harvesting, as well as for ploughing and sowing, far less damage would be caused to the soil on which the crops are grown. Unfortunately, for many crops this is not yet possible, and the development of CTF harvesting machines for this system of cultivation is expensive.
"Together with organic farmers in Flevoland, researchers are currently testing the extent to which yields are influenced in case harvesting would also be carried out using the permanent traffic lanes, and if soil tillage would be minimised. Since this type CTF harvesters are not yet available, the crops in this experiment are harvested manually. As soon as there is more solid proof, the sector will consider investing in the development of CTF harvesting machinery."
In the same experiments, scientists and growers are also looking at the effect of the system on weeds. Deep soil tillage is a non-chemical means to control perennial weeds. So the question is whether it will be possible to control them without this type of ploughing. Four arable farming enterprises (three organic and one conventional) associated in the Stichting Bodembescherming Flevoland (Foundation for Soil Protection Flevoland) are participating in the project in Flevoland.

Soil structure

In addition to soil fertility, soil structure has a large impact on the health and growth of crops. "For roots and soil life to function well, they need sufficient water and oxygen in the soil. It is therefore essential that the soil has a good and stable structure to hold air and water", says Bert Vermeulen, a specialist in soil tillage.
Vermeulen is leading a number of research projects focused on mechanical soil management. Research into soil tillage in the Netherlands is characterised by close cooperation between researchers and growers. The farmers actually often carry out the experiments themselves. One on-farm field experiment tested a controlled traffic farming (CTF) system, characterised by fixed traffic lanes. Between the fixed traffic lanes are beds in which the crops grow and the soil is not disturbed during the growing season. After four years of experimenting with CTF on clay soil in the Netherlands, researchers have shown that it has positive effects on soil structure and crop yields. Moreover, the emission of nitrous oxide decreased by more than twenty percent.

A further improvement of CTF is possible by also using the fixed traffic lanes for harvesting (see Box 'Controlled Traffic harvesting'). "High-capacity machines are needed for harvesting, and these have relatively high ground pressure levels", explains Vermeulen. "By repeatedly compacting the soil during the harvest and then tilling it 25 centimetres deep to restore its structure afterwards, the quality of the soil goes downhill. This process may eventually lead to low levels of organic content in the topsoil, deterioration of its structure, associated problems deeper in the soil profile and unnecessary use of fossil fuel."

"Repeated compacting and tillage decreases soil structure and quality"

Bert Vermeulen

A new challenge for organic agriculture is to refrain from ploughing and minimise tillage. For conventional agriculture in many countries, this is already common in so called conservation agriculture. Minimum tillage systems have proved to be able to improve soil quality, soil life, soil structure and water infiltration and transportation. Additional advantages include lower energy use, reduced labour for soil tillage, reduced mineral run-off, and prevention of wind and water erosion. Minimised tillage also involves risks, such as higher pressure of weeds, snails and mice.

Vermeulen expects the combination of CTF with reduced tillage to have large potential for organic agriculture. A few countries, including Australia and England, already have experience with CTF in combination with minimum soil tillage in conventional agriculture. “A big difference, however, is that they use this system primarily in cereal-dominated rotations. Crop rotations in the Netherlands typically include crops grown on ridges. CTF in combination with minimum tillage and organic agriculture has not been tried out on these kinds of crop rotations yet. Another major difference is that weeds and green manure crops in spring are usually killed chemically before crop sowing in conventional agriculture, while this has to be done mechanically in organic agriculture.”

Researchers are identifying possibilities and obstacles for the implementation of minimum tillage systems in the Netherlands. They are gaining valuable experience together with farmers who have switched to minimum tillage. One of the aspects scientists and growers are closely looking at, is the effect of the system on weeds. Mouldboard ploughing is known as a non-chemical means to control perennial weeds. The question is whether it would be possible to control the weeds without ploughing. The first scientific long-term experiments with the combination of organic agriculture, CTF and minimum tillage started in 2008.

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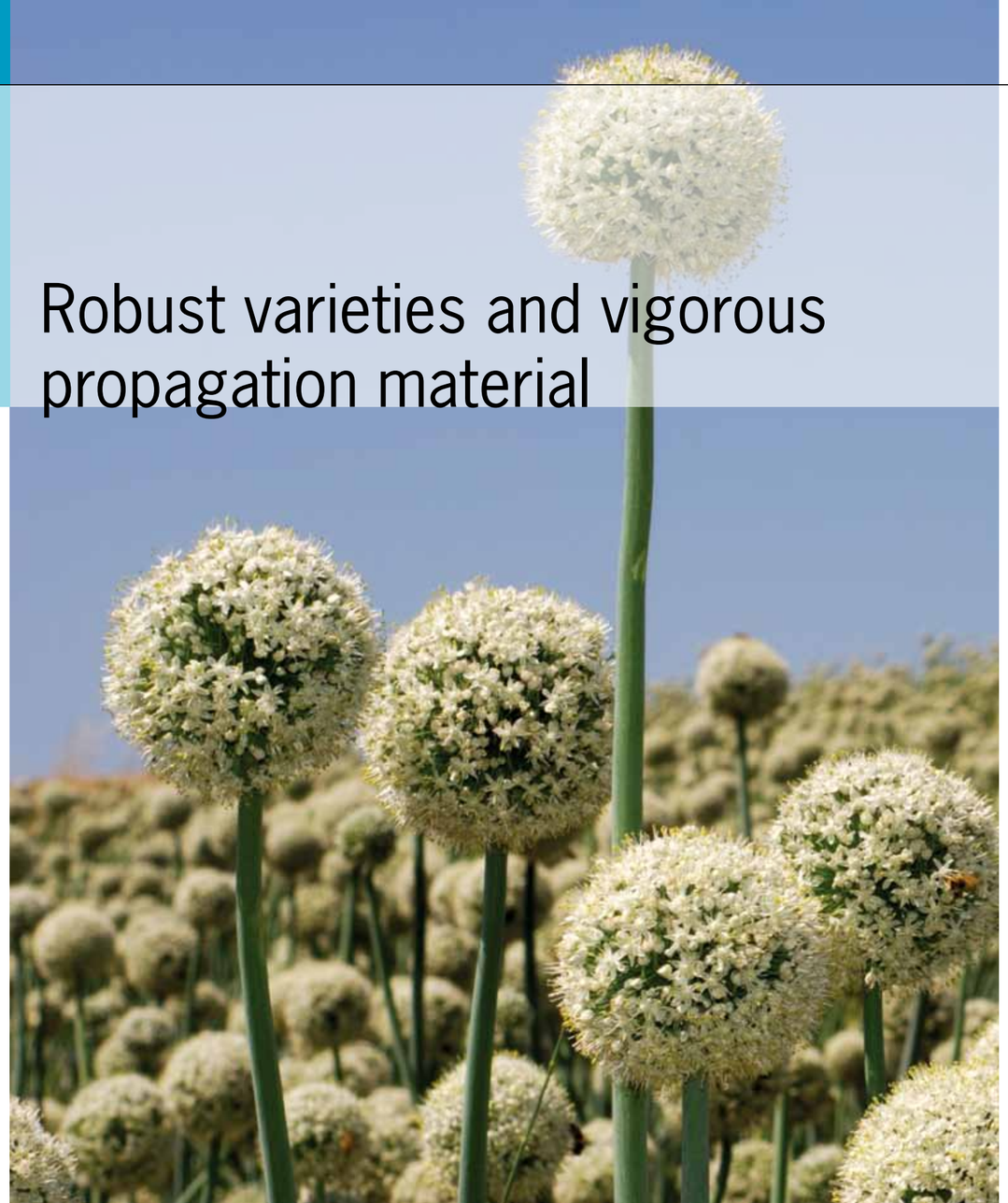
6 Robust varieties and vigorous propagation material



Research on organic plant breeding and propagation material in the Netherlands is booming. This research is carried out in close cooperation with growers, breeders and the seed industry. Is organic breeding and propagation really different from the conventional system? And which types of varieties are needed?

Edith Lammerts van Bueren

Nowadays it is clear that organic agriculture needs to focus more strongly on plant breeding and the production of healthy propagation material than it did in the past. In recent decades, too many other crop management problems needed to be solved and until recently organic farming could rely on conventional inputs from the seed and breeding industry. Dutch organic agriculture is now putting special emphasis on raising the number and the use of organically propagated varieties, making the Netherlands one of the world's front runners. Additionally, breeding research programmes are in place to support breeding of varieties that are better adapted to organic farming systems.

A group of scientists of Wageningen UR and Louis Bolk Institute are cooperating closely in the field of plant breeding and propagation material for organic agriculture. The strong involvement of organic growers and breeding companies is a unique aspect of their approach. Breeding concepts and strategies are specifically developed for organic farming. Examples of such breeding strategies are: the search for indirect resistance by defining plant traits leading to less infestation and unravelling the genetic background of such traits. Researchers also develop pre-breeding material for breeding companies, which is to be used for further development of new varieties. In such projects large sets of varieties are tested to both evaluate genetic resources for useful traits and to give valuable information for farmers on the varieties currently available. It provides growers with information they can use directly in order to decide on the varieties that best suit their farming needs. Research into organic propagation material focuses particularly on the development of new knowledge and methods to improve the quality of organic seeds and potato tubers. Emphasis of the research lies on the Dutch field crops such as potato, onion, cabbage, carrot, and wheat. Organic fruit breeding focuses on apple and pear.

Why organic breeding?

Whether breeding for organic farming differs from conventional breeding, is a relevant discussion topic. Does organic agriculture differ only because its market differs, or are other issues at stake? The Dutch research group thinks that breeding for organic farming does differ from breeding for conventional farming. Even though organic breeding applies, in part, the same techniques of crossing and selecting – except for gmo techniques – additional selection strategies are required

"Adapt the varieties to the environment rather than the environment to the varieties"

Edith Lammerts van Bueren

Researching mycorrhizas in an onion field

and perhaps more important: the variety concept is different. Organic farm management requires robust varieties that are suitable for organic management: varieties which provide sufficient yield, also under less favourable conditions. In other words: Adapt the varieties to the environment rather than adapt the environment to the varieties.

Yet, organic farming still depends largely on conventional varieties. These varieties usually lack a number of traits that are important in organic agriculture. Moreover, they have been selected under and for conventional cropping conditions which means that they may not be best suited for organic farming. “Breeding for a wider range of traits and under organic selection conditions will support the development of organic farming”, is therefore the view of Edith Lammerts van Bueren and Olga Scholten, who coordinate the organic plant breeding research in the Netherlands.

The Dutch expertise and view on organic breeding has led to the foundation of the Chair Organic Plant Breeding by Wageningen University in 2005. This is the first Chair in the world that specifically covers this field.

Breeding strategy: wide variety concept

Organic breeding research focuses on a broader variety concept including characteristics such as weed-suppressiveness as a result of crop structure. Traits that support plant health and the ability to grow under low-input conditions are also part of this concept. In case insufficient direct genetic resistance can be found, researchers start looking at morphological or physiological traits that increase plant defence: a robust plant (e.g. onions with more mycorrhizas and a larger rooting system), a thicker wax layer in cabbage (against thrips), longer straw and less compact ears in cereals (against *Fusarium spp*). Thus, organic breeding requires creative thinking.
Conventional breeding research and breeding companies are getting more and more interested in such broader variety concepts. Varieties with a more efficient nitrogen and phosphor utilisation have an advantage under lower levels of fertilizer input, while robust crops and crops with a more extensive root system have an edge in a changing climate with more unpredictable weather and dryer periods.

Participatory selection research

Researchers to interact with growers: they contribute their field experiences and indicate which variety traits they require. Research questions are based on growers’ demands and growers continue to participate during the research process. Also, breeding companies are participating in all projects. The exchange of knowledge and experience of researchers, growers and breeders provide all participants with practical solutions that can directly contribute to further developments. Organic growers indicated, for instance, that they need white cabbage varieties that are less susceptible to thrips and *Alternaria spp*. White cabbage varieties show a diversity in thrips resistance but the reason for these differences was unknown. This makes breeding for thrips resistance difficult. Researchers therefore investigated properties that may be involved in increased thrips resistance. One of these properties appears to be a thicker wax layer. Thrips apparently find this less attractive. A thicker wax layer also provides protection against some other insects and against fungi. Another major problem that needs serious attention in the years ahead is ‘late blight’ in potato, see box.

Potato farmer breeders fighting late blight

Organic potato growing in the Netherlands is becoming nearly impossible due to severe late blight (*Phytophthora infestans*) infections. These caused high yield losses in 2007 and 2006. Organic farmers urgently require potato varieties which are resistant against this aggressive pathogen, in order to retain organic potato cultivation for the Netherlands. The number of varieties suitable for organic farming is too low. Only recently two new resistant varieties appeared on the market. The demand for resistant varieties is also increasing in conventional farming, even though this sector can always use chemicals against infections.

Growers, breeders and researchers joined forces at the end of 2007. They intend to make use of organic potato farmer breeders, an old and well established system in the Netherlands. In this system some 140 (conventional) farmer breeders help conventional breeding companies by selecting progeny plants obtained from crosses. They increase the chance of finding a good potato genotype that will eventually become a new variety. A farmer breeder shares in the royalties in case his selection will end up being released as a new variety. The number of organic farmer breeders is still very low. A special grower's course is organised to improve this situation. These growers will start selecting potato plants for organic farming in close cooperation with Dutch potato breeding companies. In this new breeding programme for organic farming, pre-breeding activity will provide an important basis for introgressing several new resistances by crossing wild and cultivated potatoes. These will be further developed into suitable genitors for additional work by breeders and growers.

***Fusarium* in wheat**

Chain cooperation

Sometimes a chain-wide approach from breeder to grower and onwards through miller to baker will be most successful. This approach has been set up for breeding an organic bread wheat variety. In the Netherlands, the only good bread wheat variety that is available for use in organic farming is Lavett. Having only one variety available is not a solid basis for organic wheat farmers. Spring wheat breeders in the Netherlands are unable to set up a special breeding programme for the small acreage of organic bread wheat. The question arose: What are the possibilities to set up a spring wheat breeding programme for organic farming? "By considering breeding as a socio-economic chain activity with its own financing structure", says researcher Aart Osman. Millers and bakers also have a vested interest in good quality bread wheat. A levy of only € 0.04 per kg wheat would be sufficient to finance a breeding programme. The consumer costs would increase less than € 0.01 per bread.

The first steps in setting up an organic breeding programme have been taken. Growers, bakers, and millers have organised themselves and some breeding companies have expressed their willingness to investigate in which way they can participate. A good example of how out-of-the-box thinking can make breeding for smaller acreages realistic.

The Dutch National Annex: availability of organic propagation material

Dutch growers are increasingly using organically produced propagation material. The national annex of organic propagation material indicates which crops are available in sufficient assortments and for which crops no derogation for the use of conventionally produced seeds or planting material is possible. The 'annex' is updated annually upon request of the Dutch Ministry of Agriculture.

Most major crops such as potato and cereals are included in the list. Onions are now also included, which caused quite some debate. Organic onion seed is two to three times as expensive as conventional seed, with seed costs constituting one of the largest cost factors in onion cultivation. Inclusion of onion seed is, however, a significant step in closing the organic production chain. Further research will have to contribute to improvements in seed production and propagation of onion seeds.

The successful project 'Wie zaait zal oogsten' ('Sowing will lead to harvest') was carried out in 2007 in order to speed up the inclusion of vegetable crops that require two cultivation years for seed production. A number of seed companies have restarted or expanded their organic seed production programme. This is the result of coordinated and direct communication between seed companies and growers. Their combined efforts created a better match between the demand of organic growers and the supply of seed companies. When growers define what varieties they need, seed companies are often prepared to discuss widening their variety assortment.

Crops such as celeriac, bunched carrots, carrots for storage and industrial processing, red beet, and Chinese cabbage will probably be included in the national annex in 2010 or 2011. Much effort is still required for other crops, such as early carrot, chicory, Savoy cabbage, white and red head cabbage, leek, and babyleaf lettuce. This is partly due to technical problems in organic seed production. Also, some suppliers of important varieties are not yet prepared to propagate their varieties organically.

Quality improvement of organic propagation material

Production of good propagation material under organic conditions is still difficult for a number for crops. This not only leads to a restricted availability, but also means that organic propagation material is often more expensive.

A frequently recurring problem in organic propagation is the higher risk of diseases transferring to the next crop through the seeds or tubers. Avoiding contamination during reproduction is the preferred solution. Should this be impossible, alternative treatments are required for organic propagation material. This is why the team of researchers focusing on organic propagation material is developing knowledge to improve the quality of sowing and planting material.

This Dutch way of researching organic propagation material is special and hardly carried out in other countries. "We have been working on this for eight years and research is carried out in cooperation with almost all important producers of vegetable propagation material in the Netherlands", says researcher Steven Groot. "Producers are interested because the knowledge

Testing carrots for fungal infections

Wax layers differ between white cabbage species

Research results breeding

Striking results have been obtained in the research programme on organic breeding of field vegetables from 2004 to 2007.

Cabbage: defence against thrips

In a survey, organic growers mentioned thrips in cabbage as one of their major problems. Field experiments showed variety differences that affect the defence against thrips, such as wax layer, firmness, and earliness. An old grower's selection with a higher resistance to thrips than the best modern variety was found as well. Follow-up research focuses on the heritability of thrips resistance and the development of test methods to enable a more simple comparison of variety susceptibility.

Carrot: black spot disease

A practical method to test propagation material for three important fungi that cause black spot disease has been developed. This method highlights the most resistant varieties. The test method is now being used by breeding companies for the development of resistant varieties. Varieties have been ranked by susceptibility in field experiments. Absolute resistance has not been found but there are good perspectives for breeding.

Wheat: *Fusarium*

A screening of varieties showed large differences between varieties in resistance against *Fusarium* and the formation of the mycotoxin DON. A seed company now uses this knowledge for decision-making in organic seed production. Varieties with a more compact ear were found to be more susceptible to *Fusarium*. Breeders can use this information when selecting crossing parents.

Onion: new breeding strategies

Pot experiments showed that interaction with mycorrhizas have a positive effect on onion bulb weights. The presence of genetic variation within onion, but also between onion and crossable onion relatives, enables breeding for this property. There are also indications that mycorrhizas strengthen the defence of onion against *Fusarium oxysporum*. This fungus causes *Fusarium* basal rot in onion, an expanding disease in the Netherlands. Resistance against Fusarium has also been found in onion-related species. Follow-up research investigates whether this resistance occurs in the field as well and whether possibilities for breeding exist. The research will also include the interaction with mycorrhiza fungi and the relationship between root system and *Fusarium* resistance.

of organic cultivation is also relevant to the process of increasing sustainability in conventional agriculture. These companies, for instance, make experimental fields available for research where together we can test the developed methods under field conditions. In some cases organic growers also participate actively".

Research into quality improvement of organic propagation material was carried out from 2004 to 2007. It has yielded a range of new knowledge and practical methods. An early infestation of crops in the field can, for instance, be prevented by a hot water treatment of the seeds. For the seed companies it is important to know that hot water treatment does not affect the germination of the seeds. They also need to know why certain seed lots are more sensitive than others in this respect. It was shown that maturity of the seeds is important in this respect. Since seeds of many crops have to be harvested before shedding at maturity, it has been a great achievement that a method was developed by the researchers to remove less mature seeds from a seed lot. Recently, this sorting principle has been extended to detailed spectral analyses of individual seeds. Infected seeds can be removed by spectral sorting, if the infection results in slight changes in seed colour.

Organic fruit growing: propagation material and value for cultivation and use (vcu)

Testing new apple and pear varieties for cultivation and use in organic production in the Netherlands has been going on for three years. It is part of a systems study into organic fruit production with less scurf and reduced pesticide use. The first phase of vcu testing, which includes about one hundred apple varieties and forty pear varieties, is carried out under integrated cultivation conditions. This is followed by a division into testing for use in integrated and organic farming systems in the second phase of the testing process. Varieties that look promising for organic cultivation are planted in a special field with organic production conditions. These varieties are then carefully monitored by a steering committee of organic fruit growers. A variety profile has been drawn up beforehand, in which the growers have described the apple and pear variety they need. The sector in particular asks for a resistant, sweeter apple to replace the scab-susceptible Jonagold. Scab-resistant sour and sour-sweet apple varieties are sufficiently available. Examples are Santana, developed by Wageningen UR, and Colina, bred by a Dutch fruit grower. Tasty, resistant, sweet apple varieties are scarce, however. Growers also look for a pear variety with low scab-susceptibility.
"The second phase contains eight apple and pear varieties", says researcher Rien van der Maas, "but the steering committee has already rejected two." The varieties that successfully pass the second phase will be included in a field pilot at several locations with varying soil and cropping conditions. A pilot with the Dalinco apple variety is already running.
The direct participation of the sector in vcu testing is new. Growers still have to gain experience. They choose the varieties themselves, advised by researchers. Van der Maas: "Sometimes we talk for hours about the way you can look at variety properties, but gradually a large degree of

Steven Groot

"Propagation research is carried out in cooperation with all important Dutch producers"

Steven Groot

Researchers and breeders: mutual learning

"Offering healthy organic cabbage seed is difficult" explains Ronald Driessen of Rijk Zwaan seed company. "The high risk and the higher production costs make organic seed expensive. Should we have better control over organic seed production for cabbage and an easier production system for good quality seed, seed costs for growers would be lower." Driessen therefore welcomes research aimed at 'beating' important fungal and bacterial diseases to improve seed quality. Should *Alternaria* and *Xanthomonas* be tackled, this would already eliminate two important diseases. "Our hope is of course that the results can be transferred to other diseases and crops."

Research is progressing rapidly because industry and researchers are cooperating closely. This not only happens one-on-one between a seed company and researcher. Seed companies are also cooperating among themselves, learning from each others' knowledge and experience. Rijk Zwaan, for instance, reproduces organic cauliflower seed for researchers who take care of the field tests for the seed quality. Seed companies also test seed for germination capacity and health. "We do this every day. And we are learning from the latest research developments."

Fruit tree canker

consensus emerges. It is also important that growers think about the way in which they would be able to get production licenses for interesting varieties, at an early stage."

Prevention of fruit tree canker is a particularly important issue when developing propagation material for organic fruit production. The disease develops slowly which makes it difficult to say whether an infection in a young orchard was introduced with the planting material (tree nursery) or came from elsewhere. This means that good sanitation is always important for the cleanest possible start.

A method to detect the presence of fruit tree canker in young fruit trees has been developed. The method enables determination of the infection percentage of a batch of apple trees before planting. This way tree nurseries that produce organic propagation material can provide fruit growers with a warranty of quality. In the years to come, researchers and fruit tree nurseries will be working on an integrated approach of the disease. This will include a warning system (forecast of infection), which incorporates the application of organic products such as lime milk or slaked lime (calcium hydroxide).

Research results organic propagation material

Detection of *Alternaria* and *Xanthomonas* during seed production

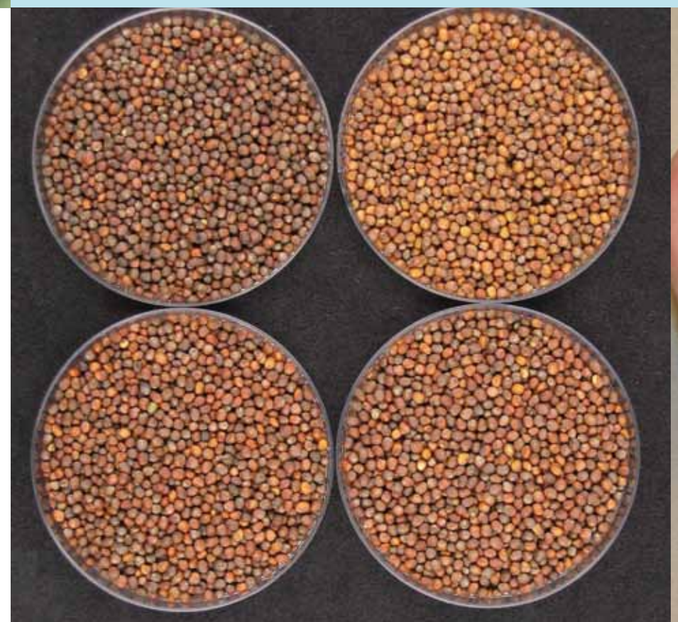
Alternaria fungi may contaminate cabbage and carrot seed during production, resulting in lower seed production and lower seed quality. Seed production is also at risk when cabbage is struck by black rot caused by the *Xanthomonas* bacterium. Seed companies therefore set up extra production fields and treat contaminated seed with hot water whenever possible. The research efforts have yielded methods to detect very small amounts of the fungus or bacterium, and new knowledge has been developed about these pathogens. Seed companies use this knowledge to reduce the risks of contamination. In due course this should result in lower production costs and higher seed quality.

Seed sorting by 'colour'

A method based on pigment colours of individual seeds has been developed for sorting diseased or low quality seeds. A spectrophotometer is used for a very accurate and high-speed determination of the exact colour composition of individual seeds. Seeds that deviate from a test set or the average pattern are recognized through their light reflection and duly removed.

The method has been developed with *Fusarium*-contaminated wheat seeds but bodes particularly well for expensive seeds of crops like carrot, cabbage, and pepper. Together with seed companies it is investigated for which diseases or germination capacity problems the method is suitable.

A rapid ethanol assay of cabbage seeds indicates vigour



Silver scurf reduces the quality of seed potatoes

Research results organic propagation material

Vigour improvement

Propagation material should have a good vigour, also after seeds have been treated with hot water to deal with pathogens. Seeds should keep their germination capacity. A rapid ethanol assay has been developed for cabbage seeds because it is difficult to predict beforehand whether seeds can withstand the treatment. Damaged seeds produce ethanol, which can be measured with a breath analyser as used by the police for alcohol testing. Seed companies can now check within 24 hours, whether cabbage seeds can withstand a specific hot water treatment without reducing their germination capacity. This involves a test treatment.

Health promoting treatments

Plants have their own defence mechanisms against pathogens. Certain substances are capable of provoking these defences. However, only a limited number of substances can be applied in organic farming. Certain salts and extracts from fungi or bacteria were effective against downy mildew on cabbage leaves. The protection level, unfortunately, is not as high as that of certain chemical substances.

Silver scurf control in potato

Silver scurf is a cosmetic problem when selling organic potatoes and also reduces the quality of seed potatoes. During seed potato production infections on mother tubers pass on to daughter tubers. A small infestation may increase substantially during storage. Research has shown that infestation can partly be reduced by treating seed potatoes with certain essential oils or organic acids.
In case the tubers are already infested, the fungus is best left to overgrow the tubers as much as possible because the fungus only forms spores at the rim of the grow spot. Complete coverage of the tuber results in reduced spore formation which in turn reduces infestation of the daughter tubers. This may, however, have adverse effects on the germination capacity of the seed tubers.

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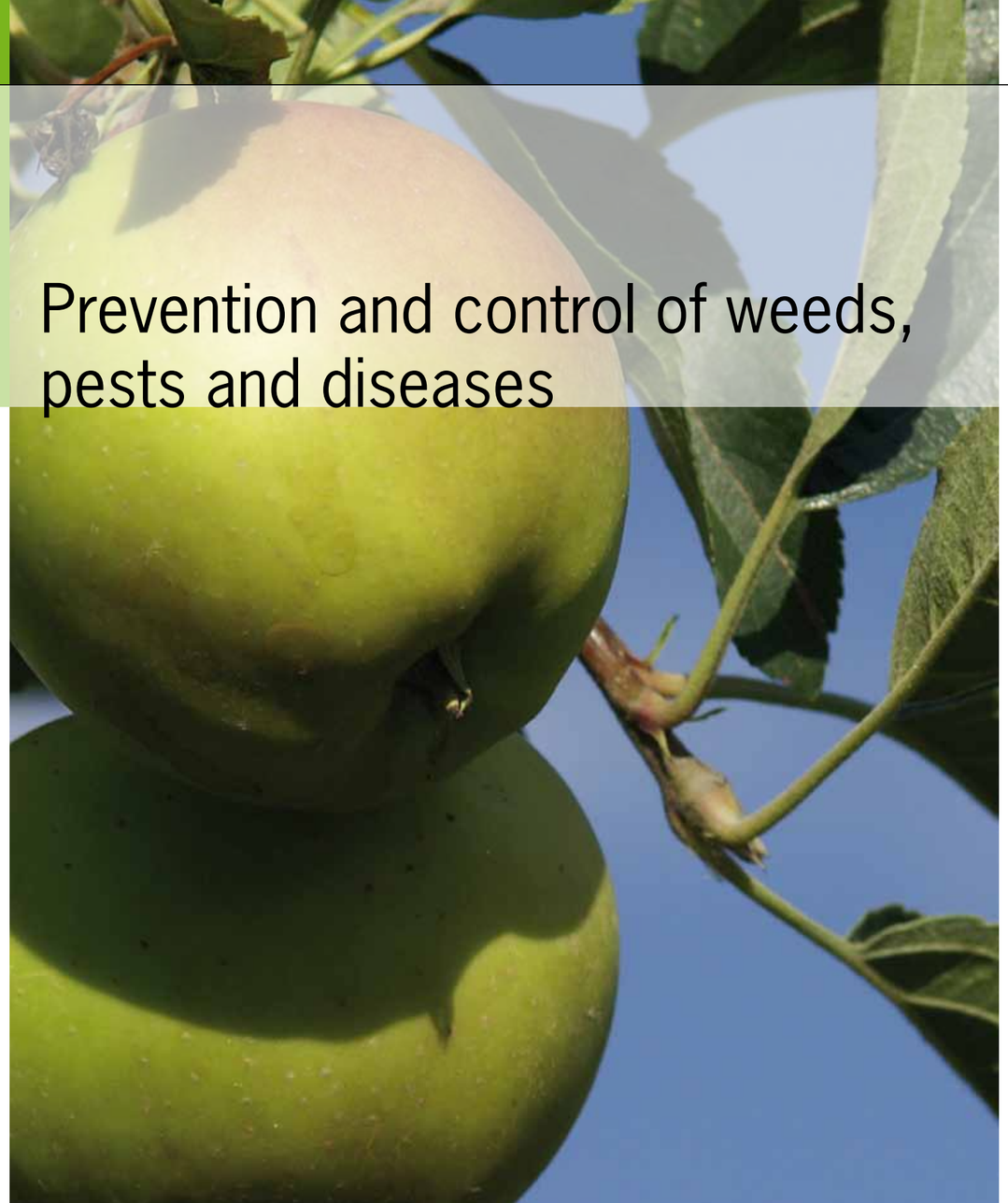
Prevention and control of weeds, pests and diseases



Weed control

Weed control still requires major investments of money and labour in organic arable farming and field vegetable cultivation. For this reason, current research is focused to a large extent on the development of weed control strategies. These incorporate prevention as well as mechanical methods, and cover a range of approaches. From inexpensive techniques to very innovative technologies.

Rommie van der Weide

Clever crop rotation, prevention of the introduction of weed seeds through manure, and prevention of seed setting of weed plants are just a few examples of preventive strategies that have been optimised in recent years in close cooperation with farmers. Research has shown that a false seedbed can also do a lot to clear weeds. With this technique, seventy per cent reduction of the weed pressure is possible. This method has already become common practice for crops that are sown or planted later in the season.
Optimisation of cheap mechanisation such as harrows, finger weeders and hoes has helped a lot as well. For example, improvement of techniques, together with improved craftsmanship of farmers and growers, no less than halved the number of hand weeding hours required in onion cultivation over the past eight years. The results of all this research and on-farm experience have been laid down in a Handbook for Practical Weed Control (figure 1).
Despite all this progress, a lot of hand weeding is still required, particularly in delicate crops such as carrot and onion. An even more drastic reduction in manual work is therefore being sought through new strategies, methods and innovative techniques. Some striking breakthroughs have already been achieved.

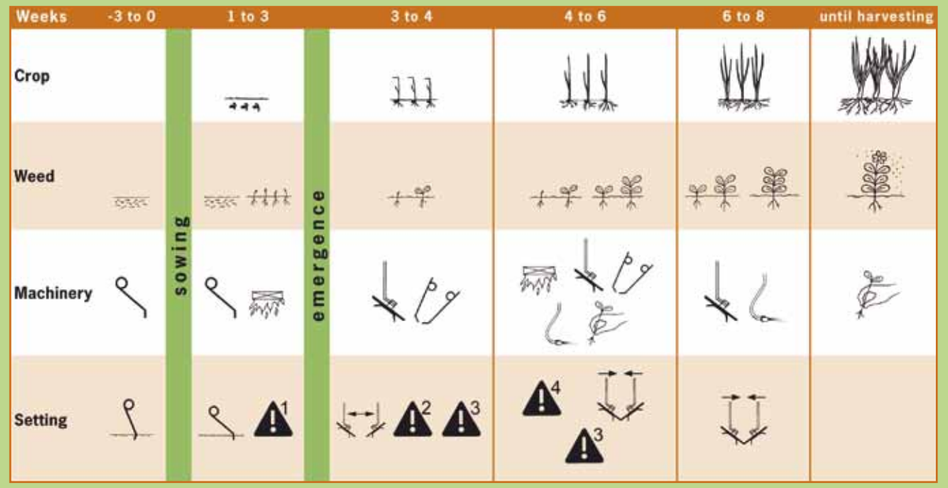
Innovation Network

Research in the Netherlands is carried out in close cooperation with the Innovation Network Weed Control, formed by seven leading organic arable farmers and field vegetable growers. They provide significant input for the research agenda by proposing research questions and helping to formulate ideas and objectives. They also participate in research carried out on their own farms. This intensive cooperation has already led to a new effective method for the prevention of weeds in carrots and direct-sown onions (see box ‘Compost prevents weeds’).

“Innovative technologies might cause a breakthrough in weed control in row crops”

Rommie van der Weide

Figure 1. Control of weeds in sown crops such as chicory, carrot, redbeet and spinach (from: Schans, D.A. van der, et al., 2006.)



Explanation of drawings

Crop	Weed	Machinery	Setting
Germination	White filaments	Harrow	Harrow tines, angle forward
cotyledon	cotyledon	Finger weeder Torsion weeder	Harrow tines at vertical setting
1 - 3 leaves	cotyledon to 2 - leaf	Pneumat	Weeder elements separated
3 - 5 leaves	2 - 4 leaves	Flame weeding	Weeder elements against each other - overlap
30-100% soil cover	6 leaves	Hand weeding	1 Harrow as shallow as possible, above sowing depth
	Flowering and seed-bearing		2 With small crops and loose soil elements approx. 1 cm apart
			3 With small crops and crust formation drive slowly and use discs
			4 Flame weeding in the crop solely for onion and chicory (onion 4 - 6 leaves and chicory 3 - 4 leaves). Results in reduced yield.

Machine which simultaneously sows and deposits a compost layer to prevent the emergence of weeds

Inter-row and intra-row weed control

Developments in mechanical and intelligent intra-row and inter-row weeding are progressing rapidly. “Innovative technologies including advanced sensing and robotics in combination with new cropping systems might cause a breakthrough in weed control in row crops leading to significant reductions in or even total elimination of hand weeding”, predicts researcher Rommie van der Weide. But we haven’t reached that stage yet. Important aspects still need to be improved, such as the driving speed of the machines (they have to go faster for the technique to become practical and economical) and proximity to the crop (each centimetre closer the machine can get to the plant will save a lot of manual weeding). Together with farmers the scientists optimise new machinery in practice, such as hoeing methods that use GPS to weed between and within rows or intelligent weeders for control within the rows (see box ‘Precision hoeing with RTK-GPS’).

Composts prevents weeds

An organic grower of the Innovation Network Weed Control came up with the idea of covering direct-sown onions and carrots with a thin layer of compost that is free of any weed seeds. By preventing the germination of annual weeds during early crop development, this compost layer substantially reduces the required amount of hand weeding. This reduces the application of finger and torsion weeders, which cannot manoeuvre well between the small plants and can damage them. One of the research questions was how much compost should cover the onion seed. The thickness of this layer proved to be very critical. A layer of about 2 cm resulted in the best crop emergence combined with good weed suppression. Results of a 2-cm compost layer again were the best in a follow-up experiment with carrots. Weed emergence was reduced by 75 to 85 per cent in both cultures.

After the successful experiments, the grower commissioned a manufacturer to develop a machine for simultaneously sowing and putting down a compost layer: the band sowing machine. In the years ahead, researchers will investigate whether the compost method is also suitable for other sown crops such as herbs, flowers and vegetables.

Precision hoeing with RTK-GPS

Research into intra-row hoeing is based on an RTK-GPS steering system (RealTimeKinetic-Global Position System). In theory, this technique enables very accurate automatic steering of intra-row implements such as torsion and finger weeders. Manufacturers claim that the RTK-GPS receiver allows no steering deviations larger than 2 centimetres left and right. But are the claims of the manufacturers correct? And are they true for all situations and for all driving speeds? "In a preliminary study we found that the RTK-GPS receiver operates best when placed on the hoeing machine", says researcher Piet Bleeker. "Hoeing up to a speed of 4 km per hour goes quite well. Deviations show some increase at higher speeds." But 4 km per hour is still too slow for on-farm use. The aim is a speed of 6 to 7 km per hour. Speeds can still be increased by improvement of the sensors and the pneumatic and hydrologic system. Bleeker is in contact with manufacturers about these aspects. Meanwhile, research continues. In the coming years researchers will look into the effectiveness of RTK-GPS on fields that are not entirely level and the traceability of previously made tracks.

Intra-row weeding with one hoe per row on the left and two hoes per row on the right

Intelligent weeders

High-precision hoes move in and out of the rows and therefore have to be able to recognise crop plants. For larger crops there is now an intelligent weeder with a simple crop detection system based on a light interceptor, which guides a hoe in and out of the crop row around the crop plants. One of the first commercially available intelligent weeders was the Sarl Radis for lettuce. Research on this machine has resulted in improvements that further reduce the number of weeds left on the field (see box 'Intra-row hoe with double blades').

The machine does not work in densely sown crops such as carrots and direct-sown onions; the light sensors see insufficient difference between plant and weed. However, when attached to a camera linked to equipment that calculates whether a plant is a weed or crop, the hoe can become effective in these crops as well. In 2009 an organic lettuce grower will start using such a hoe equipped with a camera. Researchers will then study how the system operates best.

New cropping systems

How long will we continue incorporating new technologies into existing cropping systems? It might be better to develop new cropping systems for new technologies. This is being investigated for intra-row weeding in onion. In a field experiment onions were grown in clusters of 4 to 6 plants with a 20 cm distance between the clusters instead of in the usual rows. This method caused no yield losses.

Non-ploughing systems are a new development in soil tillage (see Chapter 5). Weed control, however, is a restricting factor when switching to such reduced-ploughing or no-ploughing systems.

Controlling perennial weeds

Perennial weeds are another serious problem. Research focuses on testing new methods and machines, such as a root cutting machine to control perennial sow-thistle (*Sonchus arvensis L.*). How deep should such a machine cut and into what lengths should the roots be sliced? The Danish Kvik-up is being tested for the control of couch grass (*Elymus repens L.*). The machine loosens the soil and places the stolons on top of the soil.

Biological soil disinfestation is another method. This technique is primarily aimed at nematodes but it would probably also be effective against annual and perennial weeds. Biological soil disinfestation is a system in which a large amount of fresh organic matter (40 t/ha) is incorporated in the soil. This is then covered with vapour-tight foil for six weeks. Decomposition of the organic matter creates an anaerobic environment, which is expected to also kill the roots of perennial weeds. The efficacy of the method against various perennial weed species has been tested in pot and field experiments. Biological soil disinfestation does not work against amphibious bistort (*Polygonum amphibium L.*) and it works best against perennial sow-thistle. Biological soil disinfestation is also effective against the difficult perennial creeping yellow-cress (*Rorippa sylvestris L.*), which is a problem in organic tree nursing as well. Annual weeds are killed only partly and using organic material infested with seeds of annual weeds can give more weed infestation. The method is promising, but still fairly expensive and difficult to implement because the soil has to be sealed air tight. Further optimisation of the method is necessary.

Intra-row hoe with double blades

The first intelligent intra-row weeder for lettuce was recently improved by fitting the weeder with a cutting blade at either side of the crop row. This reduces the uncultivated area around the crop plant to half, leaving fewer weeds. And because the blade only needs to bridge half of the distance in the row it is now possible to drive almost twice as fast (4 km per h) without damaging the crop. The machine was tested in sugar beet in 2007 and onion in 2008.

Farmers want to see a further increase in the machine's speed, preferably to 7 to 8 km per hour. Possibilities to achieve such an increase will be investigated in the years ahead.

Frans van Alebeek

Strategies against pests and diseases

Growing crops under the best natural and environment-friendly conditions possible. That's what organic farming is all about. Research into pests and diseases therefore primarily focuses on improving systems and preventing infestation. However, even with maximum prevention measures some pests and diseases still cause unacceptable damage. For these residual problems control measures are being developed.

System solutions and prevention focus on issues such as farm structure, crop rotation, variety choice, and stimulation of natural enemies. If growers still face difficult pests and diseases despite all system solutions and preventive measures, they can resort to control by means of physical and thermal measures, light treatment, heating techniques, and mechanical techniques.
In principle, Dutch organic growers do not use European-authorized organic control agents. The use of these products is very low in the Dutch organic farming practice. An authorized product will only be used as an emergency measure if there is no other solution for controlling a very harmful pest or disease. At that point, research is requested to test alternative control agents. This testing focuses in particular on the environmental effects of such a product. Alternatives are currently being sought for crops that still depend on a biological control agent – such as natural pyrethroids against insects.

"Natural pest control is a challenging puzzle"

Frans van Alebeek

Main pests and diseases

Currently the main diseases are late blight (*Phytophthora infestans*) in potatoes, downy mildew in onion, and scab in apple. Thrips is a major pest in several crops such as cabbage, leek, onion and strawberry. Apart from these major problems, there are a large number of smaller ones such as carrot fly and black spot in carrot, cabbage moth in cabbage, pea aphid in peas, and *Septoria apiicola* in celery and celeriac.

Crippled by late blight

Late blight has hit so hard in recent years that organic potato production in the Netherlands has come under threat. Yield reductions of more than 50 per cent are no exception. Resistant varieties are the best remedy against this disease (see Chapter 6) but these are only becoming available sparsely. Various cultivation measures have been tested to suppress the development of late blight in the crop but so far no effective measures have been found. Escaping late blight by growing a very early crop seems to be the only way to ensure a higher yield. As chemical solutions are not allowed or available, Dutch growers are very interested in physical control measures such as the use of UVc light. In greenhouses this method is already being used against a number of diseases, such as botrytis in tomato. The efficacy of the UVc technique has been investigated in potatoes. The machine did indeed kill spores, but as yet it is uncertain whether this effect is sufficient to result in reasonable levels of control under field conditions. The manufacturer has meanwhile improved the machine with guides and air support to open up the potato crop, in order for the UVc light to better reach the oomycete.
In 2007 the problems with late blight were so serious that some growers asked permission to use copper. Unlike in surrounding countries, copper is not permitted in organic potato growing in the Netherlands. These questions are cause for new research. "We will be testing new formulations containing ten times less active substance", says researcher Huub Schepers. "If these would work, they would shed a different light on the discussion about copper. The advantage of these copper products is that with normal use once in a six year rotation, they do not increase the copper concentration in the soil." Besides copper as a preventive product, a new organic product with a very short residual effect will also be tested; this product must be applied as soon as the grower observes the first spores and infestations.

Using UVc light in leek to prevent downy mildew

Innovation Network for Control of Pests and Diseases

The Innovation Network for Control of Pests and Diseases, consisting of fifteen innovative arable farmers and vegetable growers, promotes research that is urgently needed to find practical solutions to farmers' problems. Often these growers conduct experiments themselves as well, for which they frequently call in the assistance of researchers.
Farms are excellent locations for testing and improving new techniques. For example, field tests have recently been conducted on the effectiveness of highly aromatic onion oil against carrot fly in carrot. The idea is that the carrot odour in the field is masked by the oil.
One organic farmer has tested various methods that may suppress downy mildew in direct-sown onions. The results so far are looking promising and further testing will be done in the years ahead.
Testing of the 'Beetle Eater' is another initiative of the Innovation Network. Two growers bought this Canadian 'vacuum cleaner', developed to suck up Colorado beetles, for use against the carrot fly. But the effect was disappointing. Researchers think that the machine certainly has potential against other insect pests such as caterpillars, cabbage white fly and asparagus beetle. In a first test in Brussels sprouts 89 per cent of the adult cabbage white flies were sucked up in one operation.

Control strategies against downy mildew

A few years with very heavy downy mildew infestations in onion resulted in Wageningen UR being asked to conduct a broad research programme for conventional as well as organic onion growing. Various aspects of the disease had to be studied and control strategies had to be developed.
The scientists soon showed beyond doubt that the disease is virtually always found in second-year onion set cultivation. This first infestation comes from systemically infested first-year onion sets in which downy mildew develops rapidly. Therefore it is important to start with clean planting material. Hot water treatment of the onion sets is an excellent solution (see box 'Hot water treatment now standard practice').
During cultivation downy mildew may possibly be prevented by nightly irrigation. The idea is based on the natural behaviour of the oomycete. Spore production normally starts during the night, but only if it is not raining. Farmers are now testing the efficacy of nightly irrigation, together with other measures such as control of spores with UVc light. The UVc-light treatment is expected to show better results in onions than in potatoes because the leaves are more upright and the crop is less voluminous.

Resistance management in apple

Scab-resistant apple varieties are not in themselves the ultimate solution to the problem of scab in apple. Resistance will sooner or later be broken if no additional measures are taken. The chance of this happening can be restricted by resistance management. Such management was found to be effective in systems innovation research with newly planted resistant Santana and Topaz apples. "After seven years the orchard still showed no scab, whereas scab did occur in other organic orchards nearby", says researcher Rien van der Maas.
Resistance management testing has also been carried out on three practical farms, so far successfully. In these tests, different measures are combined to create an effective resistance management system. To start with, scab-resistant apple varieties are chosen as pollinating trees. Sulphur is sprayed on the trees 3 to 6 times during the heaviest scab infestation periods. On the three test farms this is combined with windward planted scab-resistant varieties and a spatial buffer of the Concorde pear to reduce the chance of infestation from scab-infested orchards. Finally, in some years leaf decomposition in winter is stimulated by shredding the leaves and applying organic manure. This counteracts overwintering of the fungus in the event the leaves are infected. New organic scab control agents, such as potassium-bicarbonate, that could widen the possibilities of resistance management are also being tested.
A side-effect of spraying less often with a restricted number of products is that other, sometimes previously unknown, fungal diseases emerge. For example, recently rain spot disease has had to be controlled with coco soap. In particular in 2007, cork-like spots, called Topaz spots, were found in the scab-resistant apple variety Topaz. Research is underway to find solutions to these problems.

Planting field margins with flowers helps control pests

Biodiversity prevents pests

Nature can help suppress pests. This is the well-known principle used by scientists from various disciplines – entomologists, soil scientists, plant breeders, ecologists – and growers for the development of new farming systems. Functional agrobiodiversity (FAB) can be achieved with (a combination of) perennial field margins, flower strips and wooded banks. This is where natural enemies of pest insects find food and shelter and where they can reproduce. The more natural enemies there are near the cultivated field, the more effective they will be in suppressing insect pests in the crops. But this is not where FAB ends. Diversification within fields is another aspect, which involves polyculture of crops, crops with a higher natural pest resilience, mixed cropping and a soil with more natural enemies. All these techniques are studied on Dutch experimental farms. In addition, a group of five organic and conventional farmers in the Hoeksche Waard, a region in the western part of the Netherlands, is focusing on field margins.

Networks of field margins

These five farmers planted annual flower mixtures to form the largest possible length of connected field margins on 250 hectares of combined fields. As a result, for the last two years, they have used no pesticides against aphids in potatoes and cereals. This experiment in the Hoeksche Waard, a flat polder-type landscape, shows that flower banks are not only beautiful but that they are also useful in regulating pests. How pest reduction actually works is studied in detail on a Wageningen UR experimental farm in the Noordoost polder. In an organic farming system of 24 hectares, a network

Hot water treatment is standard practice

"The technique is certainly not new. Hot water treatment has been in use for quite some time in flower bulb growing, for example", explains researcher Huub Schepers. Some years of testing in onion sets eventually showed this to be a very effective preventive method. Organic growers immediately seized the method and turned it into common practice. Growers now let a specialised company 'treat' their first-year onion sets before storage or just before planting. Treatment also contributes to better relationships between conventional and organic growers. In the past, conventional growers put the blame on their organic colleagues, claiming that the organic crops were a source of infestation of their conventional crops. Schepers would also like to test hot air treatment. If successful, this would eliminate the additional step of drying out the onions before they can be stored.

Diversity in and around the cabbage field

Thrips, cabbage fly, cabbage aphid and diamond black moth can cause considerable damage in cabbage. The potential of agrobiodiversity for pest control was investigated in an experiment on a field of 2.5 hectares. The experiment included three systems:

1. **a small-scale cropping system consisting of four cabbage species and grass clover, surrounded by grass-herb and flower margins;**
2. **a small-scale cropping system consisting of headed cabbage with direct-sown onions in between, next to a hedge with a perennial grass margin and;**
3. **headed cabbage in a large-scale system without margins.**

The results of the experiment showed that the type of cabbage has an effect on the severity of damage caused by pests. Brussels sprouts were heavily affected by cabbage aphids and diamond back moth, followed by white cabbage. Red and pointed cabbage (crops with a short cultivation period) showed the least damage. Intercropping (with *Trifolium spp.* or onions) had no effect on pests and natural enemies. A striking observation in 2007 was that more thrips problems occurred in white cabbage alongside a flower margin.

In 2008 the researchers will investigate which species in the flower mixture do or do not attract thrips.

"Our cropping system is not nearly ready for implementation in practice", says Frans van Alebeek. "A proper cost-benefit analysis is lacking and pest suppression in cabbage is still insufficient for practical implementation. It is, however, clear that diversification works."

of field margins was compared with an identical system with a lower percentage of perennial grass margins. Natural enemies such as ground beetles, spiders, syrphid flies, lacewing flies, ladybirds and pests (aphids and the leaf beetle *Lema cyanella*) were intensively sampled. Counts spread over a period of six years showed that field margins are good overwintering habitats for natural enemies, such as spiders and ground beetles. In spring they move into the crops, where they eat pest insects. The number of aphids found in various crops had decreased considerably over several successive growing seasons. Wheat and potato even showed no economic aphid damage at all. An additional experiment showed that beneficial insects can clear no less than 66 per cent of the aphids in spring wheat in one week. However, field margins may have a disadvantage as well. On heavy soils flower-rich grass margins increase the risk of slug damage.

The focus of current research has expanded to include tests of biodiversity in the field (see box 'Diversity in and around the cabbage field'). Because of their economic value cabbage and leek were chosen for recent experiments. Research with leek aims at finding strategies to combat thrips using flower-rich field margins and compost. This compost is applied as a layer that remains on top of the soil. It is expected to have a positive effect on the development of predator insects. They attack the thrips at the moment they fall from the leaves onto the ground to pupate in the soil.

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Health and welfare of organic livestock

Animal health and welfare are important principles of organic animal husbandry. In the Netherlands organic animal husbandry has proven to perform better than the conventional sector on many aspects of animal welfare. The Dutch organic animal husbandry sector has recognised animal health and welfare as crucial and maintains a strong focus on further improvement. Dutch scientists are working to advance the health and welfare of organically kept animals. Additionally, they focus on innovations and directly applicable solutions to specific problems concerning diseases and behaviour. This research is often carried out in close collaboration with farmers.

Maarten Vrolijk

In the Netherlands, as in other Western European countries, the focus on animal welfare has increased strongly in recent years. Not only consumers, but also government authorities and the industry are now paying more attention to this aspect of animal husbandry. Organic agriculture centres on using natural production methods based on respect for animals and careful use of natural resources. This almost implicitly justifies the claim that organic animal husbandry ensures a high degree of animal health and welfare. Strict requirements are adhered to, for instance regarding housing space, outdoor runs, and feed. These exceed minimum legal demands. However, few objective criteria exist to substantiate the welfare claims. Certain measures, such as outdoor runs, even entail risks to animal health and welfare.

"Simple answers and straightforward solutions would be nice, but unfortunately they are not always available", says Maarten Vrolijk. He leads the research programme Organic Animal Husbandry, in which Wageningen UR and Louis Bolk Institute are pursuing a mostly demand-driven approach for developing relevant knowledge regarding animal health and welfare. Vrolijk: "Animal health and welfare are major elements of the programme, and are studied as a whole. Welfare, health, nutrition, and housing can in fact not be considered in isolation. Our research always explicitly involves the entire setup." Vrolijk sees the increased social awareness of animal husbandry as an opportunity. "The demand for sustainable products is now increasing and the organic sector should benefit."

"Welfare, health, nutrition and housing should be considered as a whole"

Maarten Vrolijk

A 2007 study on the pros, cons, and uncertainties related to animal welfare in the organic sector is an example of this integrated approach. The study presents both animal-related indicators for animal welfare and the impact of environmental factors. The results show that the Dutch organic sector scores better marks than the conventional sector on many welfare aspects. At the same time improvements on certain issues are still needed.

Role of farmers

Organic animal husbandry scores well with respect to natural behaviour. Animals are given ample opportunities to behave in a natural way. Examples are rooting possibilities for pigs and the free range system for hens. The sector also performs well with respect to health-related performance, as demonstrated by the fewer metabolic disorders found in organic cattle. There are also points of concern, however. In organic farming piglets run a bigger risk of overlying, for instance. Another example is the more frequent occurrence of lung and liver damage in pigs caused by parasites.

Monique Bestman, researcher of Animal Health and Welfare at the Louis Bolk Institute, stresses the important role of the farmer. “Health and welfare fully depend on what the farmer does. The husbandry system is important but one can still work in an animal-unfriendly way in perfect housing facilities. On the other hand you can find a very animal-friendly approach in less perfect housing facilities.” According to Bestman, the different systems cannot be classified simply as good or bad: “A more principled organic farmer would probably tend to wait longer before treating an infection with antibiotics in order to give the animal the chance to recover without interference. But waiting too long may result in needless suffering. Disease prevention is always preferable to treatment.” In a large project Bestman is monitoring a number of health characteristics in 50 flocks of organic laying hens, while at the same time recording details of their housing and care. Bestman: “We also look back on the rearing period and take the relationship between farmer and animals into account.”

Resilience

Keeping animals in a sterile environment is not acceptable in organic farming because it would be a far from natural environment. Offering optimum freedom of movement, in outdoor runs for instance, is precisely one of the objectives of organic animal husbandry. However, this may have a negative effect on resistance to diseases. “It is logical that the organic sector focuses more on increased resistance and health promotion than on direct disease control”, says Gidi Smolders. He heads a research project on the resilience of organic dairy cattle. In this project, information about health, resistance, welfare and milk production is gathered from about 100 organic dairy farms.

In a completed pilot project Smolders looked at a number of organic dairy farms in the Netherlands where, for practical and idealistic reasons, no antibiotics are used. The image of the sector will strongly benefit from this development, because many consumers of organic products actually already expect that no antibiotics are being used. Smolders: “Lower medicine costs are not a real motive but are seen as a positive side-effect. The peace of mind associated with antibiotics-free production is an unexpected benefit: there is no chance whatsoever of antibiotics getting into the milk tank by accident.” Farmers who avoid antibiotics put much emphasis on creating a herd that suits the conditions on their farm. Production demands are lower as well: annual production per cow is more than 1000 kg lower than on other farms. Smolders: “Udder health in particular requires continuous attention and is thus an integrated part of total management.” Antibiotics are partly replaced by established measures such as milking out, but other alternative therapies such as phytotherapy, homeopathy and other alternative treatments are applied as well. “The farmers are enthusiastic about this method of animal husbandry. Even without a bonus on the milk price, farmers will continue on the antibiotics-free road they have taken. In an organic farm network two groups of farmers will exchange experiences and stimulate each other to eliminate the use of antibiotics as much as possible”, says Smolders. A follow-up project will look for proven effective alternatives to antibiotics, in particular against mastitis.
In another project, the focus is more on selecting the appropriate type of animal for the organic animal production systems. This means types of animal that show less health problems with a higher ratio of roughage in their diet, while maintaining an acceptable production level.

Practical value

The experiments into animal health and welfare are carried out on experimental farms, in farm networks, or on specifically selected farms. Bestman mainly studies poultry on working farms. “This has both advantages and disadvantages. I could have included other factors in my studies, which would have yielded conclusive evidence at an earlier stage. However, the distinct advantage of working on real farms is the high practical value. Anything interesting discovered on an existing farm runs a good chance of being a good, economically feasible alternative”, concludes Bestman.

Monique Bestman

“Health and welfare fully depend on the actions of the farmer”

Monique Bestman

Natural grazing behaviour of goats

Grazing is often difficult to incorporate in organic dairy goat farming. Research by the Louis Bolk Institute shows that various factors are critical to the success of goat grazing. Goat behaviour is an important factor. Goat keepers participating in the 'BioGeit' project therefore asked researchers to analyse the natural grazing behaviour of landrace goats in Dutch nature areas. This resulted in recommendations for improvement in goat grazing. It is important, for example, to have a varied ration supply in the meadow. It is also wise to let goats start grazing at an early age and to leave them outdoors as much as possible. Harmony in the herd is another important factor in creating optimum grazing conditions and for farm management in general. To achieve this, 'escape artists' should always be removed and the structure of the group should be as stable as possible.

Thanks to this kind of practical research we now know that the rearing stage of laying hens is extremely important for health, welfare and egg production at a later age. For instance: the basis for feather pecking, a form of aberrant behaviour, is largely laid during raising. "Chicks that develop well during the first two weeks, that are healthy and that do not peck feathers, will perform well later in life. On the other hand, chickens that do start pecking feathers during rearing, will in fact continue to do so", according to Bestman. In a study that lasted several years she monitored 30 flocks of breeding hens. The hens were reared on different farms and then taken to 40 organic laying hen farms. The chicks were visited four times during rearing and again at an age of 30 weeks. According to Bestman this study shows that feather pecking at a later age can often be traced back to behaviour during rearing. "Often the symptoms during rearing are very subtle but the seeds are sown at that stage. If hens peck feathers during rearing, it only gets worse during laying. Genetic characteristics may be of some importance, but aspects around housing and care during rearing really play a key role in feather pecking. The animals can be prepared for their future housing system by creating the right conditions at the rearing stage.

Organic farrowing pen

Herman Vermeer of the Wageningen UR Animal Sciences Group, also thinks that the rearing stage plays a much more important role than is often thought. According to him this is also true for other farm animals. "Rearing aspects that go beyond the EU regulation for organic pig husbandry are not yet given much attention in organic pig farming, but do offer opportunities. Piglets in European organic pig husbandry are often kept indoors and on a paved outdoor area, as allowed by the EU regulation. We hardly know the effect of early grazing on the social development and resistance of young pigs." Vermeer himself has been closely involved in the design of a better farrowing pen for breeding sows that reduces the risk of piglets being killed by overlying. Because the mother sow has more room to show her motherly instincts in the farrowing pen, more piglets get killed by overlying in the European organic pig sector. They get crushed underneath their mother when she turns over. A diabolical dilemma, says Vermeer: "We have investigated various adaptations to the design of the farrowing pen, such as: heating or no heating around the nest, much or little straw and a low-placed bar to prevent the sow from rolling over. All these had only minimal effect on piglet mortality. We think that little is to be gained from improving the design of the pen; we are now concentrating on identifying good management measures. We will, for example, have to work towards more vital and uniform farrows." The sector has identified various measures, involving for example the monitoring and moving of piglets. The most promising of these measures are being tested on an organic experimental farm and a number of commercial farms. According to Vermeer, such a cooperative approach is a good example of the research philosophy in the Netherlands. "We as researchers provide knowledge and solutions but the pig farmers decide."

Biological fly control

Flies in organic pig husbandry are best controlled by preventive hygienic measures, such as the removal of rubbish, food leftovers, and manure from the pens. Additionally, biological control options with nematodes, predatory wasps or the use of microbial insecticides, such as *Bacillus thuringiensis*, are available. This was found during an analysis carried out by the Animal Sciences Group. Although chemical insect control is not forbidden under current EU regulations, the organic pig farming sector prefers not to use chemicals. The application of chemicals is difficult in any case because organic pigs are free-ranging and thus kept in fairly open systems. Flies are not only irritating to pigs and workers but they can also have a negative effect on production and transmit contagious diseases. Insect traps in which flies are electrocuted cannot be used in animal housing as they only increase the risk of pathogens spreading. Although biological control of flies looks promising, the scientists involved think potential side effects should be looked into first. For now, optimal monitoring and preventive measures seem to provide the best solutions.

Herbs as an alternative veterinary product

In the 'Fyto-V' project, Dutch scientists are working on the identification of herb preparations that may be suitable as veterinary medicines or health-promoting feed additives in organic animal husbandry. Such phytotherapeutics are already being used against a range of animal diseases such as diarrhoea or mastitis, but their effectiveness is frequently doubted. Nevertheless, the interest in herbs has increased, not only in organic farming. At the moment the conventional animal sector is in urgent need of alternatives after a ban on antibiotics as a growth promoter. The Dutch project is coordinated by Rikilt – Institute for Food Safety in Wageningen. So far, very little research into the veterinary application of herb preparations has been carried out. This is remarkable because there are strong indications that herbs such as oregano and garlic are capable of killing malignant bacteria. One complicating factor is that herb preparations involve a mixture of substances, which

Suppressing worm infestations in finishing pigs

Thorough cleaning of the outdoor pen and influencing defecation behaviour seem to help suppress worm infestations in organic finishing pigs. This is the view of Herman Vermeer of the Wageningen UR Animal Sciences Group, leader of a partly EU-financed research project. This study, involving a total of 480 organic finishing pigs was carried out over a two–year period. At the start of the experiment half the animals were placed in a pen infected with eggs of the very contagious *Ascaris* roundworm. After about ten weeks, half-way through the production cycle, half of the pens and outdoor ranges were thoroughly cleaned. "Keeping the dirt areas as small as possible and thorough cleaning does reduce the spreading of worm infestations, but such measures cannot fully prevent infestation", says Vermeer. Infestation causes poor technical results and rejected livers at slaughtering. Pig farmers use conventional veterinary products (anthelmintics) to control this gastrointestinal parasite. "Such pharmaceuticals are in fact in conflict with the philosophy of organic animal husbandry", acknowledges Vermeer. Besides suppressing worm infestation through hygienic measures, the preventive effect of certain herb mixtures against mild roundworm infestations in finishing pigs is also being investigated.

Calves stay with their mother

Calves suckled by their mother or another suckling cow show faster initial growth. This is the result of a comparative study by the Louis Bolk Institute into three calf-rearing methods: feeding with a milk replacer, feeding with tank milk, or suckling for three months. After three months, when they had reached the so-called 'weaning age', the suckling calves had reached a higher body weight. This difference remains visible until the age of one year. This study is part of the project 'Calves with cow', in which a number of commercial farms have adopted a more natural calf-rearing method. Currently, dairy calves are often taken from their mothers immediately after birth for separate rearing. This is a cheap, practical and orderly system. The dairy farmers participating in the project, however, wish to stimulate bonding between cow and calf. They expect this to strengthen the species-specific behaviour of the animals, while also improving their resistance.
The significance of this rearing method for cow, calf, and farm is being investigated in this experiment. Meanwhile, milkable heifers reared in the suckling system are now available on a number of farms; experiences with and performances of these animals can now be taken into account as well.

creates problems for pharmacologists and registration authorities. The Fyto-V database now contains information on the application and scientific background of hundreds of herb preparations currently on the market. Researchers will select the most promising products to determine their effectiveness. Ultimately, the Fyto-V project aims to increase the acceptance of phytotherapeutics that have proven to be effective.

Family herd network

Research in the family herd project goes beyond allowing calves to be suckled longer by their mothers. The intention is to create a husbandry system for dairy cattle in which the animals are kept together as families rather than being separated according to age or production group. While designing this new system, the focus is on animal welfare: in addition to not separating the animals, it includes a lot of grazing, no dehorning of cattle, and improved animal health (due to higher resistance). The envisioned animal husbandry system must also satisfy technical requirements as well as public concerns. Economic sustainability is also paramount. This project of the Wageningen UR Animal Sciences Group is currently still in the design phase. Twelve organic dairy farmers have volunteered to participate in the project.

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Animal production and feeding

Organic livestock farmers will try to accommodate the natural needs and behaviour of their animals as much as possible. They pay extra attention to animal health and welfare, but also set high standards for housing, outside access and feed. Dutch researchers are looking for practical solutions to the problems that currently limit the sustainability and growth of organic animal production.

Research carried out in the various sectors of organic animal production is directed not only toward improving animal health and welfare, but also at achieving 100 per cent organic livestock farming. This encompasses all aspects of production, including rearing, feeding and manure use. One of the main objectives is to create husbandry systems that provide the animals with a relatively high degree of freedom and in most cases outside access. Straw or other forms of litter are also indispensible as they offer housed animals a semi-natural area to stand or lie down in.

Organic livestock farming in the Netherlands is quite specialised. Especially pig and chicken farms use feed produced elsewhere, making it difficult to close mineral cycles on the farms. For this reason, development of the organic sector will depend to a large extent on the regional exchange of feed, straw and manure between arable farms and specialised livestock farms.

"Growth is important for organic livestock farming. The sector is currently too small and thus especially vulnerable to market swings. We hope that our research will inspire experienced as well as new entrepreneurs to make the switch", explains Maarten Vrolijk, leader of a demand-driven research programme on organic animal husbandry involving Wageningen UR and the Louis Bolk Institute. Knowledge circulation has received special emphasis in this research programme. "This applies not only to existing formal knowledge among established experts or researchers, but also to knowledge gained through experience in the field. Participation of livestock farmers in research projects is very important to us", says Vrolijk. In every sector – dairy cattle, pigs and poultry – collaboration is sought with thematic study groups consisting of advisors and organic livestock farmers. These groups facilitate the exchange and application of knowledge, and are supported where necessary with problem-directed research.

Experimental farms

Every agricultural sector in the Netherlands has access to its own experimental organic farm: Aver Heino for dairy cattle, Raalte for pigs and Spelderholt-Lelystad for poultry. These centres carry out experimental research, often in collaboration with research being conducted at commercial farms. The experimental farms also function as knowledge centres for the corresponding sector by offering demonstrations, theme days, excursions, open days and courses.

Ina Pinxterhuis

"Clover is the green motor of organic dairy"

Ina Pinxterhuis

Dairy cattle

The positive image enjoyed by the organic dairy sector has resulted in a growing demand for organic dairy products, but also in high expectations. Consumers naturally assume, for example, that organic cattle farms are more environment-friendly than conventional farms. To live up to its image, the organic dairy sector is striving, among other things, to achieve 100 per cent organic feed (see box) and closed nutrient cycles. The fixation of nitrogen is an essential factor, and clover is expected to play a key role in this regard. “Clover is sometimes called the ‘green motor’ of organic dairy farming”, says Ina Pinxterhuis, dairy farming expert of the Animal Sciences Group at Wageningen UR.

Conventional dairy farmers intending to switch to organic production have to first increase the proportion of clover in their pastures. Pinxterhuis: “In permanent grassland, clover needs a few years to become well established. If sufficient time is not allowed, discontinuing the use of synthetic fertilizers could lead to a significant decrease in production. On an annual basis, a 40 to 50 per cent proportion of clover in the grass is optimal for both dairy and grassland production. The proportion of clover can decrease quickly due to weather conditions in the winter period or serious drought in the spring or autumn, but it normally increases during the growing season. Pinxterhuis: “There are no general guidelines on how to achieve a certain proportion of clover in a pasture, but we have been able to compile a number of basic rules for cutting and harvesting. The proportion of clover decreases, for example, if the sward is cut too short or with heavy cuts. By adding clover to the production system, the farmer becomes more dependent on nature, but this is a basic aspect of organic farming.”

The ultimate objective of current research is to ensure that Dutch organic dairy farms use organic rations made up of locally or regionally produced raw materials, and that they supply manure for the production of these raw materials. This closed cycle will require, among other things, insight into the efficient use of manure in both crop rotations and grass-clover production (see Chapter 5). Another important factor, and subject of continuing research, is the farmers’ own production and efficient use of fodder. The organic sector is currently leading the development of regional and land-based farming systems, and it wants to retain this lead. Pinxterhuis: “Importing raw materials for livestock feed is not consistent with society’s image of organic farming.” For this reason, a regional project was set up to look for optimal linkages between crop production, animal husbandry, and nature and landscape management. The idea is that new forms of regional cooperation will lead to more efficient land use, more closed nutrient cycles, greater biodiversity and local, high-quality products” (see box on Overijssel in Chapter 4).

Pigs

“Our research is chain driven; the industry sets the agenda. The emphasis on animal nutrition is therefore not surprising. Feed still makes up the largest part of the cost price, especially in organic pig farming”, says Herman Vermeer, researcher in pig farming at the Animal Sciences Group. “About 10 per cent of the pig feed currently used in organic production is made up of conventional raw materials. This percentage is slowly decreasing in response to stricter European regulations. By 2012 the organic pig sector will be required to use 100 per cent organic feed. At the moment organic raw materials for feed are still scarce and therefore expensive. Switching to locally grown organic raw materials will also have important consequences for the ration composition”, explains Vermeer. The protein content of organically grown feedstuffs is generally lower than that of conventionally grown feedstuffs. Digestibility research is therefore being carried out to help the feed industry optimise the composition of organic feeds (see box ‘Digestibility of organic raw materials’). Researchers are also looking at ways to influence the feed intake of finishing pigs. “At the moment we are looking at feeding grass silage to sows. In practice this is often given as a supplement. The sows are large and robust, and the initial results are positive”, says Vermeer.

100 per cent organic feed for dairy cattle

Since early 2008, all feed given to organic ruminants has to be from 100 per cent organic sources. The experimental farm Aver Heino has for a number of years been investigating ways to optimise feeding strategies and rations for dairy cattle. This research is focused especially on maintaining high protein efficiency and sufficient mineral supply for animals given 100 per cent organic feed. One option being considered is using domestic grain in place of concentrates. Grain has a high starch concentration and low protein content, but grass-clover silage can supply the protein needed to break down the starch in the cow’s rumen. Research has shown that it is possible to feed a lactating cow six kilograms of wheat per day. Despite the low protein levels in the rations, the cows produce a sufficient amount of milk. No negative effects on the animals’ health have been found. Other research is investigating whether adding corn starch can improve the utilisation of a ration containing grass clover. Red clover is often used in organic livestock farming as a feed crop. The Animal Science Group and Belgium’s Institute for Agricultural and Fisheries Research (ILVO) are currently looking for a way to accurately estimate the nutritional value of grass-clover (red or white) mixtures.

‘Organic goat’ project

The ‘organic goat’ project coordinated by the Louis Bolk Institute is a dynamic knowledge development project that has no fixed partners. Any organic goat farmer may participate in the research. About 70 of the 600 goat farms in the Netherlands are organic, and they are all welcome to suggest new ideas for research through their sector representatives. The research carried out within the organic goat project relates to both nutrition and health. For example, researchers are looking at ways to discontinue the use of synthetic vitamins, optimise rations, manage cost price, and enhance distinguishing product quality and animal welfare characteristics. A study on the fatty acid composition of goat milk was also recently completed. Compared to cow milk, goat milk has a higher content of two medium chain fatty acids (capric acid and caprylic acid) and about the same amount of polyunsaturated fatty acids (CLA and omega-3). Feeding the goats fresh grass and adding oil to their rations increases the levels of these desirable fatty acids in their milk. Sunflower oil is especially good at stimulating the CLA content and linseed oil at increasing omega-3 levels. Higher levels of unsaturated fatty acids are not only beneficial to human health, but they can also help produce creamier goat cheese that is sliceable after just a short ripening period.

Herman Vermeer

The organic pig sector has also instigated research on organic breeding techniques. At the moment, sow stocks are replenished with conventionally reared sows, in addition to the sows reared by the organic farmers themselves. It would be costly and difficult to set up a separate breeding farm for organic pigs, because of the industry’s limited scale and the specific characteristics of organic animal husbandry in the Netherlands. However, to meet European regulations and become free of conventional inputs, the sector will have to supply its own sows in the future. A preliminary feasibility study revealed that this would lead to a significant cost increase of 7 Euros per pig and 12 euro cents per kilogram of slaughter weight. The technical aspects of breeding organic sows are also being investigated, including race options and breeding structure. The objective is to develop a more robust and resilient pig that is better suited to organic conditions. Together with the breeding organisation TOPIGS/IPG, research is being conducted to find a more suitable sire for organic pork production.

Housing is also being looked at in close cooperation with the industry. Vermeer: “Organic pig farmers planning to build new housing units often come to us for advice.” Many find inspiration in the animal-friendly housing concept ComfortClass developed at the Raalte experimental farm. Research findings have already led to practical applications, says Vermeer, including the discovery that social structures in groups of pigs are important. Groups should therefore be kept together as long as possible, from rearing all the way through to finishing. “This can actually be achieved quite simply, for example by building stalls in new housing units that correspond to the pigs’ sizes in each consecutive stage.”

Digestibility of organic raw materials in pig feed

Until now, the feed industry has assumed that organic raw materials have about the same composition and digestion coefficients as conventional, non-organically grown raw materials.
Research initiated by organic pig keepers in cooperation with the feed industry has shown that protein-rich organic raw materials, such as rapeseed and soy flakes, have a lower content of crude protein, crude cellulose and crude ash than the same non-organically cultivated crops. Their fat content and energy value are also higher than the figures given in conventional tables.
This was demonstrated by experiments on finishing pigs that looked at the intestinal and faecal digestibility and nutritional value of organically produced raw materials (such as flakes of rapeseed, soy, sunflower, sesame seed and blue lupine). The study determined the digestibility of the dry matter, organic matter, ash, crude protein, crude fat, non-starch polysaccharides (NSP), amino acids and starch.
Research into the digestibility of nine commonly used organic, high-energy and crude cellulose-rich raw materials, such as grains and wheat semolina, is still underway. At the Raalte experimental farm, research into the digestibility and nutritional value of organic forage for finishing pigs, such as grass silage and forage maize, is ongoing.

“The organic pig sector sets the agenda for our research”

Herman Vermeer

Group size of finishing pigs

It makes no difference, in terms of technical results or slaughter quality, whether organic finishing pigs are kept in groups of 15 or groups of 30. This was the conclusion of research carried out at the Raalte experimental farm. "Curious", says researcher Herman Vermeer, "because at conventional farms there is a significant difference between these two groups. There the animals perform better in small groups." The research was initiated because many organic pig farmers in the Netherlands have been forced to keep their pigs in relatively large groups (of 30 or more). Farmers' options in constructing outside runs have been limited by the layout of existing stalls. "These building limitations are not a problem when new housing units are constructed; the farmers can then choose to keep smaller groups. Our research demonstrates, however, that this is not necessary to achieve better results", says Vermeer. The health of the animals in the differently sized groups was also basically the same. There could still be other arguments for choosing smaller groups. For example, keeping smaller groups makes it easier to sort the pigs by weight and sex.

Poultry

Housing and feed are also important themes for research on organic poultry farming. Since there are very few organic broiler farms in the Netherlands, most of this research is focused on laying hens. The number of organic laying hen farms is growing steadily. "There are currently almost one million organic laying hens in the Netherlands, divided over 160 farms. We think it's important that these companies do well, and we therefore support them with research", reports Monique Bestman, poultry researcher at the Louis Bolk Institute.

"The outdoor run receives special attention, as it is the showpiece of organic farming. Consumers and farmers find it important, but its primary purpose of course is to improve the welfare of the chickens. The objective is to allow the chickens to behave naturally – to scratch and dust-bathe", explains Bestman.
Research conducted by the Louis Bolk Institute and the Animal Sciences Group of Wageningen UR revealed that the design of the run is very important. "Chickens have the tendency to seek cover, which makes them feel safer. Good landscaping, that includes trees for example, helps to entice the chickens out of the coop", says Bestman.

Outside access also has important environmental consequences. Research has shown that the amount of manure accumulated in outdoor runs can be too high. Bestman: "It is especially important that the area directly around the coop be designed in such a way that the manure can be removed." The Animal Sciences Group has also conducted several long-term projects on keeping dioxin levels in outdoor eggs within EU standards for safe food products. Although 95% of the farms in the Netherlands no longer have a problem with dioxin levels, a limited group of small poultry farms is still at risk. This is probably because these laying hens use the run more intensively and thus ingest more soil, worms and insects. Simple measures, such as restricting the amount of time the chickens are allowed outside, are enough to ensure that dioxin levels on these farms also stay within the established norm. This knowledge is valuable for organic egg producers throughout Europe.

The researchers also measured the amount of dust chickens are exposed to when kept temporarily indoors, for example during risk periods for avian influenza. The average dust concentration in the stables was 4.5 mg/m^3, which was well above the norm of 3.4 mg/m^3. Feather pecking is also a major problem among chickens that are only kept indoors, concludes Bestman. "The research confirmed what we already knew: an outdoor run is very important for chickens."

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10 Special branches: organic greenhouse production, bulbs, ornamentals and aquaculture

Organic production methods are gaining ground in Dutch specialised production branches. Interest is growing among greenhouse horticulturalists and growers of flower bulbs, ornamentals and mushrooms. In organic horticulture Dutch research is unique in the world in thinking up innovative concepts and pioneering solutions. Ultimately this will also inspire change in the conventional sector.

Rob Meijer

The Netherlands has a variety of specialised, capital-intensive branches of agricultural production, which are characterised by high turnover and a strong focus on exports. Researchers and farmers are exploring the opportunities for organic production in these branches. So far little or no research has been conducted and in some cases organic standards are still to be developed. Yet these branches do offer opportunities for organic production. Moreover, the alternative approaches needed for the organic sector can inspire the conventional production to move towards a more sustainable production.
Research programmes are linked as closely as possible to practical needs. “We work in close cooperation with producers and chain partners”, says Rob Meijer, coordinator for Covered Organic Cultivation. Researchers work together with the organic sector on sustainable organic farming systems that are economically viable.

Organic greenhouse horticulture

Growing market demands have stimulated an increase in organic production, especially of greenhouse fruit vegetables and leafy vegetables. About 35 organic greenhouse vegetable farms (25 of which have intensive heating systems) together cover an area of 85 hectares. “Each year the number of organic farms increases”, says Meijer. “This steady growth takes place primarily in greenhouse vegetables, such as cucumbers, tomatoes and sweet pepper. More than 80 per cent of these vegetables are exported”.
Organic greenhouse cultivation has its own specific problems, such as high yield loss due to diseases and plagues caused by intensive use of the soil. In open-field organic cultivation the soil stays healthy thanks to a diverse crop rotation. “But greenhouses are far too expensive to leave fallow or to produce crops with a low turnover”, says Meijer. “And crop rotation is not as easy. Tomatoes and capsicum, for example, both belong to the Solanaceae family, and they therefore contract pretty much the same soil-borne diseases, such as root-knot nematodes. And cucumbers are not very far away in the family tree either.”
Conventional fruit vegetable growers begin each new crop on a clean substrate. But this is not an option for organic growers, nor can the corresponding solutions using synthetic fertilisers be applied in organic cultivation.

“Achieving soil resilience is the biggest challenge in organic greenhouse horticulture”

Rob Meijer

Root damage caused by root-knot nematode

Meijer: “In spite of the compulsory crop rotation of 1 to 2, disease-causing nematodes and the wilt disease *Verticillium*, sometimes increase dramatically. Due to disease and damage, the yields after a few years will average no more than 70 per cent of the normal yield.”
Much research is therefore being conducted into the disease-resistant characteristics of soil life, and the optimal application of organic fertilizer to feed soil life and stimulate antagonists.
In a project called ‘Biowisselkas’, researchers are experimenting with antagonistic crops, alternative crops and fallow periods. This has led to the development of an interesting cultivation system in which cucumber plants in the greenhouse are alternated with beds of Tagetes (see box ’Controlling soil pathogens in greenhouses’). We have also thought about summer flowers as an antagonistic crop, but most fruit vegetable growers are not very interested in cultivating cut flowers. Organic flower cultivation requires different know-how and the distribution channels are not as well developed yet. It is difficult for organic flower growers to stay on the market year-round using only natural cultivation techniques and no assimilation lighting.”
The new ‘ Biovitaalkas’ project, aims to find precise and measurable criteria to define soil health and resilience. Meijer: “Achieving soil resilience is the biggest challenge in organic greenhouse horticulture.”
Generous use of compost and other organic material to improve the soil in organic cultivation can lead to excessive leaching of minerals. Research is therefore also focused on creating a better mineral balance through efficient fertilisation techniques or recycling nitrate.

Energy use in greenhouses is another issue that needs attention. Lower yields in organic cultivation lead to higher energy use per ton of product compared to conventional cultivation. Extra heat is also lost when the greenhouses are aerated in the mornings. Organic growers are always concerned about condensation on their plants, which can lead to fungal diseases. Soil-based organic cultivation also requires more energy than substrate cultivation because moisture is lost from the soil when windows are opened to air out the greenhouses. Both organic and conventional greenhouse growers strive to drastically reduce the energy use in their greenhouses. The ultimate goal is to make greenhouse production climate neutral.
Research towards reducing the energy use in glasshouses for conventional and organic agriculture is carried out jointly. Several innovations are already being used or tested in practice. One example is using residual warmth and CO2 of the generators that produce electricity for the greenhouse. Some greenhouse growers are also using waste materials for their heating. A new development is to store the surplus of warmth in the summer in underground water layers. During winter the warm water is pumped up and used for heating. Developments progress fast and greenhouses have the potential to eventually become net producers of energy.

Organic production of ornamentals

There are about 50 organic ornamental tree growers in the Netherlands. “Together with producers and potential institutional customers, we are looking at the marketing perspectives of organic tree

In the Köver system the strips of soil with different crops are separated to prevent cross-contamination

Controlling soil pathogens in greenhouses

In organic greenhouse production, controlling soil borne pathogens such as *Verticillium* and nematodes is a big challenge. Endoparasitic nematodes cause high yield losses. They invade the roots, damage plant tissue and obstruct root functions. Important species in this respect are the root-knot nematodes (*Meloidogyne spp.*).
Research has been looking at the possibilities to prevent or control these parasitic nematodes. Preventive measures are the first to be considered. Resistant or tolerant rootstocks could be used, but these rootstocks only prevent the damage. They do not influence the propagation of nematodes.
Crop rotation is an important preventive measure. Unfortunately however, most fruit crops grown in greenhouses are genetically closely related and suffer from the same pathogens. Researchers and growers are therefore experimenting with other kinds of rotations. A fallow period could help, especially when this period is used to grow green manure crops which reduce the nematode population. Marigold is a good option. But greenhouses are very expensive, so from an economical point of view fallow periods should be as short as possible.
A special kind of crop rotation that can be effective to prevent nematode infection is so-called strip cropping. The cultivation beds are divided into strips and alternatively culture plants and green manure crops are grown on the strips. The green manures that are used are able to reduce populations of soil pathogens. Marigold for example is effective against nematodes like *Meloidogyne* species. In the so-called Köver system one further step is taken by also separating the strips of soil physically.
The Köver system is tested in practice by greenhouse farmers. In cucumber and tomatoes this system proved to be applicable without any yield loss. With sweet pepper yield losses of 10% were measured.
When the population of parasitic nematodes becomes too high, control measures have to be taken. Soil steaming is an option but it is not a very sustainable solution as this method requires a very high energy input.
Researchers are experimenting with biofumigation in greenhouses. With this technique a large volume of green manure is incorporated in the soil. Specific types of green manures are used; the manure should contain compounds toxic to plantparasitic nematodes, for example mustard.

Perennial ornamental plants combine well with ornamental tree cultivation

nursery products", relates project leader Henk van Reuler. "This is the common dilemma of which comes first, the chicken or the egg. As long as buyers are not aware of what is available, where it can be found and when it can be supplied, demand will remain limited. And this does not stimulate supply. Moreover, tree nursery products are attractive, regardless of whether they are cultivated organically. They are not edible, so consumers will not specifically request organic products for health reasons."

In recent years research has been conducted into combining other crops with ornamental tree cultivation. "Our research has led to interesting, practical recommendations and crop combinations. In the cultivation of ornamental trees, for example, natural enemies can be stimulated by a combination with the cultivation of perennial ornamental plants that attract insects. Veronicas, for example attract hover flies, which feed on the larvae of aphids."

"Weeds are a big problem in organic cultivation of ornamentals", Van Reuler continues. "And weed control is always very time-consuming. Organic growers of ornamental plants use mechanical weed control methods and are experimenting with soil covers that are applicable in organic cultivation. With mechanical weed control there is a big risk of damaging the crop, which would result in an unmarketable product. We are looking into new mechanical techniques, such as a guided hoe, in combination with torsion weeders. These techniques have already proven their value in arable farming."

Organic bulb and flower cultivation

The Netherlands is the world's largest producer of flower bulbs, with a market share of about 70 per cent. Tulips, daffodils, lilies, crocuses, hyacinths, grape hyacinths, dahlias and other flowers are grown on an area covering more than 22,000 hectares. The flower bulb branch is among the most profitable Dutch agriculture. Currently only one per cent of this area is cultivated organically. The cultivation of flower bulbs and the production of cut flowers from bulbs are important economic activities. Both in organic bulb and bulb flower production, researchers and farmers have been working together to develop knowledge for a sustainable and economically viable production. Research has helped to overcome important bottlenecks for organic production, such as fertilisation and pest control.
The dry bulb mite, *Aceria tulipae*, is the most important pest in tulip crops. Without control measures cropping of tulip bulbs in the Netherlands is impossible. Researchers have developed a new treatment with a short ULO (Ultra Low Oxygen) treatment of flower bulbs in the storage which is effective. However the treatment is quite expensive and hard to organise. Scientists and farmers are still working hard to find a solution (See box 'Combating dry bulb mite in tulips').

Flower bulbs are traditionally cultivated in a rather limited crop rotation, which leads to many soil-borne diseases. The project 'Topsoil+', is directed toward developing new organic farming systems in which flower bulbs, such as tulips, daffodils or hyacinths, are rotated in an extended crop rotation supplemented with summer flowers, small ornamental shrubs and sometimes alternated with green manure crops. Smaller varieties of the more expensive ornamental shrubs, such as smoke trees (*Cotinus*), are of particular interest. Van Reuler: "The sand in the flower bulb cultivating region is rather course, and can thus be flushed out pretty easily. This makes it lucrative to export flower bulbs together with ornamental shrubs in one package to the United States. For phytosanitary reasons, the United States does not accept import products containing soil."
In addition to creating a more varied crop rotation, the increased supply of organic matter also helps suppress soil-borne diseases. Tests have demonstrated a clear effect of the previously cultivated crop and the level of organic matter on the presence of root-knot *Meloidogyne hapla*, which is a problem for many perennials. This effect has been supported by field data. Says Van Reuler: "Apparently the soil's resilience is enhanced by a richer soil life, which is stimulated by a bigger

Combating dry bulb mite in tulips

Dry bulb mite (*Aceria tulipae*) is a major problem for Dutch organic tulip bulb producers. The mite causes a lot of damage to the bulbs, especially during storage.
If the mite cannot be controlled, organic tulip bulb production is virtually impossible.
The most effective way to combat dry mite is the Ultra Low Oxygen treatment (ULO). This method however, is costly and logistically difficult. Also, with ULO all bulbs are treated whereas less than 50 per cent are actually infected.
In recent years, researchers and growers have tried to come up with a way to suppress dry mite using mite pathogens. Although half the infections could be resolved, the side-effects of these treatments were too severe. The main problem of this wet treatment is that the conditions are beneficial to the fungus *Fusarium*, which causes severe damage to the bulbs.
Because ULO is expensive and treatment with mite pathogens was not a good option, new ways out of the Aceria-problem are sought. Growers are in need of a good detection method, to quickly discover whether a batch of bulbs is actually infected with dry bulb mite. This way only the batches that are actually infected can be treated using ULO. Costs for treatment would then go down by more than half, as less than 50 per cent of all bulbs are expected to be diseased.
Researchers are now developing early-detection methods for dry bulb mite. One option is a special mite trap, the so-called Bt-trap. These Bt-traps are currently being tested in a number of bulb storage units. Growers use the traps to determine whether mites are actually present in their bulbs. Early detection of dry bulb mite can also be beneficial to conventional bulb producers, as it can save time, money, labour and chemical disinfectants.

Three tulip bulbs with from left to right: no infection, light infection and heavy infection with dry bulb mite

supply of organic matter. This knowledge could be of interest to conventional growers as well".
Another developing branch is the organic cultivation of cut flowers. These are produced in the greenhouse, in open cultivations and as flowers from flower bulbs. Sunflower is an important product for the summer season. The main challenge in this sector is to solve the problems with downy mildew. There is a demand for cut flowers all year round, not just for sunflowers in summer. Therefore, research is searching for a wider range of species and varieties that can be produced organically in the greenhouse (see Box 'Selecting Organic Flowers).

Organic aquaculture

In recent years there has been a growing interest in the socially and ecologically responsible production of fish. Animal welfare and sustainability are key considerations. Certain cultivated fish species can help lower the pressure on overfished wild populations. With plant-eating fish species like tilapia, for example, farmers can avoid the use of high amounts of fishmeal in feed, for which other fish would have to be caught. The development of organic fish production can help to improve welfare and sustainability aspects of fish farming.

Selecting organic flowers

Organic flowers are sold mostly in bouquets and sunflowers are the main flowers in these bouquets during the summer season. To facilitate organic bouquets year-round, new flower species should be grown in greenhouses. Unfortunately, research has shown that not all types of conventionally cultivated flowers and varieties are suitable to organic cultivation.
Tests on Marigold (*Calendula*), Star-of-Bethlehem (*Ornithogalum*), Lesser Bullwort (*Ammi visnaga*), Mexican marigold (*Tagetes erecta*), False Spirea (*Astilbe*) and Peruvian Lily (*Alstroemeria*), among other flowers, were conducted on test farms and cultivation guides were compiled for growers.
Most cut flowers can be produced relatively well under organic conditions. But not all periods in the year are feasible. It is especially difficult during periods in which conventional growers also have problems. The shelf life of *Calendula*, for instance, is a problem when this species is harvested during hot periods. And *Ammi visnage* is susceptible to secondary growth and neck rot. A few general issues that growers have to pay close attention to are: the vigour of the soil, the limited marketing channels, and the availability of organic means to control the most important pathogens.

Organic wine from the Netherlands

Dutch wine tastes pretty good. On a scale of 5 points, consumers awarded the wine an average of 3.4. According to market researcher Dr Frans Verhees from Wageningen UR, the taste will still have to improve if winemakers want to move into new markets. “In the gift market, customers are willing to pay the higher price because of the story behind the wine, but serious wine buyers are looking for quality.” Thanks to the emergence of new mildew-resistant and early-ripening varieties, organic wine production in the Netherlands is growing. With increasing production, marketing has become an important issue. Therefore a survey was carried out among wine buyers, at the initiative of the association of winemakers in Groesbeek and the Wijnbouwcentrum Nederland. It turns out that only two per cent of Dutch consumers prefer to buy wine produced in their own country.

To improve the image of locally produced wines, courses, wine certifications and the introduction of a quality label could help. A better image could stimulate the production of quality Dutch wines. It would not be advisable to try and compete on price with the common wine-producing countries. Verhees: “Cost prices are relatively high here, so the market for Dutch wine will always remain a niche market.”

“We are working on new methodes to measure stress levels and welfare in fish”

Marnix Poelman

Currently there are no certified organic fish farmers active in the Netherlands, but interesting innovative concepts are being developed. “The Netherlands is an important global player in the use of recirculation systems to raise fish and shrimp”, explains researcher Marnix Poelman of IMARES of Wageningen UR in Yerseke. “This system does not use a continuous stream of water: almost all the water is recycled in large breeding tanks. It is purified through filters and other technical means. The Netherlands would like to obtain an organic certification for these recirculation systems.” The Dutch firm AgroEco is leading these efforts.

In a conventional fish production system the objective is to increase production. In an organic fish production the idea is to create conditions in which the fish can behave as naturally as possible, even if this reduces production capacity. “If a fish grows normally, is not sick, eats well and is not damaged, we generally assume that it feels good”, says Poelman. “But these are definitely not the best parameters for animal welfare. That’s why we are working on new methods to more accurately measure stress levels and welfare in fish.”

Throughout the world there are various certifications for organically grown fish, but these pertain to pond systems or net cultures in open water: the cage constructions that can be found along the Canadian and Norwegian coasts, among other places. Poelman: “A European organic label for fish production is currently being developed. This label sets a number of requirements for aquaculture products such as the maximum fish density in the system, the allowable percentage of vegetable matter in fish feed, and various environmental demands. Poelman and his colleagues are evaluating these regulations and are drawing up welfare criteria for organically raised fish. The IMARES expertise is used to contribute to the discussions in Brussels.

At this moment the focus is on common cultivated fish species, such as tilapia and catfish. But shrimp could also be produced organically in the Netherlands. Furthermore, IMARES started a feasibility study for the organic production of mussels. In this case the focus is on ecological aspects and water quality. “We have great expectations”, says Marnix Poelman. “With mussels very little input is needed: it is almost organic to begin with. The only aspects that need to be optimised are the collection of mussel seed and the processing requirements.

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11 Healthfulness and quality of products

Organic producers strive to deliver organic products that have outstanding health benefits, quality and taste. This ambition is supported by research. Scientists are looking for evidence to prove that organic food is healthier and for ways to improve its quality and taste.

Lucy van de Vijver

Healthfulness of organic produce

Many consumers buy organic products because they assume these products are healthier. Despite the great need for it, so far little evidence to back this claim has been presented in scientific literature.

Dutch researchers have taken on the challenge of addressing this research question. Their approach is unique in that they are not only analysing the nutrient content and possible harmful components of organic products, but also carrying out investigations involving consumers, to determine the actual impact organic food has on human health. One example is the Koala birth cohort study, which focuses in particular on the effect organic food has on allergies (see Box 'More CLA in breast milk').

From a scientific perspective, the only way to definitively demonstrate the health effects of a certain type of food is to conduct an intervention study. To do this, people have to be selected and then assigned to one of two groups. From that moment on, one group is given only organic food to eat, and the other group is given conventional food. This type of study is very expensive and generally very long term. To come to any conclusions in the short term about health effects, scientists need to find biomarkers known to influence health over the longer term.

"Finding biomarkers for positive health effects takes a lot of time"

Lucy van de Vijver

A lot of research has been conducted into biomarkers for specific diseases, but very little into biomarkers for good health. The Dutch researchers therefore began looking for such biomarkers in chickens (see Box 'Biomarkers for health effects'). This type of research takes a lot of time. Moreover, indications gained through research with model animals, such as chickens, are not enough. Repetition is needed, preferably also in animals such as pigs, which physiologically resemble humans. "Not only do we need to find health effects, we should also explain their causes. All of this can easily take ten years", explains Lucy Van de Vijver, programme director of Food Quality and Health at the Louis Bolk Institute.

More CLA in breast milk

Mothers who consume dairy products that are at least 90 per cent organic have more Conjugated Linoleic Acid (CLA) in their breast milk than mothers who consume conventional dairy products. Their children have a 30 per cent less chance of suffering from eczema at the age of two if they too consume dairy products that are at least 90 per cent organic. This was demonstrated by the initial results of the Koala birth cohort study. It is assumed that CLA has a positive effect on human health.

The Louis Bolk Institute began this research in 2000. Koala is a Dutch acronym for Child, Parent and Health, Lifestyle and Genetic Constitution. It is a prospective birth cohort study designed to identify factors that influence the clinical expression of atopic diseases such as eczema and wheezing.
At the start of the project almost 3000 pregnant women were recruited. The researchers were especially looking for women with alternative lifestyles. For this reason, the study group contains a relatively high number of women who eat organic food. They represent about 15 per cent of the group, whereas only 2 per cent of the Dutch population falls into this category. Through detailed questionnaires, information was collected when the women's infants were 3, 7, 12 and 24 months of age. Researchers expect that the effect of organic food consumption may become even more evident as the children grow older. They therefore want to prolong this study.

Biomarkers for health effects

Small differences in feed have implications for immune reactivity, metabolites and gene activity in healthy animals. This was demonstrated through research with chickens that were fed either organic or conventional feed. This research is the first step on the way to using biomarkers in research involving people.
In the experiment, two generations of chickens were fed either organic or conventional feed. An important prerequisite for this kind of research is that the exact origin and composition of the feed be known and that the two types of feed be otherwise as identical as possible. The ingredients of both the organic and conventional feed originated from controlled production or farms known for their use of best practices. The most consistent difference between the two types of feeds is that the conventional feed had on average a 10 per cent higher protein content.
The chickens in the study were monitored very closely, and the clearest differences between the two groups were found in weight, responsiveness of the immune system, metabolism reactions in the blood and liver and gene regulation in the intestine. These appear to be interesting biomarkers for the relation between food and health. While the research results do not necessarily indicate that organic food is 'healthier', most of the researchers cautiously conclude that organic food may contribute to the 'preservation' of good health.

Components of organic food

In addition to looking at the effects organic food has on health, research is focused on the specific components of different foodstuffs. Dutch researchers are investigating a whole range of products produced in the Netherlands, including eggs, cabbage, carrots and meat. Although similar studies have taken place in other countries, it is necessary to repeat this research in the Netherlands because soil, cultivation methods and animal husbandry systems may differ among countries.

In this research a distinction has been made between substances known to have beneficial health effects and substances that are potentially harmful. In the first case, researchers would like to find specific links to organic production. In the latter case, the intention is to eliminate or minimise any negative images related to organic products. In both cases, extensive analysis of the products is required – not only to establish what is in them, but also to find evidence of more positive factors and hopefully reduce the number of negative factors associated with organic production.

Large variation

One difficulty in researching the components of food products is the large variation that can be found. "There are differences between organic and conventionally produced products, but they are often not large enough to be significant. Moreover, these factors vary too much within the products themselves", concludes Van de Vijver. Her comments are based on comparison of the different studies conducted in the Netherlands and abroad. Take, for example, the polyphenols.

Contaminants and micro-organisms

For years, many researchers and the conventional food sector believed that organic food increases food safety risks. This idea surfaced repeatedly in studies based solely on theoretical assumptions. The organic sector wanted to find out whether this was actually true.
Researchers consequently studied animal and plant products, looking for potentially hazardous contamination with heavy metals, mycotoxins, pesticide residues, pathogenic micro-organisms and nitrate. The result? Only organic carrots showed on average a higher nitrate content than conventional carrots. However, the variation between samples was very large. These findings have already resulted in specific recommendations for the fertilisation of carrots.
Otherwise no differences were found between the two systems with respect to the presence of metals and mycotoxins. Campylobacter was more common among organic chickens. The presence of Salmonella in pigs depended on the experience of the farmer. One-third of conventional pigs are infected with the bacteria. Among organic pig farmers, one half of those with one to four years of experience had infected animals, whereas Salmonella was found on only one in fourteen farms run by farmers with more years of experience. As expected, no antibiotics and much lower levels of antibiotic-resistant bacteria were found in organic meat and eggs.

These secondary plant metabolites are assumed to inhibit infection in humans. Of the fifteen studies that have looked into these components, eight concluded that organic products have more of these healthy substances, five found no difference, and two found fewer in organic products. In addition, the variation among the results was very large – too large to claim that "organic food contains more healthy nutrients than conventional food". Therefore, Van de Vijver can only conclude that "on average organic products contain as many or slightly more of the components that have beneficial health effects, and on average just as many or fewer harmful components".
In any case, this Dutch research was able to shatter the myth that organic production increases food safety risks (see box 'Contaminants and micro-organisms'). In a comparison between organic and conventional products of the presence of contaminants and micro-organisms, organic products scored on average just as well or better. Where the risk of contamination was shown to be higher among organic products, researchers were able to trace the cause and producers were able to eliminate it.

Reducing undesirable components

Additional research is directed at preventing the presence of undesirable components. Some of these substances are known to be harmful to human health. Others may not have been proven to be harmful, but still diminish the healthful image of organic products. One example is contamination with genetically modified organisms.

Chloropropham in potatoes

The issue of chloropropham (CIPC) demonstrates the success that can be achieved through optimal cooperation between industry and research. In 2006 the organic potato sector was alarmed by various discoveries of the chemical germination inhibitor chloropropham. This substance is prohibited in the organic sector. Ten of the thirteen samples taken in stores contained traces of the substance, five of these were above the limit set by the organic certification organisation SKAL. All of the values were far below the conventional standard for pesticide residues. Further research demonstrated that the farmers were not to blame. Contamination took place during transport and at washing and packaging stations. The substance is persistent and easily absorbed into wood, for example, that has come in contact with conventionally treated potatoes.
To prevent this cross-contamination, the researchers proposed a protocol that included a number of rules such as: work with two separate processing lines, use chloropropham-free crates (preferably in a different colour than those used for conventional potatoes), clean the machines and use chloropropham-free trucks. These measures have already proved to be effective. Whereas 67 per cent of the samples taken in 2006 showed traces of the germination inhibitor, this was the case for only 12 per cent in 2007. In a new sampling round in 2008, only 6 per cent of the samples had traces of chloropropham.

Every substance and every product demands its own unique approach. In case a substance enters the product unnoticed, it is important to determine how it got there. The next question is how to reduce or eliminate it. In some cases it may be sufficient to change the animals' feed, while in other cases it may be necessary to alter cleaning methods. Sometimes a problem will solve itself, as was the case with dioxin in eggs. At one time it appeared that many organic eggs contained elevated levels of this substance. Further investigation revealed that chickens raised on small farms and in private yards were particularly likely to have unacceptably high levels of dioxin. This is because these chickens are generally outdoors more often. They eat more worms, which bind dioxin in their fat. On large-scale poultry farms, the chickens tend to stay inside more, where there is food and water and where they feel safer. Thanks to the upscaling of organic poultry farms, dioxin levels in eggs have now decreased significantly. Small-scale poultry farmers can prevent high dioxin levels by giving the chickens food and water inside and by limiting the time they spend outside. For more on this issue, see Chapter 9.
Sometimes undesirable substances are needed to ensure a longer shelf-life for the product. The objective in that case is to minimise the amount of a specific substance, such as nitrite in processed meat products. In products such as ham, it is normal to add 120 to 150 ppm nitrite. But research has shown that taste, shelf-life and colour are preserved just as well at 80 ppm. Eliminating nitrite altogether is not possible without making major concessions with respect to colour and food safety.

Kees van Wijk

Research into the prevention or reduction of undesirable substances takes place in close cooperation with the industry. This leads to solutions that can be implemented immediately by farmers, retailers and processors.

Enhancing positive characteristics

The distinctiveness of organic agriculture can be increased by further enhancing its positive characteristics. One way is to increase the CLA content of milk. Dairy farmers can achieve this by allowing their cows to graze longer and by feeding them more roughage. Another possibility is to put a product on the market specifically because of its exceptional characteristics. For example, the introduction of the Santana apple was successful because this particular apple has been proven to be hypoallergenic. This means that many people who are allergic to apples can eat this apple with little or no side effects. Research has shown that about 75 per cent of patients with an apple allergy do not show an allergic reaction to Santanas. Researchers oversaw the process of introducing this new apple variety from start to finish – from cultivation and harvesting all the way through to storage in the supermarket. Most Santana apples are organically grown.

Distinguished taste

The organic sector can also distinguish itself through taste. One of the reasons consumers buy organic products is because they find them better tasting. “We want to use and expand on that argument”, explains Kees van Wijk of Wageningen UR. “If farmers produce tasty varieties, this gives consumers an extra impulse to buy organic.” Research has shown that this is possible. Old varieties of potato, carrot, onion, cabbage, garlic and pumpkin often have much more taste. The question is whether they can be profitably cultivated, stored and sold. The first step is to ask consumers in stores to taste and evaluate the new varieties. If they are positive about the tasty varieties, the next, more long-term, step is to improve these varieties where necessary in order to achieve a higher yield and less susceptibility to disease. Organic farmers participate in this type of research by testing these varieties on their farms. In addition to taste, the product’s appearance is important to consumers, especially to those who buy their food in supermarkets. Moreover, consumers who favour a particular apple variety would like to buy it throughout the year. But how can the quality be preserved for so long during storage? The apple has to remain hard and crisp, and not have a rough peel or begin to develop a brown core. Most apple varieties cannot be stored successfully for a whole year, but the feasible storage time can be extended. Researchers are trying to accomplish this for Topaz and Santana apples, two varieties that are often grown organically. Topaz can normally be stored well until about the first of April and it appears possible to extend this period by about a month. So far, however, tested measures have succeeded either in preserving the apple’s hard texture or minimizing storage defects. It has not yet been possible to achieve both improvements at the same time. But the researchers are optimistic. The same tests are now being conducted on Santana apples, which can normally be stored until the first of March.

“Organic production can distinguish itself with better-tasting varieties.”

Kees van Wijk

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12 Economy, market and chain

In their pursuit of growth and professionalisation, the Dutch organic sector focuses primarily on market development. But how do you stimulate the market for organic foods? This is the subject of many research projects concerning market, consumer preferences and the supply chain. These projects focus specifically at consumer purchasing behaviour, product development, supply chain formation and minimising cost price. As a rule, this research takes place in close cooperation with chain actors.

Marieke Meeusen

Two to three per cent of households in the Netherlands buy organic products on a regular basis. Thanks to research, the purchasing behaviour and motives of these so-called 'heavy users' are understood quite well. 'Heavy users' primarily buy organic products because they value animal- and environment-friendly production. In terms of increasing market share, however, it is especially interesting to look at the large group of 'light users'. This heterogenous group has different perspectives than 'heavy users' and thus other purchasing motives. Light users offer great expansion possibilities for the organic market.
Minimising the price difference between organic and conventional foods is often seen as key to getting light users to purchase organic products more often. However, a large-scale price experiment (see box 'Effect of price reductions') showed that a price reduction alone would not suffice to substantially increase the market share of organic.
"Thanks to the price experiment, we are now sure that other marketing instruments are needed as well", explains Marieke Meeusen, coordinator of the market and economic research. "It's all about the right mix of the four Ps: price, product, promotion and place (distribution and availability). We are now focusing much of our research on these four Ps."

'Marketing is all about achieving the right mix of the four Ps: price, product, promotion and place"

Marieke Meeusen

Selling price versus cost price

If sales are to be increased by offering attractively priced products in the supermarkets, the cost price will have to be kept low. Keeping a careful eye on the cost price is essential in any case, to ensure that organic producers receive fair pay for their labour (fair trade). This is particularly important to the animal husbandry sector with its relatively high production costs and low number of parties in the market. Organic producer associations in the dairy, meat and eggs industries negotiate with suppliers yearly. Cost price calculations are essential to the associations: they provide them with a good negotiating position and result in better contracts.
For the past eight years, economic researchers have been calculating the cost price of pigs and piglets. An independent committee uses this calculated cost price to set the recommended price

Effect of price reductions

The market share of organic products in the Netherland is about 2 per cent. One of the objectives of the Dutch policy regarding organic agriculture is to stimulate the market for organic products and thus stimulate organic production. Minimising the price difference between organic and conventional foods is often considered crucial to increase the market share of organic products.
To find out whether this assumption is true, a large scale price experiment was carried out. In ten various-sized cities spread throughout the Netherlands the prices of organic products in most of the supermarkets were decreased by 5 to 40 per cent. The effect on sales was quantified and the purchasing motives and price sensitivity of buyers and non-buyers were surveyed. The results indicated that price does matter but that it is not the only determining factor. Reducing the price of organic products does increase sales, but the extent of this increase is limited and varies strongly per product group.

for supplied pigs. These calculations also contribute to the expansion of the organic pig sector. Substantial investments are required when expanding or converting to organic production (different housing system, decreased production). Therefore, only attractive profits will entice conventional pig farmers to alter their production methods and stimulate current organic producers to expand. Currently, prices and profits in the poultry sector are also being researched. The project looks at the entire poultry chain: from poultry farm through packing station and retail store. This research is initiated by the organic poultry farmers, who believe that the profits in their sector are not distributed evenly.

Opportunities to reduce cost price

Cost price calculations for the animal sector show that the cost price for animal feed has increased sharply in recent years. The upcoming requirement that organic animals be given only 100 per cent organic feed, will probably push this cost up even further.
Cost reduction is therefore a serious issue in organic production chains. Two research projects are looking into ways to decrease costs. One project studies the way in which scale influences cost price. Would an increase in scale actually decrease the cost price, as is often assumed? And how do entrepreneurs interpret such data? A second project looks at the social impact of production on a larger scale. How do consumers value this development and what do the entrepreneurs themselves think? Does large-scale production fit the famers' vision of organic agriculture and does it agree with their working practices?
In plant production, reduction of the cost price could primarily be realised through a better control of pests, weeds and diseases. Production costs in organic plant production are strongly influenced

by yield losses caused by pests and diseases. Additional labour required for manual weeding is also very expensive. In the Netherlands, research focuses mainly on prevention and control of weeds, pests and diseases (see Chapter 7).

The second 'P': Product

Looking at the P for product, the focus tends to be on intrinsic qualities such as taste, convenience and shelf-life. Healthfulness is another important quality. But do consumers really associate organic mayonnaise, for example, with healthfulness? How should such a product be promoted? When the reasons behind product choices of individual groups of people are known, targeted promotional campaigns can be created that are geared to the specific perceptions of each group. Dutch research is trying to find answers to these questions to support the market development for organic products.

Increasing importance of promotion

When promoting an organic product, attention could be paid to an appealing product characterisation, to the layout of the shelves and to the product appearance. Eye-catching floor stickers or hanging signs have proven to be effective in directing consumers' attention – to organic meat for example – and in stimulating purchases. The more extensive and visible the promotional materials were, the larger their effect. The signs do not have to contain a lot of information. On the contrary, according to Meeusen. "Consumers are often in a hurry, so they are more interested in simple directions on how to find something than in lots of information."

Increasing attention is given to the packaging of organic products. Natural food stores prefer as little packaging as possible, but supermarkets want detailed packaging that effecively distinguishes organic foods from conventional products. Supermarkets also want to stand out by using biodegradable packaging. One disadvantage of this type of packaging is that it is 15 to 200 per cent more expensive. For some producers this is a reason to not choose biodegradable materials (yet). The organic product is already more expensive than the conventional one and additional expenses for packaging would make it too expensive to sell. However, environment-friendly packaging may also create an additional incentive to buy the product. There is no hard evidence for this effect, but research has shown that consumers definitely favour biodegradable packaging. Unfortunately, few are familiar with the labels for this type of packaging.
"Packaging certainly plays a role in sales. Research into this effect has only just started," says researcher Ulphard Thoden van Velzen. A superabundant package design is probably preferable for light users, whereas heavy users would respond better to a more unruffled design. Thoden van Velzen believes it is a positive development that companies are starting to experiment with packaging. "Many producers still don't even think about the best way to sell their product. The rising attention to packaging is therefore a good sign." Currently, the researcher works together with the industry on various new types of packaging for meat and cheese.

Willie van den Broek

Increasing product availability

The last 'P' refers to product availabity. Consumers have to be able to continuously find organic food in their neighbourhood. The demand for organic products has been growing steadily during the last decades. The production volume, however, did not increase in the last five years. Demand and supply are badly balanced, which causes considerable fluctuations in price and availability. There is a pressing need for new organic producers, but only a few farmers actually convert to organic production each year.

An evaluation amongst stakeholders, organic and conventional farmers provided insight in the causes of this insufficient growth of production. The pioneer farmers who were the first to believe in organic agriculture, made the transition years ago. The group that's next in line is often referred to as 'early adopters'. These farmers have other motives besides idealistic ones for converting to organic farming: economic motives, for instance. Another problem is that many conventional farmers do not have a realistic concept of organic agriculture. This makes it important to increase conventional farmers' knowledge about organic production. "We need to create a breeding ground for young agricultural entrepreneurs who see organic production as a serious business strategy", says Wijnand Sukkel. He investigated the reasons behind the recent lack of growth of organic production. Sukkel: "If they eventually do decide to make the switch, this decision will be based primarily on good market prospects for organic products." Realising expansion is primarily the organic sector's own responsibility. "Chain actors in the dairy and meat industries can use their close contacts with conventional farmers to inform and interest them. They are able to offer a secure market for the farmers' products, ensure balanced growth and purchase the products during the conversion period."

"If companies have an interest in a product, they will work hard to make it successful"

Willie van den Broek

Introduction of new products

In addition to maintaining a sufficient supply to the supermarkets, it is also important to introduce new products with which the organic sector can distinguish itself. One way to speed up the introduction of new organic products in the supermarkets is through company restaurants, explains Marieke Meeusen. Research has already shown that company restaurants are a good place to try out new products. If people like a product, they will look for it in the supermarket. Many freshly squeezed fruit juices, fruit salads and sushi products have already found their way to the supermarket through this catering channel. Consumers can thus help to stimulate the introduction of new products in the retail channels.

Establishing and strengthening marketing chains

Actual strengthening and professionalisation of the market for organic products will require coordinated and innovative efforts. These efforts should involve everyone in the chain: from producers all the way to the supermarket. Companies and research institutes work in joint projects on the development and marketing of organic products. The industry initiates these studies and helps to finance them. "We think that when companies have an interest in a product, they will work hard to make it a success", explains research coordinator Willie van den Broek.

Chain research is by definition multidisciplinary. Companies and research institutes innovate together. Researchers not only do research, but they also play a role as project directors and managers. If necessary, they receive intensive training and coaching to build up the expertise and skills required for their new roles.

Wine cheese and hypoallergenic apples

So far, sixteen chain projects have been carried out. Some focused on the development of new products (such as wine cheese and wild cucumbers), others on new concepts (including better positioning of products on the market). There were projects aimed at introducing a product to new target groups (organic wine to restaurants and gift basket companies, organic milkshakes for students), and some centred on adding value (organic vegetable juice made of by-products). Also, the marketing of products with a special quality or health aspect was researched (hypoallergenic apples, gluten-free foods based on quinoa and amaranth and health-promoting cranberries).

In a short time new products were developed, strong chains emerged and new markets were created. This included using by-products from the organic processing industry to make organic vegetable juice (see box) and the introduction of the wild cucumber (see box).

In some cases it takes more time to build a solid supply chain for a new product. An example is the production of Dutch cranberries. Until now, cranberries have only been collected on the Wadden islands of the Netherlands. Most cranberries are imported from other countries.

Organic vegetable juices made from by-products

Processors of organic vegetables – companies that rinse, cut, freeze and conserve the vegetables – create large amounts of by-products. For winter carrots alone this represents fourteen per cent of the product volume. These by-products are usually used in animal feed, but this gives insufficient financial return. Meanwhile, there is a growing demand for organic vegetable juice. This raised the question whether the residuals of vegetable processing could be used to produce vegetable juices.

The vegetable juice producer 'Provalor' makes food products from by-products and wanted to investigate the possibilities in the organic sector. Wageningen UR directed the development of a supply chain that includes the processor, trade organisation and organic juice producer. A number of studies were conducted into the requirements for introducing the juice into the market. Following a number of successful production and sales tests, contracts were drawn up for the supply of organic vegetable juice.

Researcher Noen Jukema: "Through learning by doing and product development we came up with an innovative and sustainable product." Provalor expects to increase production in the coming years to 3 to 5 million litres of organic vegetable juice per year. This means a 50 per cent increase in the value of the by-products from Dutch organic vegetable production.

Wild cucumber a big success

Tomatoes are available in various colours and sizes. Consumers can choose from a wide selection of varieties including vine-ripened, cherry and plum tomatoes. This is not the case with cucumbers. Up to now, a cucumber has always been just a cucumber. But this is about to change. A tasteful old cucumber variety that has a dark-green colour, a rough peel and prickles, has been reintroduced specifically for the organic market. It is called the wild cucumber. Aside from having a distinguishing colour and appearance, this product reminds consumers of 'the old days'.
This cucumber was developed together with the spring cucumber as part of a collaborative effort between Wageningen UR, the Centre for Genetic Resources Netherlands (CGN), a breeding company, a grower and a trade company in organic vegetables. CGN selected primitive cucumber varieties. The grower looked at production and product qualities.
A retail study in German stores investigated consumers' response to the cucumbers and listed what characteristics they found important. Consumers appeared to prefer the most natural packaging design using only a banderole (no plastic, no glue, little refuse). During the Fruit Logistica trade show 2008 in Berlin, the chain that introduced this cucumber to the market was runner-up for the Innovation Award. The wild cucumber is being introduced in stores in the Netherlands and Great Britain.

Consumer research provided insight in the type of cranberry products that interest consumers and suggestions on how these products could be marketed. Colour, taste, size, firmness and perishability turned out to be most important. As the cultivation method was relatively unknown to Dutch growers, a cultivation guide was prepared for them.
After market perspectives and cultivation possibilities were clear, a number of chain actors signed a declaration of intent to work together on building a chain for organic cranberries in the Netherlands.

Creating the right image

Once a target group for an innovative product has been selected, the next question is how to bring the organic product to their attention. A milk factory, a caterer, two machine manufacturers and researchers are looking into this at two schools of professional education. The researchers are looking for ways to stimulate the students to buy organic dairy products. They are working with milkshakes (a new product) and yoghurt drinks (an existing product). What will the cups, vending machines and refrigerators have to look like in order to attract the students? This was investigated by using a number of image designs. Students responded least to a green, natural and old-fashioned image. A McDonald's type image and a modern, hi-tech image both worked much better. For both the milkshake and the yoghurt drink these two images were combined to create a design and slogan for the vending machines and cups.

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13 People and society

Organic agriculture has excellent opportunities to create strong links between the environment it operates in, the people who live there and local nature and landscape. The Dutch organic sector aspires to strengthen these links and it is already well on its way. Together with researchers and stakeholders new concepts are being developed and put into practice.

Andries Visser

Nowadays, many consumers have no idea where their food comes from. Rural and urban life seem to have drifted apart. Nature and landscape management are not even intrinsic elements of farm life anymore. Research shows that organic agriculture may well be capable of bridging the gap between consumers, farm and nature. Many organic farmers derive their motivation not only from primary production. They also want to restore the ties between urban and rural life, and between agriculture and nature. This way they contribute to what is considered 'social sustainability'.

People

What exactly is social sustainability and what role can organic agriculture play in it? To answer this question researcher Marieke Meeusen refers to the definition of sustainability given in the Brundtland report 'Our common future'. Within the framework of the three P's (people, planet and profit), social sustainability focuses on the P of People. This means that a socially sustainable farming business, for example, does not exploit people. To be more precise: its business practices do not involve child labour or excessive physical labour, and they do not negatively impact the labourers' mental well-being. The P of People also implies that people work together to increase environmental awareness. This is exactly what organic agriculture does through the large number of linkages it creates with its environment. Meeusen: "This way, people become more aware of what good food really is. If you want to judge organic agriculture on its social sustainability, you have to look at aspects like labour conditions, the physical burden on labourers and the links to society created by the sector."

Linking farmer and general public

Agriculture often takes the connection between producer and consumer (citizen) for granted. In the past this connection was mostly based on geographic proximity. In a globalised society the principle mainly represents a close emotional relationship between producer and consumer. For such a relationship to develop, the identity of the producer has to be apparent to the consumer. There are various ways for producers to connect with their social environment. The Dutch organic

"Organic agriculture creates linkages between farmers and the general public"

Andries Visser

Labour conditions on organic farms

One aspect of social sustainability concerns labour conditions. How does organic agriculture perform compared to conventional agriculture? The physical workload has been studied in a number of sectors. The results vary.
Labour conditions on organic arable farms and field vegetable farms are worse than those on conventional farms. This is mainly due to the large number of hours spent weeding by hand. These activities put much strain on the back. Also, monotonous work during planting, weeding, harvesting, and preparation for auction may cause Repetitive Strain Injury.
Organic poultry farms perform better than their conventional counterparts, as far as labour conditions are concerned. Organic poultry farmers keep fewer animals, which results in fewer hours spent in the poultry house. Organic pig farmers, on the other hand, have more physical work thanks to filling, cleaning and mucking out the pens, and because of the way the animals are fed. This leads to more physical strain (in particular on the lower back) than on conventional farms.
Little more information is available about labour conditions in organic enterprises. Nothing is known about absence due to sickness and accidents. Research into the work satisfaction of organic farmers has only just started. Existing literature shows that 'going organic' brings the joy back into farming for many farmers. Interviews were held with 'care farmers'; farmers who allow people with a mental or physical disability to work on their farms on a therapeutic basis. These interviews showed that having such activities on the farm improves the farmer's quality of life.

sector aims to strengthen these connections. Research has already looked at the types of services organic farmers offer the general public and how these services help (re)connect the urban and rural worlds. It would be interesting to find out which linkages best suit the needs of the public. Research on this topic has recently started.

Organic farmers can contribute to these linkages through on-farm nature and landscape conservation. Organic farmers inspire scientists through their nature and landscape management – not only by providing space for nature and landscape on their farms, but also by explicitly thinking about ways to turn nature and landscape into inseparable parts of organic farm management.
A second way to contribute to a closer connection is through what the Dutch call 'experience farming'. This basically means locating agricultural activities within a city or near urban agglomerations. The short distance between farmer and city-dweller is a distinctive characteristic: many people visit the farm, they see the farmer at work, they come to pick their own apples or to play with the goats. Because of the direct contact these people have with agricultural activities, farming systems in which no chemicals are used are preferred. The project 'Tomorrow's taste' is currently testing which cultivation systems might be suitable for this form of agriculture.

Multi-functional organic farms

It turns out that organic farms do indeed play a linking role, more so than conventional farms. Organic farms serve a wide range of functions, including recreation, health services, nature conservation and education. An analysis of these side-activities of Dutch organic farms shows that, proportionally, organic farms offer over three times more activities than conventional farms. On-farm sales are offered five times more often on organic farms than on conventional farms, recreational activities six times more often, and healthcare activities seventeen times more often. Compared to conventional farms, the linkages in organic farms seem to be more related to emotional values like dedication, passion and conviction (see Table 1).

Table 1. Types of linkages and underlying consumer values

Type of linkage	Emotional value	Schwartz's values*
Product		
Regional/brand product	Interest	Novelty and curiosity
Quality label	Conviction	Equality and responsibility
Service		
On-farm sales	Diversion	Novelty and pleasure
Farmers' market	Interest	Curiosity and social harmony
Farm shop	Conviction	Safety and social harmony
Subscription	Dedication	Sense of connectedness and obedience
Experience		
Day recreation	Amusement	Curiosity and pleasure
Overnight recreation	Diversion	Freedom and curiosity
Education	Interest	Curiosity and justice
Child care	Interest	Social harmony and responsibility
Care farm	Passion	Safety and connectedness
Participation in discussions and labour activities	Conviction	Helpfulness and equality
Participation in decision making	Dedication	Responsibility and tolerance

* Schwartz's values are common values that act as 'guiding principles for one's life'. The 'Schwartz Value Inventory' (1992) was a wide survey of over 60,000 people in which Schwartz identified ten 'value types' that gather multiple values into a single category.

Anton Stortelder

"Nature should not only be tolerated on a farm, but integrated actively"

Anton Stortelder

Agromere, agriculture in a new suburb

Research into urban farming in the Netherlands evolves around the projects 'Agromere' and 'Tomorrow's taste'.
In Agromere scientists are attempting, together with stakeholders, to develop concepts for urban farming to be implemented in future urban extensions of the city of Almere. Many stakeholders in Almere are enthusiastic about urban farming. Together, scientists, farmers, landscape architects, project developers and town and country planners are preparing the conditions and requirements for urban agriculture.
The issues encountered by the stakeholders of the Agromere project are serving as input for the 'Tomorrow's taste' project. Urban farming should focus on growing crops that give city dwellers something 'extra'. Examples are colourful crops like tulips, or crops people may taste or pick themselves, such as strawberries.
One of the issues that are yet to be resolved, is how farmers can make the landscape attractive to the general public. In a pilot project, scientists designed a 'Mondriaan field' with crops of different colours and shapes. GPS-techniques were used to enable easy sowing and harvesting of these fields.

The crops in a Mondriaan field are a colourful and graphic addition to the landscape

Values such as equality, responsibility, safety, social harmony, helpfulness and tolerance are typical of these relations. The linkages created by conventional agriculture, with innovation, pleasure, freedom and curiosity as their main values, are less engaging.
Organic farmers often view their farms in a holistic way, which explains the different values of the connections they create. They often pass this message of wholeness on to visitors and consumers. Because the different farm activities are often interwoven, organic farmers are able to emphasize the link with food production and natural cycles.

Research only gives a first indication of the extent of the linkages. The framework for assessment of these linkages needs further substantiation. Further surveys among consumers and the general public are also required. Whether the theoretically formulated values for the various activities are indeed valid, is one of many questions that still need to be answered.
"Even though this research is still in its early stages, it shows the clear distinction between organic and conventional agriculture. This gives the sector new arguments with which to communicate to society the added value of 'organic' production", says Andries Visser, leader of the 'Multifunctional' research programme. "Pergola farms or Community Supported Agriculture (CSA), where local citizens have a say in farm management, are the most far-reaching form of linkage between a farmer and the general public."

Urban agriculture

The most important contributions made by farms in urban environments are the various linkages and experiences they provide for urban citizens. This form of agriculture can be found only sporadically in the Netherlands, but scientists believe it could be applied much more frequently in the extension of urban areas. The concept needs further elaboration, but it is already evident that organic agriculture is the most suitable form of urban farming. Agricultural activities that take place in the middle of housing developments should not involve the use of chemicals. Farms should also offer services and activities to people living in the neighbourhood. This not only legitimises the use of valuable land for urban agriculture (rather than for commercial or residential buildings), it is also the only way to run an economically viable farm.

Nature and landscape

Many organic farmers are convinced that nature and landscape elements are, or should be, an inextricable part of organic farms. Literature shows that organic farmers provide "green services" such as clean water, biodiversity, and attractive landscapes through their farming efforts and by refraining from the use of chemical pesticides and fertilizers. On average, organic farms provide more biodiversity and characteristic (regional) agricultural landscapes than conventional farms. Organic farmers are more inclined to grow traditional crops and varieties; there are more herbs and insects on organic fields; and the farms have more landscape elements that attract breeding birds and insects.

The above is not true for all organic farms. Conventional farms in old landscapes, such as the 'Friese Wouden' in the Netherlands, contain a higher than average biodiversity. On the other hand, biodiversity is lower than average on an efficiently organised organic arable farm with large fields in Groningen. Biodiversity is threatened by the trend towards scale enlargement and mechanisation, which also affects a number of organic farms.

Farmers and researchers discussing nature and landscape on organic farms

The organic nature farmer

The organic nature farmer provides a package of region-specific green services. This is the focus of his entire farming system. The following conditions also apply:

- **Crops are regularly rotated on soils that are suitable for this purpose.**
- **At least 5 per cent of the farm area consists of landscape elements typical to the region.**
- **The farmer looks after these landscape elements.**
- **Clippings and other organic material resulting from the maintenance of these landscape elements are removed, composted and reintroduced into the mineral cycle of the farm,**
- **Meadow birds are not disturbed during the breeding season.**
- **The design of the farm yard receives additional attention: at least 40 per cent of the built-on and paved surfaces will be made more attractive by using landscape elements that are characteristic of farm yards in the region.**
- **The farm is open to visitors.**

Quantifiable nature

To retain its pioneering position in landscape and nature management, the organic sector needs proper compensation for their tangible contributions to biodiversity. These contributions to nature and landscape must be substantial and should be integrated into the farm. “Nature should not only be tolerated on a farm, but actively integrated as part of total farm management. You have to be able to utilise your position as a farmer”, explains researcher Anton Stortelder. Together with a number of farmers he has developed a concept for interweaving nature and landscape management on organic farms with quantifiable nature targets.

During workshops in three regions, organic farmers expressed their enthusiasm and willingness to provide a fixed package of region-specific nature and landscape contributions. In return they wanted a lasting, inflation-adjusted annual compensation (from financial investors). The possible shape of such a package was investigated together with the farmers. This resulted in seven requirements (see box ‘The organic Nature farmer’) that were found acceptable by the farmers who participated in the project.
The most important requirement, according to Stortelder, is that farmers reintroduce clippings and other organic waste into their farms through composting. “This creates a link between the farmer, nature and the landscape. By taking nutrients away from the surrounding natural habitats, he creates opportunities for the development of valuable biodiversity. At the same time he works towards closing the mineral cycle of his farm.” It is essential that the nature farmer works in a structured way by making a farm nature plan. This way his investors can confirm that nature management agreements are being met. According to Stortelder it would not be fair to judge a nature farmer’s performance based on the number of plants or meadow birds counted on his fields. Spontaneous establishment of plants, for instance, is not only influenced by management but also by the natural potential of the farm environment.

The framework for this new farming concept has been made. The researchers will now present it to the same farmers who participated in the workshops. Follow-up research with two or three farms that will apply the concept will be next. This still requires a few preparations, such as drawing up a list of typical regional landscape elements (e.g. alder belts and reed borders in peat meadow areas) finding investors, and working out a realistic compensation scheme. Results are expected in 2012. A successful pilot project would enable the organic sector to extend the methodology to more organic farms.

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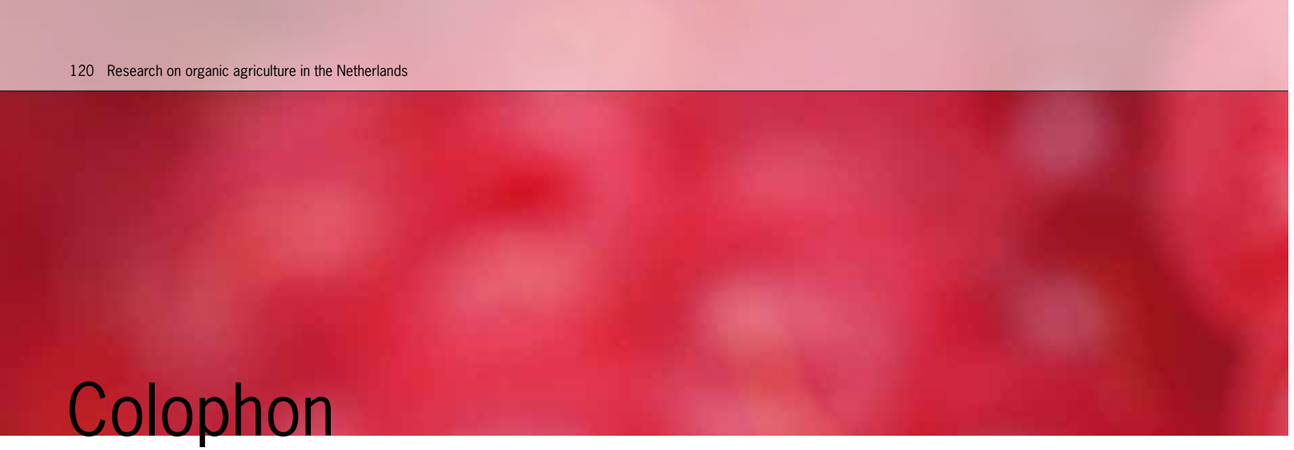

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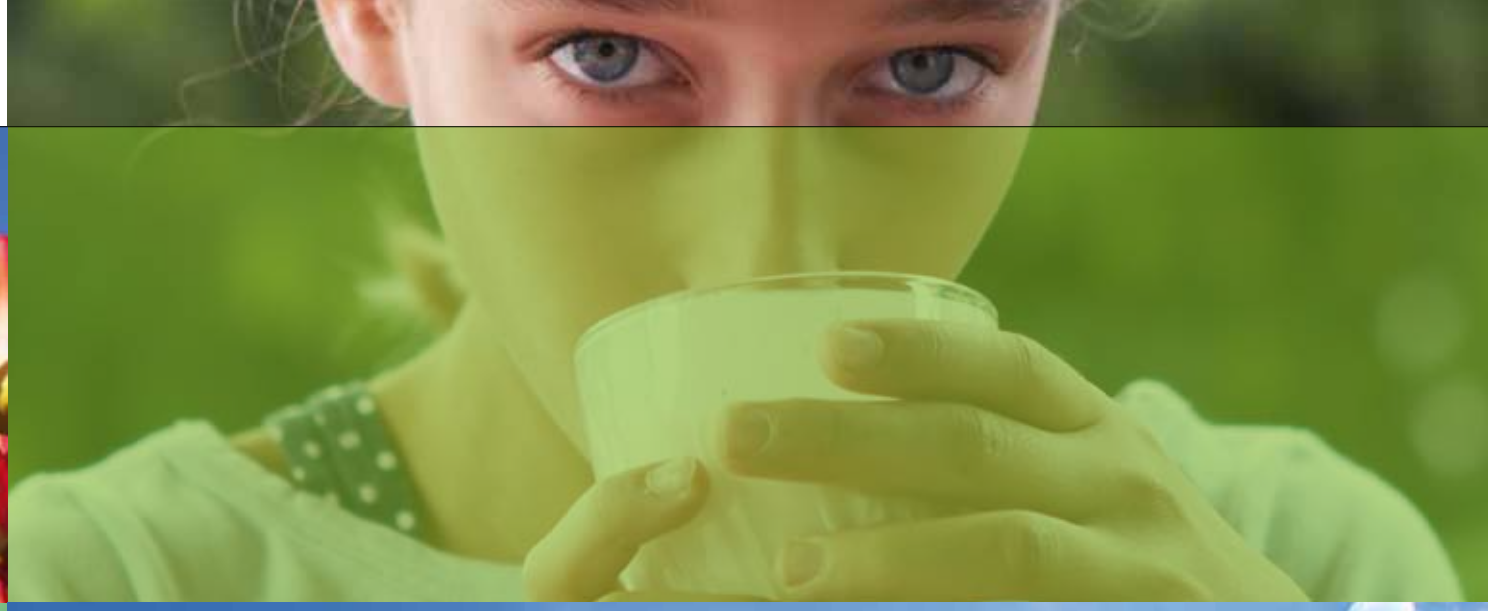

In the Netherlands, policy makers focus on developing knowledge and markets for organic agriculture. The budget available for research into all aspects of organic agriculture is one of the highest in Europe. All government funded research on organic agriculture is brought together in a comprehensive research cluster in which Wageningen UR and the Louis Bolk Institute are the main partners.

Research on organic agriculture in the Netherlands covers a wide range of topics. These vary from the basic production factors such as soil and seeds, to food quality, health, economic research and social topics such as animal welfare and citizens' well-being.

The organic sector in the Netherlands is, through the Bioconnect organisation, structurally and actively involved in setting the agenda for research and knowledge transfer. Sector representatives take active part in the project teams directing the research projects.

Research on Organic Agriculture in the Netherlands gives you an introduction to the way the cooperation between sector, government and research organisations is structured and managed. It also provides the reader with a comprehensive and up-to-date overview of the results of research and innovation in organic agriculture in the Netherlands.

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The innovation network of organic agricultural chains

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