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.**

Literature

Bos, J.F.F.P., Haan, J.J. de, Sukkel, W., and R.L.M. Schils. 2007. Comparing energy use and greenhouse gas emissions in organic and conventional farming systems in the Netherlands. In: Improving sustainability in organic and low input food production systems. Proceedings of the 3rd International Congress of the European Integrated Project Quality Low Input Food (QLIF), Hohenheim, Germany.

Haan, J.J. de, Zwart, K.B., Clevering, O.A., Smit, A.L., Geel, W.C.A. van and H.A.G. Verstegen. 2006. Nutrients waterproof: post harvest measures and treatment of drainage water to meet water quality targets. In: N management in agrosystems in relation to the Water Framework Directive; proceedings of the 14th N workshop, Maastricht, the Netherlands.

Prins, U., De Wit, J. and W.J. Nauta. 2005. Combining on-farm participatory research methodologies with modelling in order to create a regionally based organic agriculture in Holland. In: Researching Sustainable Systems: Proceedings of the Scientific Conference of ISOFAR in Adelaide (U. Köpke et al. eds.): 489-492.

Sukkel, W. and W. van Geel. 2008. Carbon sequestration in organic and conventional managed soils in the Netherlands. In: Cultivating the Future Based on Science. Proceedings of the Scientific Conference of ISOFAR in Modena, Italy.

Information

Wijnand Sukkel MSc.
e-mail: wijnand.sukkel@wur.nl
Researcher Organic Agriculture
Applied Plant Research
Wageningen UR

Udo Prins MSc.
e-mail: u.prins@louisbolk.nl
Researcher Organic Systems
and Feed Production
Louis Bolk Institute