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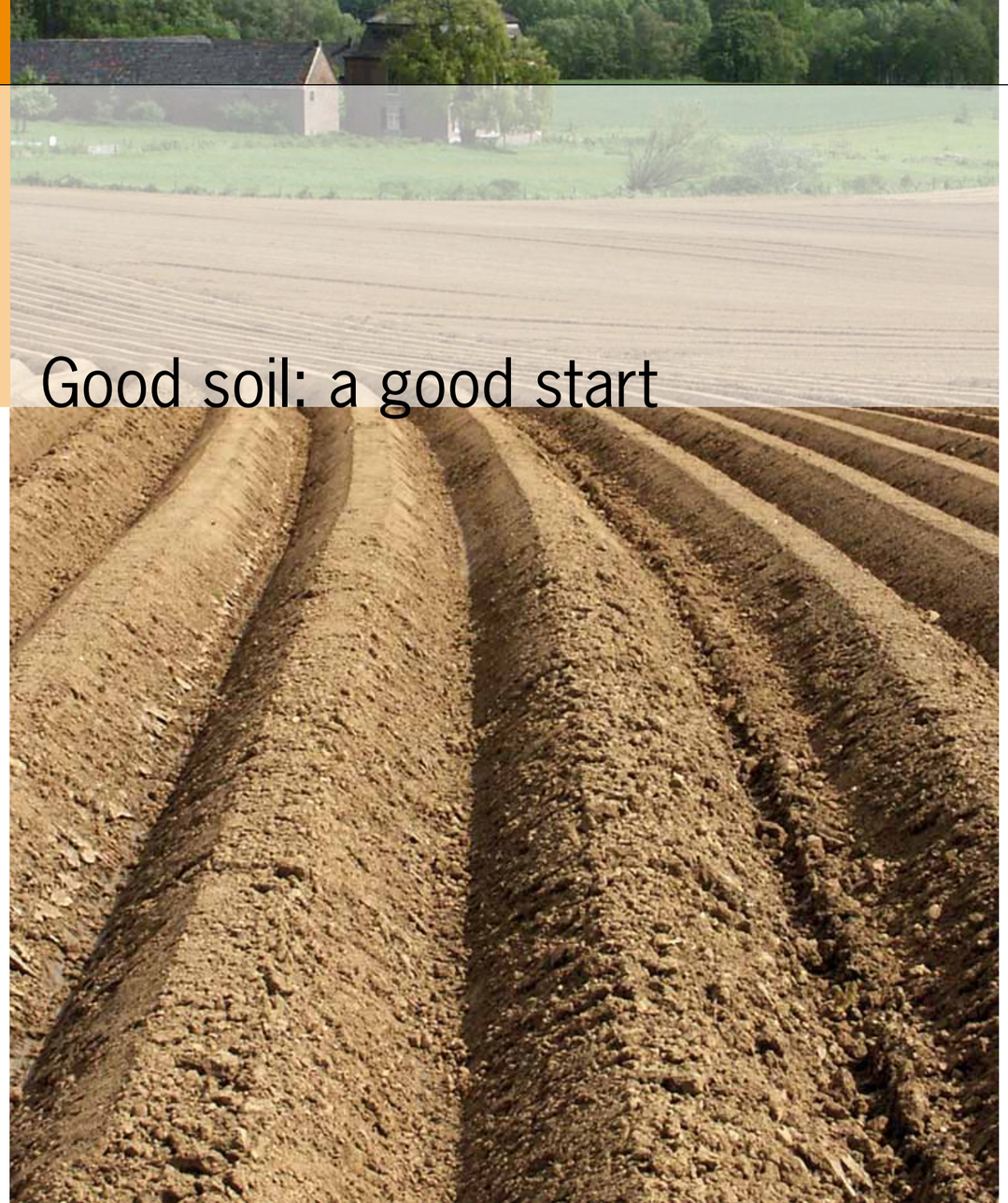
Good soil: a good start



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.

Literature

Vermeulen, G.D., Mosquera, J., Wel, C. van der, Klooster, A. van der and J.W. Steenhuizen. 2007. Potential of controlled traffic farming with automatic guidance on an organic farm in the Netherlands. In: Precision Agriculture '07, 6th European Conference on Precision Agriculture: 473-481.

Koopmans, C.J. and G.J.H.M. van der Burgt. 2005. NDICEA as a user friendly model tool for crop rotation planning in organic farming. In: Researching sustainable systems. Proceedings of the first scientific conference of the International Society of Organic Agriculture Research (ISOFAR), 21-23 September 2005 (U. Köpke, U. Nigli, D. Neuhof, P. Cornish, W. Lockeretz, H. Willer eds.): 534-537.

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