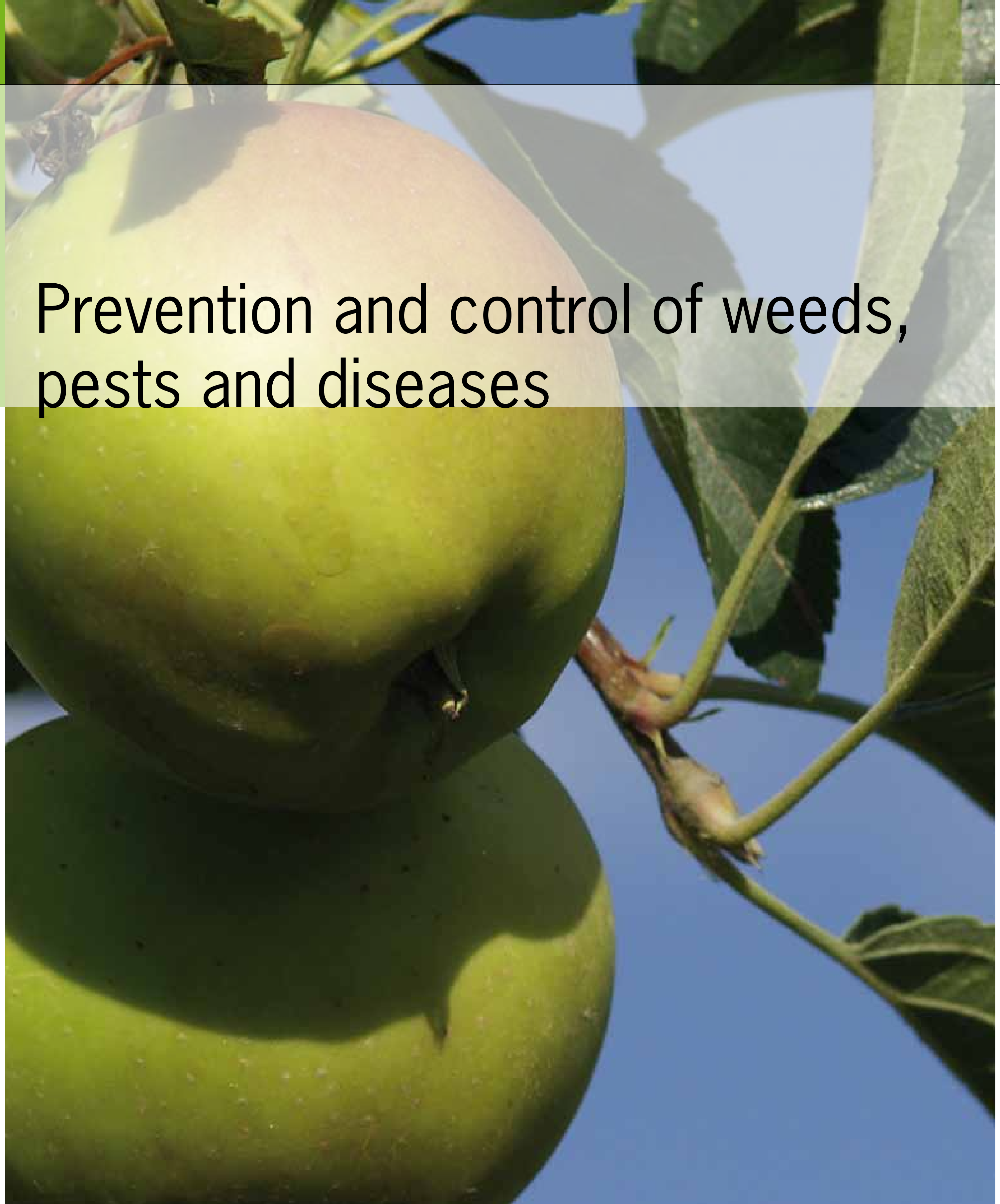


7

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.

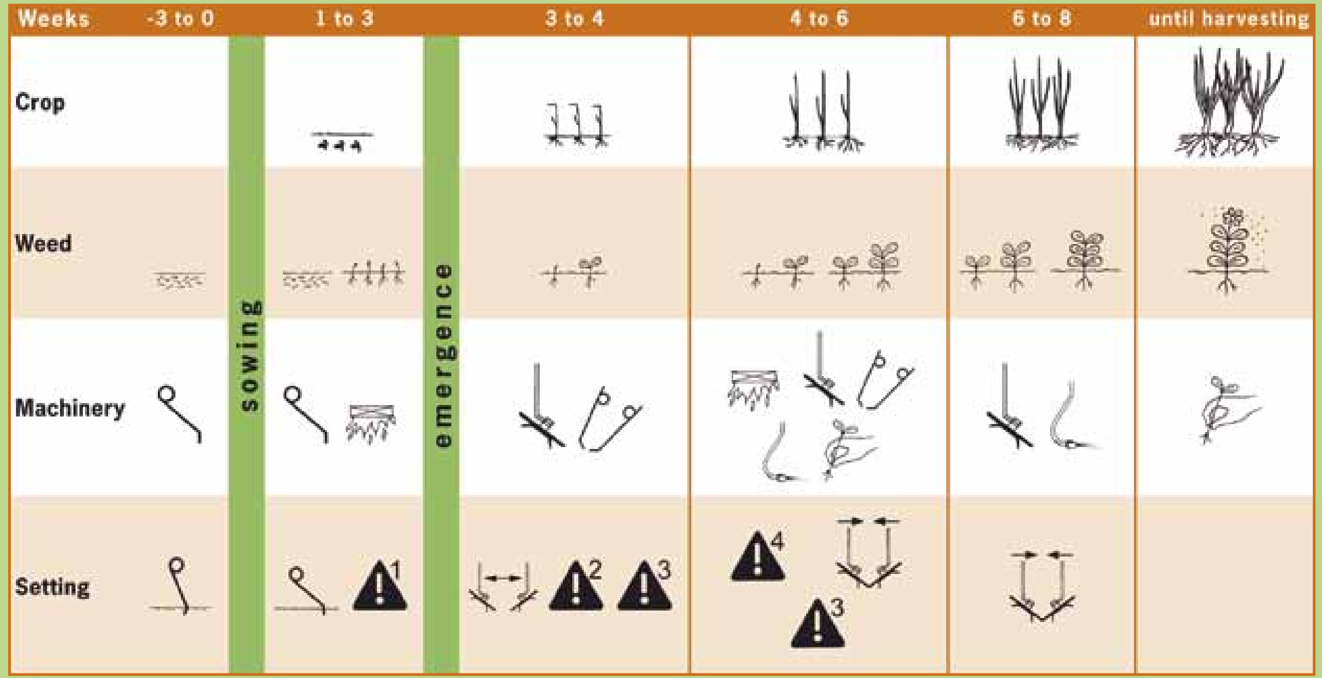
“Innovative technologies might cause a breakthrough in weed control in row crops”

Rommie van der Weide

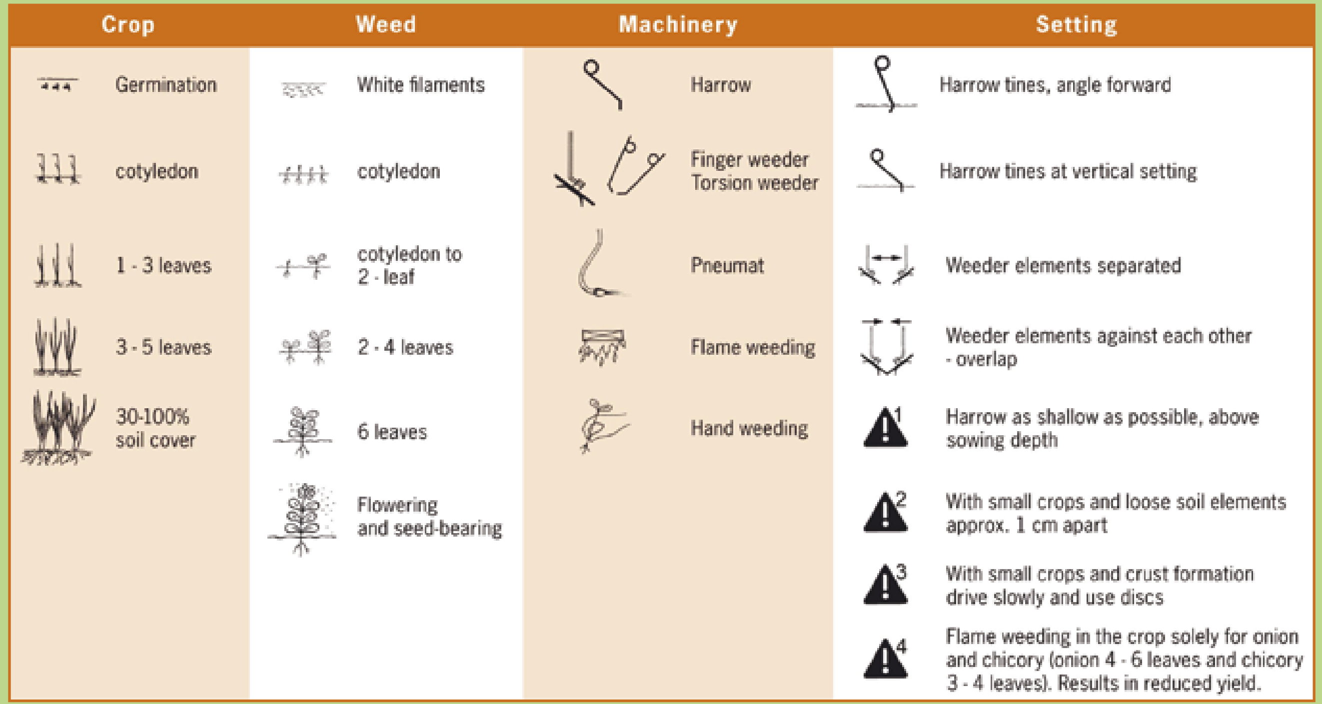
Innovation Network

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’).

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



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

Using UVc light in leek to prevent downy mildew

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.

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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