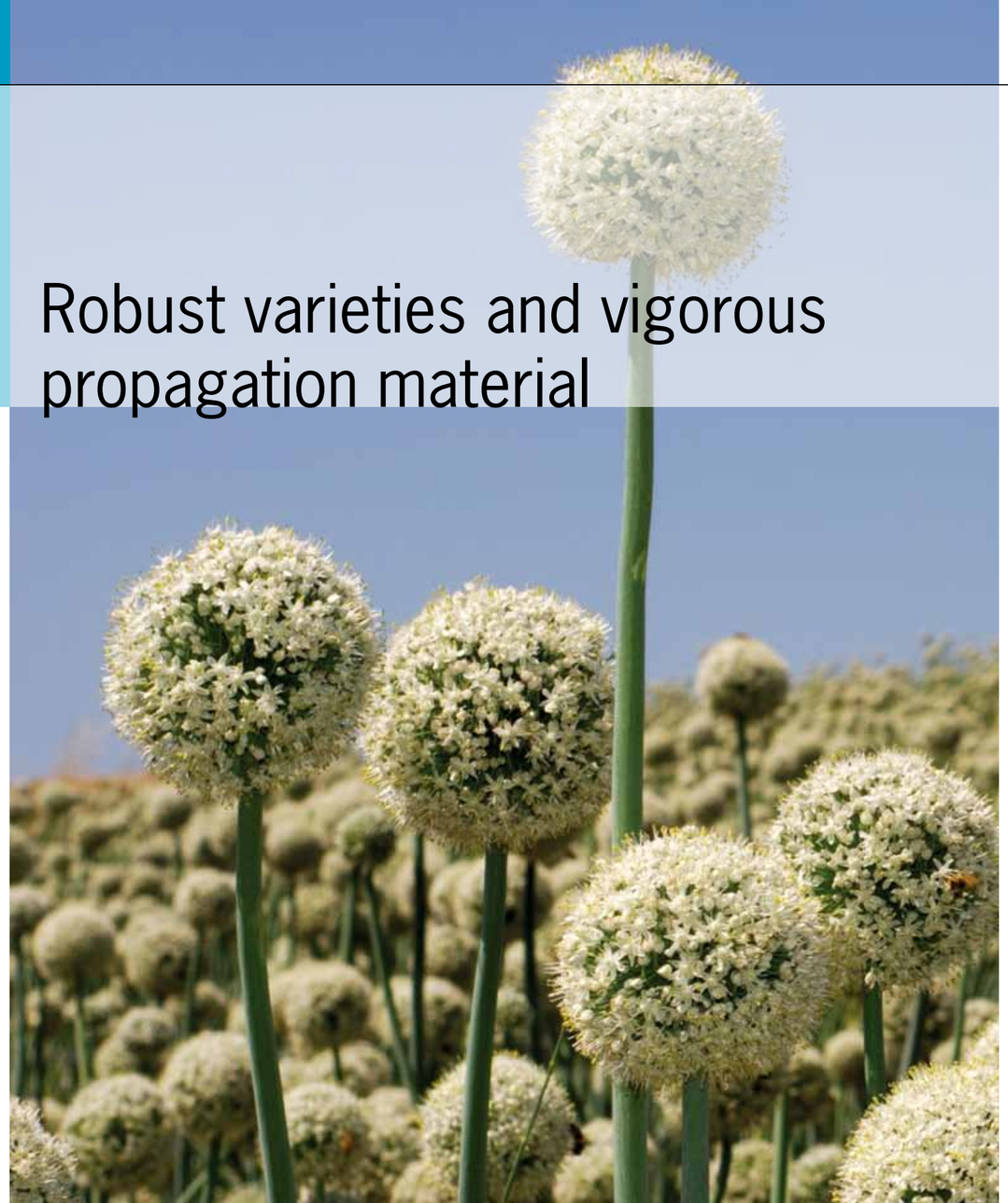
# 6 Robust varieties and vigorous propagation material



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

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**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

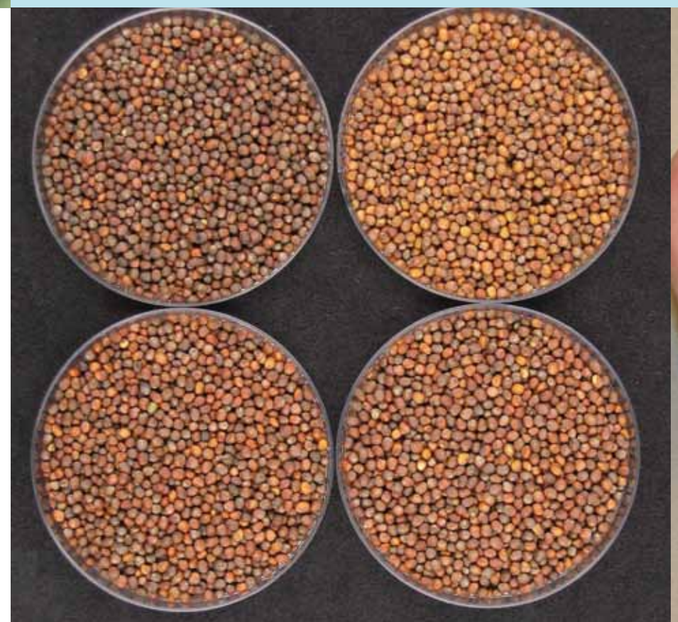
**Alternaria fungi may contaminate cabbage and carrot seed during production, resulting in lower seed production and lower seed quality. Seed production is also at risk when cabbage is struck by black rot caused by the *Xanthomonas* bacterium. Seed companies therefore set up extra production fields and 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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